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| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Management and orchestration;  Study on enhancement of Management Data Analytics (MDA)  (Release 17) | |
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# Foreword

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

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

Version x.y.z

where:

x the first digit:

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2 presented to TSG for approval;

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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:

**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

**can** indicates that something is possible

**cannot** indicates that something is impossible

**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

**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

# Introduction

# 1 Scope

# 2 References

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

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

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

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

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

[2] 3GPP TS 28.550: "Management and orchestration; Performance assurance".

[3] 3GPP TS 28.533: "Management and orchestration; Architecture framework".

[4] 3GPP TS 28.530: "Management and orchestration; Concepts, use cases and requirements".

[5] 3GPP TR 28.861: "Study on the Self-Organizing Networks (SON) for 5G networks".

[6] 3GPP TR 28.805: "Study on management aspects of communication services".

[7] 3GPP TS 28.554: "5G end to end Key Performance Indicators (KPI)".

[8] 3GPP TS 28.552: "Management and orchestration; 5G performance measurements".

[9] 3GPP TS 22.101: "service aspects; service principles".

[10] 3GPP TS 32.500: "Telecommunication management; Self-Organizing Networks (SON); Concepts and requirements".

[11] 3GPP TS 37.816: "Study on RAN-centric data collection and utilization for LTE and NR".

[12] 3GPP TS 37.320: "Radio measurement collection for Minimization of Drive Tests (MDT); Overall description".

[13] 3GPP TS 23.501: "System Architecture for the 5G System (5GS); Stage 2".

[14] 3GPP TS 28.310: "Energy efficiency of 5G".

[15] 3GPP TR 21.866: "Study on Energy Efficiency Aspects of 3GPP Standards".

[16] 3GPP TS 26.247: "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)".

[17] 3GPP TS 26.114: "IP Multimedia Subsystem (IMS); Multimedia Telephony; Media handling and interaction".

[18] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[19] 3GPP TS 28.313: "Self-Organizing Networks (SON) for 5G networks".

[20] 3GPP TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".

[21] 3GPP TS 38.304 NR: "User Equipment (UE) procedures in idle mode and in RRC Inactive state".

[22] 3GPP TS 28.545: " Management and orchestration; Fault Supervision (FS) ".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

**<defined term>:** <definition>.

## 3.2 Symbols

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

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

AI Artificial Intelligence

MDA Management Data Analytics

MDAS Management Data Analytics Service

ML Machine Learning

# 4 Concepts and overview

Editor’s note: this clause is to accommodate the concepts and overview of MDA/MDAS.

## 4.1 Overview

The Management Data Analytics is defined in TS 28.550 [2] and has also been mentioned by various other technical specifications and reports including for example TS 28.533 [3], TS 28.530 [4], TR 28.861 [5] and TR 28.805 [6].

The MDA provides a capability of processing and analysing the raw data related to network and service events and status (e.g., performance measurements, Trace/MDT/RLF/RCEF reports, QoE reports, alarms, configuration data, network analytical data, and service experience data from AFs, etc.) to provide analytics report (including recommended actions) to enable the necessary actions for network and service operations.

The MDA, in conjunction with Artificial Intelligence (AI) and Machine Learning (ML) techniques, brings intelligence and automation to the network service management & orchestration.

MDA can help to perform management tasks in preparation, commissioning, operation as well as in the termination phases. For example, MDA can support service provisioning by preparing service catalogues, evaluating network requirements for a new service and carrying out feasibility check. During operation phase, the MDA can identify ongoing issues impacting the performance of the network and service, and discover in advance the potential issues that would 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 deployment.

The MDAS can be consumed by various consumers, for instance the MFs (i.e., MnS service 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.

The MDA is an enabler for the automation and cognition of the network and service management & orchestration.

## 4.2 MDA functionality

Figure 4.2.1 illustrates the functionality provided by MDA. Depending on the scenario, MDA may collect data for analysis by acting as an MDAS Consumer, and/or as an MnS Consumer, and/or as an NWDAF subscriber. After analysis, MDA acts as an MDAS Producer to expose the analysis results to MDAS Consumers.

**Management**

**Data Analytics**

Analysis

MDAS

MDAS

MnS

Nnwdaf

Other MDAS Producer

MnS Producer

NWDAF

MDAS Consumer

MDAS Producer

MDAS Consumer

MnS Consumer

NWDAF Subscriber

Figure 4.2.1: Functional overview of MDA

# 5 MDA process and role

Editor’s note: this clause is to accommodate the MDA process (in connection with AI/ML techniques), relation between MDA and SON, relation between MDA and NWDAF, position of MDAS producer in SBMA, etc.

## 5.1 MDA role in management loop

The MDA forms a part of the management loop (which can be open loop or closed loop, see TS 32.500 [10]), and it brings intelligence and generates value by processing and analysis of management and network data, where the AI and ML techniques may be utilized.

The MDA plays the role of Analytics in the management loop illustrated in figure 5.1-1 below.



Figure 5.1-1: Analytics in management loop

**Observation**: The observation of the managed networks and services. The observation involves monitoring and collection of events, status and performance of the managed networks and services, and providing the observed/collected data (e.g., performance measurements, Trace/MDT/RLF/RCEF reports, network analytics reports, QoE reports, alarms, etc).

**Analytics**: The data analytics for the managed networks and services. The MDA described in the TR plays the role of Analytics in the management loop. The MDA prepares, processes and analyzes the data related to the managed networks and services, and provides the analytics reports for root cause analysis of ongoing issues, prevention of potential issues and prediction of network or service demands. The analytics report contains the description of the issues or predictions with optionally a degree of confidence indicator, the possible causes for the issue and the recommended actions. Techniques such as AI and ML (e.g., ML model) may be utilized with the input data including not only the observed data of the managed networks and services, but also the execution reports of actions (taken by the execution step). The MDA classifies and correlates the input data (current and historical data), learn and recognize the data patterns, and makes analysis to derive inference, insight and predictions.

**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) if necessary. The decision may be made by the consumer of MDAS (in the closed management loop), or a human operator (in the open management loop). The decision includes 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.

## 5.2 Management interaction with NWDAF and gNB

There are two types of data analytics services, one is the network data analytics service provided by NWDAF, another is the MDAS provided by 3GPP management system. The MDAS producer provides the analytics data for management purposes based on the data related to different types of NFs, e.g., data reported from gNB and other core network functions. The MDAS producer may use the analytics result of NWDAF as input.

Figure 5.2-1 shows an example of the coordination between NWDAF, gNB and MDAS producer for data analytics purpose.

1. The NWDAF may consume the MDAS for identified scenarios and provide analytics service for 5GC NF for control purpose.

2. The CN Domain MDAS producer may consume the service provided by NWDAF and other 5GC NFs and provide analytics data for management purpose.

3. The gNB many consume the MDAS for identified scenarios for RAN control purpose.

4. The RAN Domain MDAS producer may consume the service provided by gNB and provide analytics data for management purpose.

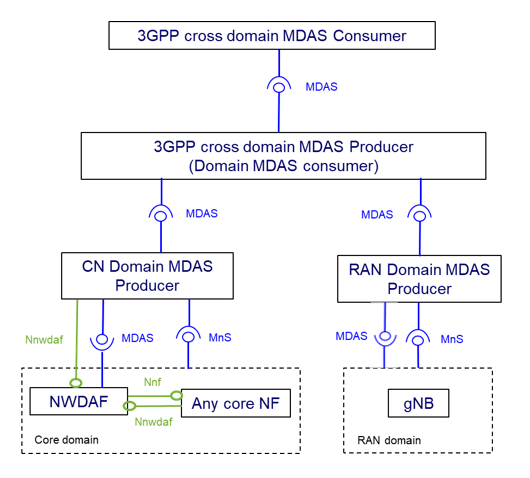


Figure 5.2-1: Example of coordination between NWDAF, gNB and MDAS producer for data analytics

Figure 5.2-2 shows another example of the coordination between NWDAF and MDAS producer for data analytics purpose.

1. The NWDAF may consume the MDAS for identified scenarios and provide analytics service for 5GC NF for control purpose.

2. The gNB may consume the MDAS for identified scenarios for RAN control purpose

3. The Domain MDAS producer may consume the service provided by NWDAF, other 5GC NFs and gNB, provide analytic data for management purpose.

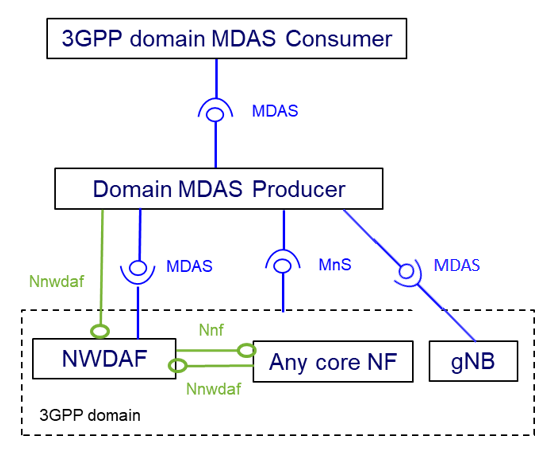


Figure 5.2-2: Example of coordination between NWDAF, gNB and MDAS producer for data analytics

## 5.3 MDA process

The MDA may rely on ML technologies, which may need the consumer to be involved to optimize the accuracy of the MDA results.

The MDA process in terms of the interaction with the consumer, when utilizing ML technologies, is described in the figure below.



Figure 5.3-1: MDA process

There are two kinds of processes for MDA, the process for ML model training and the process for management data analysis. In the process for ML model training, the MDA producer classifies the input data for training purpose, trains the ML model and provides the ML training report. The process for ML model training may also get the consumer involved, i.e., allowing the consumer to provide input for ML model training. The ML model training may be performed on an un-trained ML model or a trained ML model. In the process for management data analysis, the MDA producer classifies the analytics input for management data analysis purpose, analyses the data by the trained ML model, and provides the analytics report to the consumer.

**Data classification**: The data input to the MDA producer could be used for ML model training or for the actual management data analysis. The MDA producer classifies the input data into the category for ML data training and the category for management data analysis, and passes the classified data along to corresponding step for further processing.

**ML model training**: The MDAS producer trains the ML model, i.e., to train the algorithm of the ML model to be able to provide the expected training output by analysis of the training input. The data for ML model training may be the training data (including the training input and the expected output) and/or the validation data provided by the consumer. After the ML model training, the MDAS producer provides an ML model training report.

**Management data analysis**: The trained ML model analyses the classified data and generates the management data analytics report(s). Analytics reports were presented in Section 5.1.

**Validation**: The consumer may validate the output data provided by the MDAS producer. The output data to be validated may be the analytics report and/or the ML model training report as described above. The consumer may provide the validation data as feedback to the MDAS producer, and the MDAS producer will use the validation data for further ML model training with the historical data that are used to generate the validated output data.

# 6 Use cases, potential requirements and possible solutions

## 6.1 Coverage related issues

### 6.1.1 Coverage issue analysis

#### 6.1.1.1 Use case

The coverage issue may cause various UE and network failures and degrade the network performance offered the UEs.

The coverage issue could be a weak coverage, a coverage hole, a pilot pollution, an overshoot coverage, or a DL and UL channel coverage mismatch as described in clause 5.1.1, 3GPP TS 37.816 [11]. The weak coverage may result in low success rate of random access, paging, RRC connection establishment and handover, low data throughput, more abnormal releases of RRC connection, DRB retainability, QoS flow and/or PDU session resources, and dissatisfied QoE. The coverage hole is a more severe problem and would further lead to the UE out of service in the area.

The 5G related coverage issue may exist only in 5G (i.e., 5G issue only with good coverage provided by other RATs) or exist in all RATs (i.e., no RAT provides good coverage in the area).

Coverage performance should be assured to guarantee user service experience. It is desirable that the coverage issue can be detected by MDA from the various symptoms, together with the geographical and terrain data and the configuration parameters of the RAN.

Once the coverage issue is detected, the MDAS producer provides the analytics report that precisely describes the coverage issue, and the analytics report needs to contain sufficient information to enable the MDAS consumer (e.g., SON CCO function) to take the remedy actions. The MDAS producer may also provide the recommended actions to solve the identified coverage issue in the analytics report, so that the MDAS consumer can execute the actions accordingly or by taking the recommended actions into account.

The MDAS producer is informed when the actions are taken by the MDAS producer consumer to solve the coverage issue described in the analytics report, so that the MDAS producer can start evaluating the result of the executed actions.

The MDAS producer gets the execution reports describing the actions taken by the MDAS consumer, and takes the execution reports into account to fine-tune the accuracy of the future (new or updated) analytics report.

The MDAS producer also provide update(s) of the analytics report to indicate the status change (e.g., solved, mitigated or deteriorated) of the coverage issue.

#### 6.1.1.2 Potential requirements

**REQ-COV\_ANA-CON-1** The MDAS producer should have a capability to provide the analytics report describing the coverage issue.

**REQ-COV\_ANA-CON-2** The analytics report describing the coverage issue should contain the following information:

- The identifier of the coverage issue described in the analytics report;

- Indication of whether the coverage issue is weak coverage or coverage hole, a pilot pollution, an overshoot coverage, or a DL and UL channel coverage mismatch;

- The start time and end time of the coverage issue;

- The geographical area and location where the coverage issue exists;

- Root cause of the coverage issue;

- Whether the coverage issue exists in 5G only or in all RATs;

- The cells affected by the coverage issue;

- The severity level (e.g., critical, medium, or cleared) of the coverage issue;

- The recommended actions to solve the coverage issue.

#### 6.1.1.3 Possible solutions

##### 6.1.1.3.1 Solution description

The MDAS producer correlates, processes and analyzes the data described in the following subclause within a time period on a regular basis or trigged by events (e.g., the RLF reports) to identify the coverage issue, and provide the analytics reports to describe the identified coverage issues (which could be new issues or the updates of existing issues).

##### 6.1.1.3.2 Data required for coverage issue analysis

The following table describes the data required for coverage issue analysis:

|  |  |
| --- | --- |
| **Data category** | **Required data** |
| Performance measurements | - Average/distribution of UE reported RSRPs/RSRQs/SINRs of the serving cell when the TA (Timing Advance) or UE rx-tx applied to the UEs is in a specific range;  - Average/distribution of UE reported RSRPs/RSRQs/SINRs of each neighbour cell when the UE reported RSRPs/RSROs of the serving cell is in a specific range, measured per NCR (neighbour cell relation), per SSB index and per CSI-RS index of each NCR;  - Number of abnormal releases of DRBs, QoS flows, PDU sessions, and UE contexts in the serving cell measured per SSB index and per CSI-RS index |
| MDT reports | MDT reports containing RSRPs and RSRQs of the serving cell and neighbour cells reported by each UE with anonymous id (e.g., C-RNTI) and location information. |
| RLF reports | RLF reports containing RSRP(s) and RSRQ(s) of the serving cell and neighbour cells reported by each UE with anonymous id (e.g., C-RNTI) and location information. |
| RECF reports | RCEF reports containing RSRP(s) and RSRQ(s) of the serving cell and neighbour cells reported by each UE with anonymous id (e.g., C-RNTI) and location information. |
| UE location reports | UE location information provided by the LCS with the anonymous id (e.g., C-RNTI) which can be used to correlate with the MDT/RLF/RCEF reports. |
| QoE reports | Editor’s note: the level of details of QoE reports required in this solution for FFS. |
| Geographical data and terrain data of the RAN | - The geographical information (longitude, latitude, altitude) of the deployed RAN (gNBs and eNodeBs, antennas, sector carrier equipments, etc.).  - The terrain data for the area of the deployed RAN.  Editor’s note: which MnS provides this kind of data is FFS. |
| Configuration data | - The current NRMs containing the attributes affecting the RAN coverage, such as maximum transmission power of the cell, directions and tilts of the antennas or beams, etc.  - The NRM update reports (notifications or logs) containing the creations or changes of the MOIs (Managed Object Instance) affecting the RAN coverage. |

##### 6.1.1.3.3 Analytics report for coverage issue

The analytics report describing the coverage issue contains the following information:

- Coverage issue identifier: The identifier of the coverage issue;

- Coverage issue type indication: Indication that the coverage issue is weak coverage or coverage hole, pilot pollution, overshoot coverage, or DL and UL channel coverage mismatch;

- Start time: The start time of the coverage issue;

- Stop time: The stop time of the coverage issue;

- Location: The geographical area and location where the coverage issue exists;

- Root cause: Root cause of the coverage issue, e.g., weak transmission power, blocked by constructions, restricted by terrain, etc;

- RAT indication: Indication that the coverage issue exists in 5G only or in all RATs;

- Affected objects: The MOIs of the cells affected by the coverage issue;

- Severity level: The severity level (e.g., critical, medium, cleared) of the coverage issue;

- Recommended actions: The recommended actions to solve the coverage issue. The recommended action could be re-configurations of coverage related attributes, creation of new cells or beams, or manual operations to add or change the physical units.

Editor’s Note: Quantification of severity levels is FFS.

## 6.2 Resource related issues

### 6.2.1 RAN user plane congestion analysis

#### 6.2.1.1 Use case

With the development of diverse communication services and the increasing number of connections, user data volume demanded by end users grows rapidly which may not be satisfied by the current deployed 5G network.

In clause 3.1 of TS 22.101 [9], the RAN user plane congestion is defined as the situation where the demand for RAN resources to transfer user data exceeds the available RAN capacity to deliver the user data for a significant period of time in the order of few seconds or longer. The case where a short-duration burst of user plane traffic is not identified as RAN congestion.

Due to the complexity of 5G network and wireless environment, multiple types of performance deteriorate are related with RAN user plane congestion, e.g., high drop rate of PDCP PDU, the full PRB utilisation, inappropriate mobility parameters configuration or inefficient usage of radio resources. The root causes should be analysed and identified to help to resolve the RAN user plane congestion and improve the end users’ experience, e.g., the issue of lack of physical or virtual resources or unsuitable resources allocation, unsuitable mobility parameters. The recommended actions may also be provided, e.g., recommended policies of physical and virtual resources allocation, possible means to improve the radio condition, load balancing mechanisms etc.

The producer of MDAS is able to, from the perspective of the management aspects, provide the user plane data congestion analytics report related to a specific cell, specific network slicing instance or subnetwork. This analytics report can be considered as an input to support SLS assurance to perform further evaluation.

Editor’s Note: The more detailed descriptions of user plane congestion are FFS.

#### 6.2.1.2 Potential requirements

**REQ-CONG\_ANA-CON-1**: The MDAS producer shall be able to provide the analytics report describing the RAN user plane congestion problem.

**REQ-CONG\_ANA-CON-2**: The analytics report describing the RAN user plane congestion problem should contain the following information:

- The identifier of the RAN user plane congestion;

- Indication of the RAN user plane congestion type;

- The start time and end time of the RAN user plane congestion;

- The geographical area and location where the RAN user plane congestion affects;

- Root cause of the RAN user plane congestion;

- The objects affected by the RAN user plane congestion;

- The severity level of the RAN user plane congestion;

- The recommended actions to solve the RAN user plane congestion problem.

#### 6.2.1.3 Possible Solutions

##### 6.2.1.3.1 Solution description

The MDAS producer correlates and analyses the management data described in the following subclause to identify the RAN user plane congestion problems. As the table in 6.2.1.3.3 shows, the analytics report is able to be provided by the MDAS producer to describe the root causes and recommendations of identified RAN user plane problem. This procedure may be triggered by the request or periodically.

##### 6.2.1.3.2 Data required for RAN user plane congestion problem

Following table shows the potential data required to analyse the RAN user plane congestion problem.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | UE throughput: The IP throughput of end users, see clause 5.1.1.3 of TS 28.552 [8];  Radio resource utilization: The usage of physical radio resource utilization of the network, see clause 5.1.1.2 of TS 28.552[8];  PDCP Data Volume: The transmitted PDCP data volume, see clause 5.1.2.1 and 5.1.3.6 of TS 28.552 [8];  TB related measurements: The TB transmitted in a cell, see clause 5.1.1.7 of TS 28.552 [8];  CQI related measurements: the distribution of Wideband CQI (Channel Quality Indicator) reported by UEs in the cell, see clause 5.1.1.11 of TS 28.552 [8];  MCS related Measurements: the distribution of the MCS scheduled for PDSCH RB by NG-RAN, the distribution of the MCS scheduled for PUSCH RB by NG-RAN, see clause 5.1.1.12 in TS 28.552 [8];  RAN UE throughput: A KPI that shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [7];  Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [7];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [7]; |
| MDT Data | UE measurements related to RSRP, RSRQ, SINR and UE location information. |
| QoE Data | The details information of QoE data required by this case is FFS. |
| Configuration Data | The execution data including the changes or the configuration of the MOIs related with RAN user plane congestion. |

Note: The above parameters may not be the complete list.

##### 6.2.1.3.3 Analytics report for RAN user data congestion

Following table shows the potential information carried in the analytics report of RAN user plane congestion.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of RAN user plane congestion** | **Attribute Name** | **Description** |
| Resource issue identifier | The identifier of the RAN user plane congestion |
| RAN user plane congestion type indication | Indicator of the root cause of the RAN user plane congestion, e.g., PRB resources shortage, unsuitable resource allocation, inappropriate mobility parameters configuration, inefficient usage of radio resources |
| Start time | The start time of the RAN user plane congestion problem |
| Stop time | The end time of the RAN user plane congestion problem |
| Location | The geographical area or the cells where the RAN user plane congestion exists |
| Root cause | The root cause of the UP congestion issue, e.g. poor radio condition, inappropriate radio resource allocation, bad handover parameters etc |
| Affected objects | The MOIs of the cells or subnetworks or network slices affected by the RAN user plane congestion problem |
| Severity level | The severity level (e.g., critical, medium, not important) of the RAN user plane congestion |
| Recommended actions | The recommend actions to solve the RAN user plan congestion problem. The recommended actions could be to update the policies of physical and virtual resources allocation, improve the radio condition quality, or optimize load balancing mechanisms. |

Editor’s Note: Quantification of severity levels is FFS.

### 6.2.2 Resource utilization analytics

#### 6.2.2.1 Use case

The network is a resource limited system, it is therefore quite imperative to ensure an optimum resource utilization for the network so that the required resources can be efficiently allocated while ensuring no wastage or under allocation of resources to cause additional CapEx and OpEX.

The resources usage for a network, a portion of network or a network slice could be higher or lower during different time periods depending on the traffic patterns. The traffic patterns could also vary in different geographical locations (e.g., business area, entertainment area and residential area) of the network, and could vary for different network slices. It could happen that at some point in some areas or network slices the resources are in shortage status while in some other areas or network slices there are abundant resources. This may result in that the users cannot be satisfactorily served in some areas or network slices due to lack of resources even though the overall maximum capacity is sufficient. Resource shortage may affect the QoS and potentially impact user quality of service experience, e.g., lowering down the user data throughput, prolong the user data delay, raise the rejections and failures for establishment of new connections (e.g., RRC connection), sessions (e.g., PDU session) and resources (e.g., QoS flows, DRBs, etc.) and increase the drops of the existing connections, sessions and resources and deteriorates user quality of service experience. Especially in shared scenarios, it is usually that network slices may share the same RAN resources, TN resources and/or some CN network resources. When resources become limited, the suddenly high increase in resource usage by one network slice may potentially affect the performance of other network slices. If resources are not limited but one network slice is in relatively higher resource usage and the others are in lower resource usage, the proportion of resource distribution may need to be reallocated without provisioning additional spare resources in order to achieve efficient and optimum network resource usage, which can effectively reduce the CapEx and OpEx.

Therefore, it would be desirable that the spare resource of the under-utilized usage areas or network slices can be re-allocated to areas or network slices that requires more resources within the same period of time to prevent the resource shortage from happening.

The MDA can analyze the current and historical performance data related to resource usage, network traffic and user quality of service experience for the network or network slices, and identify the ongoing issues on resource utilization and predict potential issues.

The MDAF may provide analytical report on capacity planning, resource requirements, resource utilization, resource availability and resource reservation proposals to assist the feasibility check by network and network slice management system before the provisioning of the communication service.

The MDAS producer provides analytics report describing the ongoing and/or potential resource utilization issues to the authorized consumers. The issues need to be described precisely, including (but not limited to) the information about which part of the network or network slice has encountered or is going to encounter the resource utilization issue, it is resource shortage or resource excess, over which time period, etc. The MDAS producer may also provide the recommendations to solve the resource utilization issues identified by the analytics report. The recommended actions may be for example to schedule the “scale-in” and “scale out” of VNFs to dynamically (re-)allocate the virtualized resources to where they are needed, or to create/update the resource allocation policy for different network slices to allow the network slices getting different percentage of resources in different time periods according the traffic patterns and user quality of service experience. In case of sharing scenario, the MDAS producer should also weighs the resource usages of the shared network resources which belong to different network slices. If reallocating the already allocated network resource can solve the resource utilization issues, no other newly allocated network resource is needed.

The MDAS producer gets the execution reports of the actions taken by the MDAS consumer to solve the resource utilization issue, and takes the execution reports into account in the following analysis.

The MDAS producer continue analyzing the reported issue and provides update(s) if there is any status change (e.g., solved, mitigated or deteriorated) till it is solved.

#### 6.2.2.2 Potential requirements

**REQ-RES-ANA-1** The MDAS producer should have a capability to provide the analytics report describing the resource utilization issue.

**REQ-RES-ANA-2** The analytics report describing the resource utilization issue should contain the following information:

- The identifier of the resource utilization issue;

- Indication that it is an ongoing issue or potential issue;

- The time period(s) during which the resource utilization issue has happened or is potentially going to happen;

- Indication that resource issue is shortage or excess over each time period;

- Percentage of resource shortage or excess in each time period;

- The network entities involved in the resource utilization issue;

- The network slices involved in the resource utilization issue;

- The recommended actions to solve the resource utilization issue.

**REQ-RES-ANA-3** The MDAS producer should have a capability to weigh the allocation of shared network resource when providing the analytics report describing the resource utilization issue.

#### 6.2.2.3 Possible solutions

##### 6.2.2.3.1 Solution description

The MDAS producer correlates and analyzes the ongoing and/or potential resource utilization issues based on the the current and historical performance data related to resource usage and network traffic for the network or network slices. The required data can be from RAN domain or CN domain or both. Based on the analysis above, the MDAS producer is able to provide the domain specific or cross domain analytics report as defined in 6.2.2.3.4 related with resource utilization analytics triggered by event or periodically.

To assist the feasibility check, the MDAS producer may consider the following information: e.g., capacity planning of the network slice instance and/or network slice subnet instance, existing active or non-active network slice instance and/or network slice subnet instance resource information, slice provisioning requirements, etc.

##### 6.2.2.3.2 Required data for resource utilization analysis for RAN domain

The management data required to analyze the RAN related resource utilization are defined as the following table.

|  |  |  |
| --- | --- | --- |
| **Input data** | **Data type** | **Description** |
| S-NSSAI | Service data | “S-NSSAI” as defined in clause 5.15.2, TS 23.501 [2]. MDAS uses this information to identify target network slices for resource utilization analytics and may derive network topology information according to S-NSSAI. |
| Performance measurement | Measurement data | UE throughput: The IP throughput of end users, see clause 5.1.1.3 of TS 28.552 [3];  RAN UE throughput: A KPI that shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [4];  Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [4];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [4];  Radio resource utilization: The usage of physical radio resource utilization of the network, see clause 5.1.1.2 of TS 28.552[3]; |
| MDT Data | Measurement data | UE measurements related to RSRP, RSRQ, SINR and UE location information, see TS 37.320 [12]. |
| Capacity planning data | Use case and procedures | Capacity management use case and procedure, see clause 5.4.15 of TS28.530 [5] and clause 7.15 of TS28.531[6]. |
| Network topology | Network topology data | The topology of the network for resource utilization analytics. |
| User service experience | Analysis data | User service experience relevant attributes and/or analytics analysis obtained from NWDAF or AF, see clause 6.4 of TS 23.288 [18]. |

Note: The above parameters may not be the complete list.

##### 6.2.2.3.3 Required data for resource utilization analysis for CN domain

The management data required to analyze the CN related resource utilization are defined as the following table.

|  |  |  |
| --- | --- | --- |
| **Input data** | **Data type** | **Description** |
| S-NSSAI | Service data | “S-NSSAI” as defined in clause 5.15.2, TS 23.501 [2]. MDAS uses this information to identify target network slices for resource utilization analytics and may derive network topology information according to S-NSSAI. |
| Performance measurement | Measurement data | User subscription data by performance measurement for AMF as defined in clause 5.2 of TS 28.552 [3];  Performance measurement data for SMF as defined in clause 5.3 of TS 28.552 [3];  Performance measurement data for UPF as defined in clause 5.4 of TS 28.552 [3];  Performance measurement data for NF as defined in clause 5.7 of TS 28.552 [3];  Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [4];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [4];  PDU sessions for network slice instance: number of PDU sessions and PDU session establishment time of network slice instance, see clause 6.4.1 and clause 6.4.3 of TS 28.554 [4];  Virtualised resource utilization: Virtualised resource utilization of Network Slice Instance, see clause 6.4.2 of TS 28.554 [4]; |
| Capacity planning data | Use case and procedures | Capacity management use case and procedure, see clause 5.4.15 of TS28.530 [5] and clause 7.15 of TS28.531[6]. |
| Network topology | Network topology data | The topology of the network for resource utilization analytics. |

Note: The above parameters may not be the complete list.

##### 6.2.2.3.4 Analytics report for resource utilization analysis

Following table provides the potential contents of the domain specific or cross domain analytics report of resource utilization analysis based on the required data received as described in 6.2.2.3.2 and 6.2.2.3.3.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of resource utilization analysis** | **Attribute Name** | **Description** |
| Resource utilization issue Identifier | The identifier indicates the resource utilization issue |
| Indication of resource utilization issue type | Indicates the type of the resource utilization issue, e.g., ongoing or potential resource utilization issue |
| Time period | Describes the time period(s) during which the resource utilization issue has happened or is going to happen |
| Indication of resource usage demand | Indicates that resource issue is shortage or excess in each time period |
| Percentage of resource usage demand | Describes percentage of resource shortage or excess in each time period |
| List of network entities | Lists the network entities involved in the resource utilization issue |
| A List of network slices | List of the network slices involved in the resource utilization issue |
| Recommended actions | Describes the recommended actions to solve the resource utilization issue |

### 6.2.3 Cross-slice resource optimization

#### 6.2.3.1 use case

In TR 28.861 [5], SON use case of cross-slice network resource optimizations described. The resource allocated for each network slice instance may vary considering the network resource utilization, traffic patterns, network bandwidth and the demand of resources for each NSI, the priorities of NSI, etc.

The MDAS producer is expected to have the capability to provide analytics report of resource optimization for multiple network slices. Resource optimizations for multiple network slices may be dependent on each other. Resource scale out / in of one slice may impact resource allocation strategy of the other network slices considering the overall resource availability constraints. Aspects to be considered by MDAS include network slice type, priority, resource availability, traffic load, QoS requirements and QoS flow related measurements etc. The recommendations of the most optimal resource allocation for each network slice and the predictions of the resource demand for each NSI may aslo be provided. This analytics report can be consumed by SON function to help the optimization of cross-slice resource optimization.

#### 6.2.3.2 Potential requirements

**REQ-Multi-SLICE-Resource\_MDA-1**: MDAS producer shall have the capability to provide analytics report describing resource optimization across multiple network slices.

**REQ-Multi-SLICE-Resource\_MDA-2**: The analytics report describing the resource optimization across multiple network slices should include the following information:

- Resource optimization threshold for each network slice;

- Recommendations of resource allocation for each NSI;

- The predictions of resource demand for each NSI

#### 6.2.3.3 Possible Solution

##### 6.2.3.3.1 Solution description

The MDAS producer correlates and analyzes the resource optimization strategies across multiple network slices based on the current and historical resource utilization measurements and network traffic for each network slice instances. Based on the analysis above, the MDAS producer is able to provide the analytics report as defined in 6.2.3.3.3 related with cross slice resource optimization analytics triggered by event or periodically.

##### 6.2.3.3.2 Required data for cross-slice resource optimization analysis

The input data in clause 6.2.2.3.2 and 6.2.2.3.3 can be reused as the required management data to analyze the resource optimization across multiple network slices.

##### 6.2.3.3.3 Analytics report for cross-slice resource optimization

Following table provides the potential contents of the analytics report of cross-slice resource optimization.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of cross-slice resource optimization analysis** | **Attribute Name** | **Description** |
| Cross-slice resource optimization Identifier | The identifier indicates the Cross-slice resource optimization |
| Resource optimization threshold | Indicates the thresholds to trigger network resource optimizations for each network slice; |
| Resource allocation recommendation | Describes the recommendations of resource allocation (e.g. increase or decrease NSI capacities like storage, computing, network bandwidth and radio resources) for each NSI; |
| Resource demand prediction | Describes the predictions of resource demand for each NSI |

### 6.2.4 NAS level congestion control optimization

#### 6.2.4.1 Use case

The current NAS level congestion control as described in TS 23.501 [13] uses back-off timer to avoid AMF receiving large amounts of NAS messages from UEs including Mobility Registration Update request. The AMF will accept or rejects the request depending on various aspects. In virtualized environment, the Mobility Registration Update request may be rejected due to inadequacy of available resources with the target AMF. The resource may include virtual resource (e.g., compute, memory and disk). If the Mobility Registration Update request is rejected by the AMF, UE will receive the reject message with a Mobility Management back off time and send a new Mobility Registration Update request after the timer. It is possible that the new Mobility Registration Update request will be rejected again because of the load of the AMF. This mechanism results in wastage of UE and network resources. It also brings inefficiency in network procedures.

It is desirable to use MDAS (Management data analytic service) to assist congestion control in order to avoid too many rejections of NAS messages at the AMF. MDAS producer provides analytical report containing the current and future/predicted resource consumption status for the target AMF. The analytical report also provides recommended actions to optimize the target AMF for congestion control. Based on the report MDAS consumer adjusts (e.g., scale-out/up the virtual resource, set the suitable timer) the resources before continuing processing the received messages.

#### 6.2.4.2 Potential requirements

**REQ-NAS\_OPT\_CON-1** MDAS producer shall have the capability to provide analytics report describing the NAS level congestion issue at AMF.

**REQ-NAS\_OPT\_CON-2** The analytics report describing the NAS level congestion issue should contain the following information:

- The identifier of the NAS level congestion issue described in the analytics report;

- The start time and end time of the NAS level congestion issue;

- Affected AMF;

- Root cause of the NAS level congestion issue;

- The recommended actions to solve NAS level congestion issue.

#### 6.2.4.3 Possible solutions

##### 6.2.4.3.1 Solution Description

The MDAS producer correlates and analyses the management data described in the following subclause to provide AMF resource consumption statistics/predictions, identification of NAS level congestion issues and the root cause as the table in clause 6.2.4.3.3 shows. This procedure may be triggered by the request or periodically

##### 6.2.4.3.2 Data required for NAS level congestion control analysis

The management data required to analyze the NAS level congestion issue are defined as the following table.

|  |  |
| --- | --- |
| **Data category** | **Required data** |
| Performance Measurements | Performance measurement for AMF: registration and service related measurement for AMF as defined in clause 5.2 of TS 28.552 [3].  Virtual resource usage measurement for AMF as defined in clause 5.7 of TS 28.552 [3]. |
| QoE Data | The details information of QoE data required by this case is FFS. |

##### 6.2.4.3.3 Analytics report

The NAS level congestion issue analytics report contains the following information.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of NAS level congestion issue** | **Attribute Name** | **Description** |
| Issue identifier | The identifier of the NAS level congestion. |
| Start Time | The start time of the issue happened. |
| Stop Time | The end time of the issue has been solved. |
| Affected AMF | The MOI of the AMF that affected by the NAS level congestion issue. |
| Root cause | The root cause of the NAS level congestion issue, e.g. increased resource consumption. |
| Recommended actions | Recommendation for AMF in order to make it optimal for NAS level congestion control e.g. scale-out AMF, Increase or adjust back-off time to avoid large amounts of UEs initiate deferred requests simultaneously. |

## 6.3 SLS assurance related issues

### 6.3.1 E2E latency analysis

#### 6.3.1.1 Use case

Latency is one of the SLA parameters 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, e.g. configuration of service priority, RAN capacity, network load, number of re-transmissions, Wireless channel environment and the processing time of the network functions, etc. These factors may be the root cause if the latency requirements cannot be achieved. Packet transmission latency may dynamically change if one or multiple of these factors change. The latency requirement should be assured even if some of the network conditions may degrade. There are some mechanisms to assure latency, e.g. to upgrade the service priority, allocate or reserve more network resource, prepare backups.

With regard to latency analysis for URLLC services, the performance data and fault data are required to be collected, reported and analysed in near real time. Distributed MDAS deployment architecture should be applied for this scenario. The domain MDAS Providers located in the edge network provides latency analysis or predictions for local services in near real time. E.g. for latency and other related QoS evaluation or prediction for V2X application, user location and user trajectory may need to be analyzed in near-real time. The analytical report can be consumed by edge AFs to perform actions in time. The centralized MDAS Providers analyzes integrate latency performance for cross domain. It may provide more comprehensive analytical report to the centralized AF. AI/ML models or analytical data may need to be exchanged between the neighbouring domain MDAS Providers, or between domain MDAS Providers and the centralized MDAS Providers.

From the management perspective, resource configuration and allocation algorithms or policies should support latency assurance. E2E latency is the latency across multiple domains, e.g. RAN domain, core network domain and transport network domain, each domain should ensure its own latency requirement to achieve the total E2E latency goal. The domain specific MDAS can be utilized to provide the domain specific latency analysis, and together with the cross-domain MDAS to provide E2E latency analysis to support SLS assurance.

#### 6.3.1.2 Potential requirements

**REQ-LATENCY\_ASS-CON-1**: MDAS producer should have the capability to provide analytics report describing the latency problem.

**REQ-LATENCY\_ASS-CON-2**: The MDAS producer should have the capability to provide the latency analytics report in time for URLLC services according to the corresponding latency requirement.

**REQ-LATENCY\_ASS-CON-3**: Distributed MDAS deployment and exchange of analytical data between MDAS producers should be supported.

**REQ-LATENCY\_ASS-CON-4**: The analytics report describing the latency problem should include the following information:

- The identifier of the latency issue;

- Indication of latency issue type;

- The start time and end time of the latency issue;

- The geographical area and location where the latency issue exists;

- Root cause of the latency issue;

- The objects affected by the latency issue;

- The severity level of the latency issue;

- The recommended actions to solve the latency issue.

#### 6.3.1.3 Possible solutions

##### 6.3.1.3.1 Solution description

The performance measurements, e.g., network latency, UE throughput, network resource utilization and packet loss can be utilized for E2E latency analysis. To support E2E latency assurance in order to satisfy the latency requirements from the vertical users, MDAS producer is able to provide the analytics report as defined in 6.3.1.3.5 related with E2E latency analytics triggered by event or periodically.

##### 6.3.1.3.2 Required data for latency analysis for RAN domain

The management data required to analyze the latency are defined as the following table.

|  |  |  |
| --- | --- | --- |
| **Input data** | **Data type** | **Description** |
| S-NSSAI | Service data | “S-NSSAI” as defined in clause 5.15.2, TS 23.501 [13]. MDAS may derive network topology information according to S-NSSAI |
| Performance measurement | Measurement data | Packet delay: “packet delay” measurement as defined in clause 5.1.1.1, clause 5.1.3.3, TS 28.552 [8];  IP Latency measurements: “IP Latency measurements” as defined in clause 5.1.3.4, TS 28.552 [8];  UE throughput: The IP throughput of end users, see clause 5.1.1.3 of TS 28.552 [8];  RAN UE throughput: A KPI that shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [7];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [7];  Radio resource utilization: The usage of physical radio resource utilization of the network, see clause 5.1.1.2 of TS 28.552[8];  CQI related measurements: the distribution of Wideband CQI (Channel Quality Indicator) reported by UEs in the cell, see clause 5.1.1.11 of TS 28.552 [8];  MCS related Measurements: the distribution of the MCS scheduled for PDSCH RB by NG-RAN, the distribution of the MCS scheduled for PUSCH RB by NG-RAN, see clause 5.1.1.12 in TS 28.552 [8]; |
| MDT Data | Measurement data | UE measurements related to RSRP, RSRQ, SINR and UE location information, see TS 37.320 [12]. |
| QoE Data | Measurement data | The details information of QoE data required by this case is FFS. |

Note: The above parameters may not be the complete list.

##### 6.3.1.3.3 Required data for latency analysis for CN domain

The management data required to analyze the latency are defined as the following table.

|  |  |  |
| --- | --- | --- |
| **Input data** | **Data type** | **Description** |
| S-NSSAI | Service data | “S-NSSAI” as defined in clause 5.15.2, TS 23.501 [13]. MDAS may derive network topology information according to S-NSSAI |
| Performance measurement | Measurement data | Round-trip GTP Data Packet Delay: “Round-trip GTP Data Packet Delay” as defined in clause 5.4.1.9, TS 28.552 [8];  GTP packets delay in UPF: “GTP packets delay in UPF” as defined in clause 5.4.5, TS 28.552 [8];  Round-trip GTP Data Packet Delay on N9 interface: “Round-trip GTP Data Packet Delay on N9 interface” as defined in clause 5.4.4.1, TS 28.552 [8];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [7]; |

Note: The above parameters may not be the complete list.

##### 6.3.1.3.4 Required data for E2E latency analysis for cross domain

For cross domain analysis, the RAN and CN domain required data as described in 6.3.1.3.2 and 6.3.1.3.3 may be also needed, as well as the potential data described in the following table.

|  |  |  |
| --- | --- | --- |
| **Input data** | **Data type** | **Description** |
| S-NSSAI | Service data | “S-NSSAI” as defined in clause 5.15.2, TS 23.501 [13]. MDAS may derive network topology information according to S-NSSAI |
| Performance measurement | Measurement data | End-to-end Latency of 5G Network: “End-to-end Latency of 5G Network” as defined in clause 6.3.1, TS 28.554 [7];  Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [7]; |
| QoE Data | Measurement data | The details information of QoE data required by this case is FFS. |
| “Required data for latency analysis for RAN domain” or RAN domain “Analytics report for latency analysis” | Measurement data and/or analytical data | Raw data in “6.3.1.3.2 Required data for latency analysis for RAN domain”, or analytical data of RAN domain in “6.3.1.3.5 Analytics report for latency analysis” |
| “Required data for latency analysis for CN domain” or CN domain “Analytics report for latency analysis” | Measurement data and/or analytical data | Raw data in “6.3.1.3.3 Required data for latency analysis for CN domain”, or analytical data of CN domain in “6.3.1.3.5 Analytics report for latency analysis” |

Note: The above parameters may not be the complete list.

##### 6.3.1.3.5 Analytics report for latency analysis

Following table shows the potential information of the domain specific or cross domain E2E analytics report for latency analysis based on the required data received as described in 6.3.4.3.2, 6.3.4.3.3 and 6.3.4.3.4.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of E2E latency analysis** | **Attribute Name** | **Description** |
| SLS assurance issue Identifier | The identifier indicates the SLS assurance issue |
| Indication of SLS assurance issue type | Indicates the type of the SLS assurance issue, e.g., RAN latency issue, CN latency issue, TN latency issue. |
| Location | The geographical area and location where the latency issue exists |
| Start time | The start time of the latency issue |
| Stop time | The stop time of the latency issue |
| Root cause | The root cause of the E2E latency degradation, e.g. coverage issue, load issue in RAN, load issue in CN, low throughput in RAN, low throughput in CN etc. |
| Affected objects | The MOIs of cells, subnetwork or network slices affected by the latency issue; |
| Severity level | The severity level (e.g., critical, medium, not important) of the latency issue; |
| Recommended actions | The recommended actions to solve the latency issue, e.g., resource radio resources re-allocation in gNB, scaling the VNF. |

Editor’s Note: Quantification of severity levels is FFS.

### 6.3.2 Network slice load analysis

#### 6.3.2.1 Use case

Network slice load may vary over time. Therefore, network resources allocated initially could not always satisfy the traffic requirements, for example, the network slice may be overloaded or underutilized. Various factors may impact the network slice load, e.g. number of UEs accessing the network, number of PDU sessions, service types and the end users distribution. Overload of signalling in control plane and/or user data congestion in user plane will lead 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 level and detailed load distribution analytic result may be provided, e.g. load distribution for different applications (probably coming from respective AFs), different frequency layers, different RATs, different locations and/or time periods, different NFs etc. Proportion of high loaded/light loaded cells, NSSI, NFs etc can also be provided.

The analysis of network slice load should consider the network slice capacity, so that the number of users and the numbers of PDU sessions setup can be further supported by certain network slice could be analysed and predicted. *“maxNumberofUEs”* and *“maxNumberofConns”* are two capacity related requirements in the ServiceProfile in [20]. In addition, from end to end network slice perspective, the capacity related requirements and the actual network performance measurements also help to reflect the slice load and slice capacity headroom.

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 and provide the analytic reports of load analysis. For example, the analytic report for a RAN NSSI, slice load related information may include load of DRBs and SRBs, radio resource utilization and availability, virtual resources of RAN CU, etc. MDAS may provide statistic or predictive results of the above load related information and their correlations for multiple cells in certain coverage areas and time periods. MDAS may further provide recommendations of slice RRM Policy ratio for the analysed cells. In addition, MDAS may utilize the analytical data of slice load analysis (as appropriate), NF load analysis, UE mobility statistics/predictions and UE communication statistics/predictions from NWDAF [18] to assist its network slice load analysis. The producer of MDAS is able to, from the perspective of the management aspects, provide the network slice load analytics report related to an NSI, a specific RAN NSSI, a specific CN NSSI. This analytics report can be considered as an input to support SLA assurance to perform further evaluation.

#### 6.3.2.2 Potential requirements

**REQ-NS\_LOAD\_ANA-1**: MDAS producer shall have the capability to provide analytics report describing the network slice load problem.

**REQ-NS\_LOAD\_ANA-2**: MDAS producer shall have the capability to analyse and predict the network slice load based on the slice capacity including the number of users and the numbers of PDU sessions setup supported by certain network slice.

**REQ-NS\_LOAD\_ANA-3**: The analytics report describing the network slide load problem should include the following information:

- The identifier of the network slice load problem;

- Indication of the network slice load problem;

- The start time and end time of the network slice load problem;

- The type of network slice load problem (overloaded or underutilized);

- The geographical area, location (UE, gNB, or UPF), domain (RAN, CN) where the network slice load problem exists;

- The cause(es) of network slice problem (e.g., number of UEs accessing the network, number of PDU sessions, service types and the end user’s distribution);

- Root cause of the network slice load problem;

- The applications affected by the network slide load problem

- The severity level of the network slice load problem;

- The recommended actions to solve the network slice load problem.

#### 6.3.2.3 Possible solutions

##### 6.3.2.3.1 Solution description

The MDAS producer correlates and analyzes the ongoing and/or potential network slice load problem based on the the current and historical performance data related to resource usage and network traffic for the target network slice. The slice load is a comprehensive result.  Various factors may impact the network slice load, e.g. number of UEs accessing the network, number of QoS flows, the resource utilizations of different NFs which is related with the network slice instance. 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. To identify degradation of the KPIs documented in an SLS due to load issues, traffics and resources related performance measurements and UE measurements can be utilized. Note that this solution covers both domain specific and cross-domain load problem analysis scenarios. Based on the analysis above, the MDAS producer is able to provide the analytics report as defined in 6.3.2.3.5 related with the network slice load analytics triggered by event or periodically.

##### 6.3.2.3.2 Required data for network slice load analysis for cross domain

For cross domain analysis, the RAN and CN domain required data as described in 6.3.2.3.3 and 6.3.2.3.4 may be also needed, as well as the potential data described in the following table.

|  |  |  |
| --- | --- | --- |
| **Input data** | **Data type** | **Description** |
| S-NSSAI | Service data | “S-NSSAI” as defined in clause 5.15.2, TS 23.501 [2]. MDAS uses this information to identify target network slices for network slice load analytics and may derive network topology information according to S-NSSAI. |
| Performance measurement | Measurement data | End-to-end Latency of 5G Network: “End-to-end Latency of 5G Network” as defined in clause 6.3.1, TS 28.554 [4];  UE throughput: The IP throughput of end users, see clause 5.1.1.3 of TS 28.552 [3];  Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [4];  Virtualised resource utilization of Network Slice Instance, see clause 6.4.2 of TS 28.554 [4] |
| MDT Data | Measurement data | UE measurements related to RSRP, RSRQ, SINR and UE location information, see TS 37.320 [12]. |
| Capacity planning data | Use case and procedures | Capacity management use case and procedure, see clause 5.4.15 of TS28.530 [5] and clause 7.15 of TS28.531[6]. |
| Network topology | Network topology data | The topology of the network for network slice load analytics. |

Note: The above parameters may not be the complete list.

##### 6.3.2.3.3 Required data for network slice load for RAN domain

The management data required to analyze the network slice load for RAN domain are defined as the following table.

|  |  |  |
| --- | --- | --- |
| **Input data** | **Data type** | **Description** |
| S-NSSAI | Service data | “S-NSSAI” as defined in clause 5.15.2, TS 23.501 [2]. MDAS uses this information to identify target network slices for network slice load analytics and may derive network topology information according to S-NSSAI. |
| Performance measurement | Measurement data | RAN domain measurement data:  RAN UE throughput: A KPI that shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [4];  Radio resource utilization: The usage of physical radio resource utilization of the network, see clause 5.1.1.2 of TS 28.552[3];  Performance measurement data for gNB as defined in clause 5.1 of TS 28.552 [3]; |
| MDT Data | Measurement data | UE measurements related to RSRP, RSRQ, SINR and UE location information, see TS 37.320 [12]. |
| Capacity planning data | Use case and procedures | Capacity management use case and procedure, see clause 5.4.15 of TS28.530 [5] and clause 7.15 of TS28.531[6]. |
| Network topology | Network topology data | The topology of the network for network slice load analytics. |

Note: The above parameters may not be the complete list.

##### 6.3.2.3.4 Required data for network slice load for CN domain

The management data required to analyze the network slice load for CN domain are defined as the following table.

|  |  |  |
| --- | --- | --- |
| **Input data** | **Data type** | **Description** |
| S-NSSAI | Service data | “S-NSSAI” as defined in clause 5.15.2, TS 23.501 [2]. MDAS uses this information to identify target network slices for network slice load analytics and may derive network topology information according to S-NSSAI. |
| Performance measurement | Measurement data | CN domain measurement data  User subscription data by performance measurement for AMF as defined in clause 5.2 of TS 28.552 [3];  Performance measurement data for SMF as defined in clause 5.3 of TS 28.552 [3];  Performance measurement data for UPF as defined in clause 5.4 of TS 28.552 [3];  Performance measurement data for NF as defined in clause 5.7 of TS 28.552 [3];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [4]; |
| Capacity planning data | Use case and procedures | Capacity management use case and procedure, see clause 5.4.15 of TS28.530 [5] and clause 7.15 of TS28.531[6]. |
| Network topology | Network topology data | The topology of the network for network slice load analytics. |

Note: The above parameters may not be the complete list.

##### 6.3.2.3.5 Analytics report for network slice load analysis

Following table provides the potential information of the domain specific or cross domain analytics report for network slice load analysis based on the required data received as described in 6.3.2.3.2, 6.3.2.3.3 and 6.3.2.3.4.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of resource utilization analysis** | **Attribute Name** | **Description** |
| Network slice load problem identifier | The identifier indicates the network slice load problem |
| Type of network slice load problem | Indicates the type of the network slice load problem, e.g., ongoing/potential or overload/underutilized network slice load problem |
| Time period | Describes the time period(s) during which the network slice load problem has happened or is going to happen |
| Slice load level and distribution | Describes the detailed load distribution e.g., load distribution for different applications (probably coming from respective AFs), different frequency layers, different RATs, different locations and/or time periods, different NFs etc. |
| Slice load information | Describes the load of the following resources in the network slice: DRBs and SRBs, radio resource utilization and availability, virtual resources of RAN CU, etc |
| Slice load statistics | Describes the load statistics of the above resources and their correlated results in terms of coverage and time periods |
| Slice load predictive results | Describes the load predictive results of the above resources and their correlations in terms of coverage and time periods |
| Indication of network slice load demand | “Indicates, for each time period, that the network slice is overutilized (load is too high) or underutilized (load is too low) |
| Percentage of network slice load demand | Describes how much of the slice load capacity is either overloaded or underutilized in each time period |
| List of network entities | Lists the network entities involved in the network slice load problem |
| Recommended actions | Describes the recommended actions to solve the network slice load problem |

### 6.3.3 Service experience analysis

#### 6.3.3.1 Use case

In 5G network, the variety of the services provided to the verticals is an important feature. The network requirements which support different services may vary a lot. For example, the users who require URLLC service have high requirements on the network latency and reliability, while the users who require NB-IoT service considers the maximum access UE numbers as the first priority for network requirement. The analysis of service experience of different vertical consumers is important to support the SLA assurance from the network aspect.

The UE level’s experience analysis based on the information from AF provided by NWDAF, e.g., the service MOS may be utilized by MDAS producer as one of the service performance inputs. The network performance measurements from RAN, e.g., the UE IP throughput, coverage, latency, successful handover ratio, etc. and network performance measurements from core network could also be used by MDAS producer for the analysis of service fulfilment by the network. Resource utilization efficiency may impact the user quality of service experience as described in clause 6.2.2. The analytics information from combining the user quality of service experience and, network performance and network resource utilisation analysis could be made available to operators or verticals for further action and analysis. For example, root cause for service deteriorating and recommendation actions may be provided by MDAS producer if some of the SLA requirements cannot be achieved, operators could perform the network optimization actions when needed. The MDAS producer may also coordinate with other management services producer to perform close loop SLA assurance of the network under the operator configured policies.

#### 6.3.3.2 Potential requirements

**REQ-Ser\_Exp\_CON-1** The MDAS producer should have a capability to provide the analytics report on service experience analysis

**REQ- Ser\_Exp \_CON-2** The analytics report describing the service experience should contain the following information describing the service experience aspects and potentially future prediction:

- The predictive service experience or observed service experience statistics, may split into subcounters in different levels, e.g. per S-NSSAI, per 5QI, per UE etc;

- Service experience indication and root cause analysis;

#### 6.3.6.3 Possible solutions

##### 6.3.6.3.1 Solution description

The MDAS producer correlates and analyses the management data described in the following subclause to provide service experience analysis and identify the root cause. As the table in 6.3.6.3.3 shows, the analytics report is able to be provided by the MDAS producer to describe the service experience issue, root causes and recommendations. This procedure may be triggered by the request or periodically.

##### 6.3.6.3.2 Data required for service experience analysis

Following table shows the potential data required to analyse the service experience analysis.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | Packet delay: The average and distribution of DL/UL packet delay between UPF and UE, see clause 5.4.9 of TS 28.552[8]  UE throughput: Average and distribution of DL/UL UE throughput in gNB, see clause 5.1.1.3 of TS 28.552[8];  RAN UE throughput: A KPI that shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [7].  Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [7]; |
| MDT Data | UE measurements related to RSRP, RSRQ, SINR, packet delay and UE location information. |
| QoE Data | The details information of QoE data required by this case is FFS.  The App data which shows the end user experience. |
| Analytics Data | NWDAF analytical data: Slice QoE, see clause 6.3 of TS 23.288 [18]  NWDAF analytical data: Observed Service Experience and/or observed Service MoS, see clause 6.4 of TS 23.288 [18] |

Note: The above parameters may not be the complete list.

##### 6.3.6.3.3 Analytics report for service experience analysis

Following table shows the potential information of the domain specific or cross domain analytics report for service experience analysis based on the required data received as described in 6.3.6.3.2.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of service experience** | **Attribute Name** | **Description** |
| Service experience identifier | The identifier indicates the analytics report is related with service experience analysis. |
| Managed Objects of service experience | The object instances where the service experience is applicable, e.g., SubNetwork Instance, NetworkSlice Instance, S-NSSAI. |
| Service experience level | The level of service experience, e.g. there are five levels which represented by 1, 2, 3, 4, 5 where level 1 represents the users are endures bad experience while level 5 represent the users requirements are perfectly satisfied. |
| Info of service experience | Statistics or predictions of the service experience, may be analysed in different levels, e.g. per S-NSSAI, per network slice, per network slice subnet, per 5QI, per UE etc. |
| Root cause | The root cause of the service experience issues, e.g., unstable handover successful rate, high latency, low QoS retainability etc. |

### 6.3.4 Network slice throughput analysis

#### 6.3.4.1 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 the 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. The related performance measurements in 28.552 [2] and KPIs in 28.554 [3] are utilized as the input data for analysis.

MDAS producer should have the capability to detect potential throughput issues and identify the root cause to assist throughput assurance. Network slice throughput analysis can be for a specific domain or for cross-domain. It is expected that 3GPP Cross Domain MDAS producer provides the federated throughput analytics report and Domain MDAS producer provides the domain specific throughput analysis. These two levels of MDAS producers worked in a coordinated way to assure the throughput performance.

The CSC concerns the statistics or predictions of subscribers’ DL/UL throughput for the network slice, e.g. average percentage of users, for which the required SLS throughput is met or the average percentage of time, during which the required SLS throughput is, or could be, met. The 3GPP Cross Domain MDAS producer may indicate whether the problem is caused by NG-RAN or CN. In general, NG-RAN is the bottleneck because of the limited radio resources and complicated wireless radio conditions. In this case, resource reconfigurations may be needed to resolve the throughput degradation issue. To identify the root causes, RAN Domain MDAS Producer may collect radio resource related configurations and measurements, radio condition related measurements and throughput related measurements.

The producer of MDAS is able to, from the perspective of the management aspects, provide the network slice throughput analytics report. This analytics report can be considered as an input to support SLS assurance to perform further evaluation.

#### 6.3.4.2 Potential requirements

**REQ-THP\_CON-1** The MDAS producer should have a capability to provide the analytics report on network slice throughput.

**REQ-THP\_CON-2** The analytics report of the network slice throughput should contain the following information:

- Network slice throughput statistics/predictions;

- Root cause analysis of network slice throughput degradation;

#### 6.3.4.3 Possible solutions

##### 6.3.4.3.1 Solution description

The MDAS producer correlates and analyses the management data described in the following subclause to provide network slice throughput statistics/predictions, identification of throughput degradation issues and the root cause as the table in 6.3.4.3.5 shows. This procedure may be triggered by the request or periodically.

##### 6.3.4.3.2 Data required for network slice throughput statistics/predictions for RAN domain

Following table shows the potential data required to analyse the network slice throughput for RAN domain.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | Packet Delay, see clause 5.1.1.1.1 in TS 28.552 [8];  UE throughput, see clause 5.1.1.3 of TS 28.554 [7];  RAN UE throughput, KPI shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [7];  Throughput at N3 interface, Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [7];  Radio resource utilization, the usage of physical radio resource utilization of the network, see clause 5.1.1.2 of TS 28.552[8]. |
| MDT Data | UE measurements related to RSRP, RSRQ, SINR and UE location information. |
| QoE Data | The details information of QoE data required by this case is FFS. |
| Configuration Data | The execution data including the changes or the configuration of the MOIs. The data comes from the provisioning MnS provider, e.g., the configured ServiceProfile. |

Note: The above parameters may not be the complete list.

##### 6.3.4.3.3 Data required for network slice throughput statistics/predictions for CN domain

Following table shows the potential data required to analyse the network slice throughput for CN domain.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | Throughput at N3 interface, Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [7];  Number of incoming/outgoing GTP data packets on the N3 interface, see clause 5.4.1.1 and 5.4.1.2 of TS 28.552 [8].  Number of octets of incoming/outgoing GTP data packets on the N3 interface, see clause 5.4.1.3 and 5.4.1.4 of TS 28.552 [8].  Virtualised resource usage measurement, see clause 6.2 of TS 28.552 [8]. |
| QoE Data | The details information of QoE data required by this case is FFS. |
| Configuration Data | The execution data including the changes or the configuration of the MOIs. The data comes from the provisioning MnS provider, e.g., the configured ServiceProfile. |

Note: The above parameters may not be the complete list.

##### 6.3.4.3.4 Data required for network slice throughput statistics/predictions for cross domain

For cross domain analysis, the RAN and CN domain required data as described in 6.3.4.3.2 and 6.3.4.3.3 may be also needed, as well as the potential data described in the following table.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | Latency of 5G Network, see clause 6.3.1 of TS 28.554 [7];  Throughput for network slice instance, see clause 6.3.2 of TS 28.554 [7];  Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.3 of TS 28.554 [7]. |
| QoE Data | The details information of QoE data required by this case is FFS. |
| Configuration Data | The execution data including the changes or the configuration of the MOIs. The data comes from the provisioning MnS provider, e.g., the configured ServiceProfile. |

Note: The above parameters may not be the complete list.

##### 6.3.4.3.5 Analytics report for network slice throughput analysis

Following table shows the potential information of the domain specific or cross domain analytics report for network slice throughput analysis based on the required data received as described in 6.3.4.3.2, 6.3.4.3.3 and 6.3.4.3.4.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of network slice throughput** | **Attribute Name** | **Description** |
| Network slice throughput issue identifier | The identifier of the network slice throughput issues; |
| Network slice throughput statistics/predictions | Average percentage of users, for which the required SLS throughput is, or could be, met.  Average percentage of time, during which the required SLS throughput is, or could be, met. |
| Root cause | The root cause of the network slice throughput degradation issues, e.g. PRB resource shortage; |
| Recommended actions | The recommend actions to solve the network slice throughput degradation issues. |

### 6.3.5 Uplink/downlink throughput per UE in network slice analysis

#### 6.3.5.1 Use case

Uplink/downlink throughput per UE in network slice is one of the SLA parameters. Data rate in uplink and downlink should be guaranteed to assure quality experience of UE using specific network slice.

UE uplink/downlink throughput could be impacted by the network capability and network configurations, e.g. configuration of service priority, RAN capacity, network load, number of UE in one TA, Wireless channel environment and the processing time of the network functions, etc. These factors may be the root cause if the UE uplink/downlink throughput requirements cannot be achieved. There are some mechanisms to assure UE uplink/downlink throughput, e.g. to upgrade the service priority, allocate or reserve more network resource.

From the management perspective, resource configuration and allocation algorithms or policies should support UE uplink/downlink throughput assurance. MDAS can be utilized to provide UE uplink/downlink throughput analysis to support SLS assurance.

#### 6.3.5.2 Potential requirements

**REQ-UETHROUGHPUT\_ASS-CON-1**: MDAS producer shall have the capability to provide analytics report describing the UE uplink/downlink throughput problem.

**REQ-UETHROUGHPUT\_ASS-CON-2**: The analytics report describing the UE uplink/downlink throughput problem should include the following information:

- The identifier of the UE uplink/downlink throughput issue;

- Indication of UE uplink/downlink throughput issue type;

- The start time and end time of the UE uplink/downlink throughput issue;

- The geographical area and location where the UE uplink/downlink throughput issue exists;

- Root cause of the UE uplink/downlink throughput issue;

- The objects affected by the UE uplink/downlink throughput issue;

- The severity level of the UE uplink/downlink throughput issue;

- The recommended actions to solve the UE uplink/downlink throughput issue.

#### 6.3.5.3 Possible solutions

##### 6.3.5.3.1 Solution description

The performance measurements, e.g., UE throughput, network resource utilization can be utilized for UE uplink/downlink throughput analysis. To support UE uplink/downlink throughput assurance in order to satisfy the throughput per UE requirements from the vertical users, MDAS producer is able to provide the analytics report as defined in 6.3.5.3.3 related with UE uplink/downlink throughput analytics triggered by event or periodically.

##### 6.3.5.3.2 Required data for UE uplink/downlink throughput analysis

The management data required to analyze the UE uplink/downlink throughput are defined as the following table.

|  |  |  |
| --- | --- | --- |
| **Input data** | **Data type** | **Description** |
| S-NSSAI | Service data | “S-NSSAI” as defined in clause 5.15.2, TS 23.501 [13]. MDAS may derive network topology information according to S-NSSAI |
| Performance measurement | Measurement data | UE throughput: The IP throughput of end users, see clause 5.1.1.3 of TS 28.552 [8];  RAN UE throughput: A KPI that shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [7];  Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [7];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [7];  Radio resource utilization: The usage of physical radio resource utilization of the network, see clause 5.1.1.2 of TS 28.552[8];  CQI related measurements: the distribution of Wideband CQI (Channel Quality Indicator) reported by UEs in the cell, see clause 5.1.1.11 of TS 28.552 [8];  MCS related Measurements: the distribution of the MCS scheduled for PDSCH RB by NG-RAN, the distribution of the MCS scheduled for PUSCH RB by NG-RAN, see clause 5.1.1.12 in TS 28.552 [8]; |
| MDT Data | Measurement data | UE measurements related to RSRP, RSRQ, SINR and UE location information, see TS 37.320 [12]. |

Note: The above parameters may not be the complete list.

##### 6.3.5.3.3 Analytics report for UE uplink/downlink throughput analysis

Following table provides the potential contents of the analytics report of UE uplink/downlink throughput analysis.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of UE uplink/downlink throughput analysis** | **Attribute Name** | **Description** |
| SLS assurance issue Identifier | The identifier indicates the SLS assurance issue |
| Indication of SLS assurance issue type | Indicates the type of the SLS assurance issue, e.g., |
| Location | The geographical area and location where the UE uplink/downlink throughput issue exists |
| Start time | The start time of the UE uplink/downlink throughput issue |
| Stop time | The stop time of the UE uplink/downlink throughput issue |
| Root cause | The root cause of the UE uplink/downlink throughput degradation, e.g. coverage issue, load issue in RAN, load issue in CN, low throughput in RAN, low throughput in CN etc. |
| Affected objects | The MOIs of cells, subnetwork or network slices affected by the UE uplink/downlink throughput issue; |
| Severity level | The severity level (e.g., critical, medium, not important) of the UE uplink/downlink throughput issue; |
| Recommended actions | The recommended actions to solve the UE uplink/downlink throughput issue, e.g., |

Editor’s Note: Quantification of severity levels is FFS.

### 6.3.6 KPI anomaly analysis

#### 6.3.6.1 Use case

KPI(s) are of great importance for network operators to monitor the key performance of the network. For 5G and beyond, a large amount of KPIs are defined in TS 28.554 [7]. The correlations between different KPIs are complicated and it is hard to monitor the KPI(s) manually. Also, how to assign each KPI threshold is a big challenge for network operators, since each KPI threshold should not be a fixed value considering many factors such as network capacity, service types, end user’s experiences, etc. In addition, the criteria to determine whether a KPI is anomalous also depends on a variety of requirements.

MDAS is expected to have the capability to analyze KPI(s) for both cross domain and single domain. 3GPP Cross Domain MDAS producers may coordinate with domain MDAS producer to identify the anomalous KPI(s) and the corresponding root cause(s).  The KPI anomaly analysis should consider both a single KPI and KPI correlations of different domains. For cross domain KPI anomaly analysis, KPIs or KPI analytical report from each domain should be collected. The MDAS producer should also be able to identify anomalous network situations. A network situation can be characterized as a combination of KPIs with respect to a predefined context that includes time, location, amount of traffic, user characteristics, etc.

MDAS is also expected to have the capability to detect and predict the anomalous KPI(s) and anomalous network situations in different levels e.g. per S-NSSAI, per NSI or per NSSI, etc. The detection and prediction of single KPI anomaly and in relation with multiple correlated KPIs anomaly may be involved. The detection and prediction may also involve a single or multiple KPIs in relation with a network situation. By utilizing Machine learning technology, historical KPI data and performance data may also be used as the input to perform the ML model training. Besides, along with the KPI or network situation anomaly identification and root cause analysis, MDAS may also recommend more appropriate network configurations to optimize and resolve the KPI anomaly issue and improve the slice QoE.

The KPI anomaly analysis is also expected to have the capability to analyse the correlations between SLS and KPIs or network situations according to service model and identify the most relevant anomalous KPIs and network situations, which cause the SLS degradation, this corresponding analytics report can be considered as an input to support further SLS assurance.

#### 6.3.6.2 Potential requirements

**REQ-KPI\_ANOMALY\_CON-1** The MDAS producer should have a capability to provide the analytics report on KPIs anomaly analysis.

**REQ- KPI\_ANOMALY\_CON-2** The analytics report describing the KPIs anomaly should contain the following information describing the KPI anomaly aspects and potentially future prediction:

- The predictive anomaly KPI(s) or observed anomaly KPI(s), may split into subcounters in different levels, e.g. per S-NSSAI, per NSI, per NSSI, per 5QI, per UE etc;

- KPI anomaly indication and root cause analysis;

- Cross domain and domain KPI anomaly analysis;

- The recommendations for the configurations of network resource and KPI threshold.

**REQ- KPI\_ANOMALY\_CON-3** The MDAS producer should have a capability to provide the analytics report that identifies a possible anomalous KPIs with respect to network situations for a particular network location and network.

#### 6.3.6.3 Possible solutions

##### 6.3.6.3.1 Solution description

The MDAS producer correlates and analyses the management data described in the following subclause to provide KPI anomaly analysis and identify the root cause. The required data can be from RAN domain or CN domain or both. As the table in 6.3.6.3.4 shows, the analytics report is able to be provided by the MDAS producer to describe the KPI anomaly issue, root causes and recommendations. This procedure may be triggered upon request or periodically.

##### 6.3.6.3.2 Data required for KPI anomaly analysis for RAN domain

Following table shows the potential data required to analyse the RAN domain KPI anomaly.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | Radio resource utilization: The usage of physical radio resource utilization of the network, see clause 5.1.1.2 of TS 28.552[8];  Performance Measurements for gNB: for example, for RRC connection related KPI anomaly analysis, see clause 5.1, TS 28.552[8], e.g., RRC connection number, RRC connection establishment, RRC connection re-establishment, RRC connection resuming;  RAN UE throughput: A KPI that shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [7]. |
| MDT Data | UE measurements related to RSRP, RSRQ, SINR and UE location information. |
| QoE Data | The details information of QoE data required by this case is FFS. |
| Configuration data | The execution data including the changes or the configuration of the MOIs. |
| Context data | The information on the conditions applicable to the data considered for analytics, e.g. time of day, season or event in relation to location. |

Note: The above parameters may not be the complete list.

##### 6.3.6.3.3 Data required for KPI anomaly analysis for CN domain

Following table shows the potential data required to analyse the CN domain KPI anomaly.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | Performance Measurements for AMF: for example, for number of registered subscribers related KPI anomaly analysis, see clause 5.2.1, TS 28.552[8];  Performance Measurements for SMF: for example, for PDU session management related KPI anomaly analysis, see clause 5.3.1, TS 28.552[8];  Throughput at N3 interface: KPI related to Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [7]; |
| QoE Data | The details information of QoE data required by this case is FFS. |

Note: The above parameters may not be the complete list.

##### 6.3.6.3.4 Data required for KPI anomaly analysis for cross domain

For cross domain analysis, the RAN domain and CN domain required data as described in 6.3.6.3.2 and 6.3.6.3.3 may be needed, as well as the potential data described in the following table.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [7];  NWDAF analytical data: Slice QoE, see clause 6.4 of TS 23.288 [18]. |
| QoE Data | The details information of QoE data required by this case is FFS. |
| Configuration data | The execution data including the changes or the configuration of the MOIs. |
| Context data | The information on the conditions applicable to the data considered for analytics, e.g. time of day, season or event in relation to location. |

Note: The above parameters may not be the complete list.

##### 6.3.6.3.5 Analytics report for KPI anomaly analysis

Following table shows the potential information of the domain specific or cross domain analytics report for KPI anomaly analysis based on the required data received as described in 6.3.6.3.2, 6.3.6.3.3 and 6.3.6.3.4.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of network slice KPI anomaly** | **Attribute Name** | **Description** |
| KPI anomaly identifier | The identifier of the KPI anomaly; |
| Anomalous KPI Name | The name of the KPI(s) which is identified or predicted as anomalous, the KPI name refers to bullet a) in TS28.554 (7); |
| Managed Objects of anomalous KPI | The object instances where the KPI is applicable, e.g., SubNetwork Instance, NetworkSlice Instance |
| Info of KPI anomaly | Statistics or predictions of the anomalous KPIs, may concern single KPI or multiple correlated KPIs, and may split into subcounters at different levels, e.g. per S-NSSAI, per NSI, per NSSI, per 5QI, per UE etc. |
| Root cause | The root cause of the network slice KPI anomaly issues, e.g., unstable handover successful rate, low PRB utilization, low QoS retainability. |

##### 6.3.6.3.6 Analytics report for network situation analysis

Following table shows the potential information of the domain specific or cross domain analytics report based on the required data received as described in 6.3.6.3.2, 6.3.6.3.3, and 6.3.6.3.4.

|  |  |  |
| --- | --- | --- |
| **Analytics Report on network situations** | **Attribute Name** | **Description** |
| Network situation identifier | The identifier of the possible network situations. |
| Network situation description | The network performance, QoE and UE location and context data that describe a network situation. |
| Network situations anomaly status | The status of a network situation. This may be a simple binary function that indicates a normal or anomalous status. |
| Severity level | Describes the degree of anomaly (low, medium, high). |
| Location | Geographical location of anomalous network situations |
| Managed Objects of network situation | The object instances, e.g., cell, carrier. |
| Type of analytics | Statistics or predictions of the anomalous situation. |

### 6.3.7 Jitter analysis

#### 6.3.7.1 Use case

In addition to E2E latency, some new network services have extra new demands for SLA parameters. In extreme business scenarios such a V2X and telemedicine, network jitter also needs to be satisfied. Jitter assurance with high certainty becomes a new dimension of end-to-end delay-sensitive service quality.

The analysis of jitter does not cover the entire network, but the analysis should consider the whole process of data frame and also the definition of different network layers. It could be impacted by the configuration of clock synchronization, traffic forwarding, bandwidth reservation and latency etc. In some circumstances, it will also be affected by the external environment, which can only be resolved non-automatically.

The performance measurements and measurements related to data forwarding mechanisms can be used by the MDAS producer to generate a jitter analysis report. For example, in some network node, one particular data flow can have bandwidth competition with normal data flow which causes high network jitter. The MDAS will first analyse the bandwidth resource and provide bandwidth reservation modification so that it can satisfy network performance requirement of this particular data flow. Jitter is also related to E2E latency parameter, the jitter analysis will then need to be cross-domain, e.g. RAN domain, core network domain transport network domain. The jitter analysis from the multiple domains may be combined to calculate the end-to-end jitter, which can be checked against end-to-end SLA requirements. The jitter analysis will reference the E2E analysis result to support SLS assurance. In case of excessive end-to-end jitter, the jitter analysis from each domain may be used to identify the likely source of problems.

#### 6.3.7.2 Potential requirements

**REQ-JITTER\_ASS-CON-1**: MDAS producer shall have the capability to provide analytics report describing the jitter problem.

**REQ-JITTER\_ASS-CON-2**: The analytics report describing the jitter problem should include the following information:

- The identifier of the jitter issue;

- Indication of jitter issue type;

- The start time and end time of the jitter issue;

- The geographical area and location where the jitter issue exists;

- Root cause of the jitter issue;

- The objects affected by the jitter issue;

- The severity level of the jitter issue;

- The recommended actions to solve the jitter issue.

## 6.4 Fault management related issues

### 6.4.1 Alarm incident analysis

#### 6.4.1.1 Use case

In 5G network, millions of alarms are generated due to the network complexity. Since the topological relations between different network elements and logical relations between different generated alarms, a series of alarms caused by a same root cause should be correlated with each other. In addition, the same root causes may give rise to the network performance deterioration. For example, an alarm in a lower layer of the communication protocol stack or an alarm related to virtualized resource in the virtualization deployment environment may cause multiple alarms in higher layers. Sequence of alarms may be generated in multiple domains along a communication link if one fault in the source domain occurs.

Large amount of alarms brings difficulties in network operation and maintenance. Therefore, the alarms and deteriorated performance measurements of same root cause should be correlated and analysed. Some ML models and algorithms may be used to group or filter the correlated alarms and indicate the root cause. Also, the historical alarms, performance measurements and network topology data can be utilized as the foreknowledge.

To improve the efficiency of network operation and maintenance, the MDAS producer is able to provide the analytics result including the root alarm or root cause by correlate and group the related alarms and performance measurements into an alarm incident.

#### 6.4.1.2 Potential requirements

**REQ-ALARM\_MDA-01:** The MDAS producer shall have a capability to provide the analytics report describing the alarm incident analysis.

**REQ-ALARM\_MDA-02:** The analytics report describing the alarm incident should include the following information:

- Alarm incident Identifier

- List of Correlated Alarms, performance measurements

- The start time and end time of the Alarm incident

- The root cause or root alarm of the Alarm incident

- Severity level

- Affected objects

- Recommended actions

#### 6.4.1.3 Possible Solutions

##### 6.4.1.3.1 Solution description

The MDAS producer correlates and analyses the management data described in the following subclause to identify the alarm incident. The required data can be from RAN domain or CN domain or both. As the table in 6.4.1.3.4 shows, the analytics report is able to be provided by the MDAS producer to describe the root causes and recommendations of identified alarm incident. It can be a domain specific or cross domain analytics report. This procedure may be triggered by the request or periodically.

##### 6.4.1.3.2 Data required for alarm incident analysis for RAN domain

Alarm data and performance measurements from correlated logical and physical resources are able to be utilized to perform the alarm incident analysis. The data listed in following table are the potential management data for RAN domain used to construct the alarm incident.

Table 6.4.1.3.2-1: Potential data required for alarm incident analysis

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Alarm Data | The alarm information, e.g., the alarm of NG-U, the alarm of radio frequency unit, the alarm of cell outage.  The alarm information related to virtualized resource, see clause 8 of TS 28.545 [22].  The types of alarms are FFS. |
| Performance measurements | The deteriorated performance or the abnormal performance measurements based on certain performance monitoring threshold. Following performance measurements may be used.  UE throughput: The IP throughput of end users, see clause 5.1.1.3 of TS 28.552 [8];  PDCP Data Volume: The transmitted PDCP data volume, see clause 5.1.2.1 and 5.1.3.6 of TS 28.552 [8];  TB related measurements: The TB transmitted in a cell, see clause 5.1.1.7 of TS 28.552 [8];  CQI related measurements: the distribution of Wideband CQI (Channel Quality Indicator) reported by UEs in the cell, see clause 5.1.1.11 of TS 28.552 [8];  MCS related Measurements: the distribution of the MCS scheduled for PDSCH RB by NG-RAN, the distribution of the MCS scheduled for PUSCH RB by NG-RAN, see clause 5.1.1.12 in TS 28.552 [8];  RAN UE throughput: A KPI that shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [7];  Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [7];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [7];  Inter-gNB handovers: Number of requested/successful handover/failed handover preparations/resource allocations/executions, see clause 5.1.1.6.1 of TS 28.552 [8].  Intra-gNB handovers: Number of requested/successful handover executions, see clause 5.1.1.6.2 of TS 28.552 [8].  RRC connection establishment related measurements: Attempted/ successful RRC connection establishments, see clause 5.1.1.15 of TS 28.552 [8].  RRC connection Re-establishment and RRC connection Resuming related measurement, see clause 5.1.1.17 and 5.1.1.18 of TS 28.552 [8].  Packet loss rate, Packet drop rate and Packet delay including the average delay and distribution of delay in CU-UP, F1-U, gNB-DU, CU-UP both of downlink and uplink.  Virtualised resource usage measurement, see clause 6.2 of TS 28.552 [8]. |
| Configuration Data | The execution data including the changes or the configuration of the MOIs. |
| Network topology | The topology of the network deployment. |

Editor’s Notes: The data above may not be the complete list for alarm incident detection, other types of management data may also be utilized.

##### 6.4.1.3.3 Data required for alarm incident analysis for CN domain

Alarm data and performance measurements from correlated logical and physical resources are able to be utilized to perform the alarm incident analysis. The data listed in following table are the potential management data for CN domain used to construct the alarm incident.

Table 6.4.1.3.3-1: Potential data required for alarm incident analysis

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Alarm Data | The alarm information, e.g., the alarm of AMF, the alarm of UPF.  The types of alarms are FFS. |
| Performance measurements | The deteriorated performance or the abnormal performance measurements based on certain performance monitoring threshold. Following performance measurements may be used.  Mobility related measurements for AMF: Number of requested/failed PDU sessions/QoS flows for inter-AMF handovers and number of attempted/successful/failed handover between 5GS and EPC, see clause 5.2.5.1, 5.2.5.3 and 5.2.5.4 of TS 28.552 [8].  Session related measurements for SMF: Number of successful/failed PDU session creation and number of requested/successful/failed PDU session modifications, see clause 5.3.1 of TS 28.552 [8].  QoS flow monitoring for SMF: Number of requested/successful/failed QoS flows to create/modify, see clause 5.3.2 of TS 28.552 [8].  Session related measurements for UPF: Number of requested/failed N4 session establishments, see clause 5.4.3.1 of TS 28.552 [8].  Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [7];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [7]; |
| Configuration Data | The execution data including the changes or the configuration of the MOIs. |
| Network topology | The topology of the network deployment. |

Editor’s Notes: The data above may not be the complete list for alarm incident detection, other types of management data may also be utilized.

##### 6.4.1.3.4 Analytics report for alarm incident analysis

Following table provides the potential information of the domain specific or cross domain analytics report for alarm incident analysis based on the required data received as described in 6.4.1.3.2 and 6.4.1.3.3.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of alarm incident** | **Information** | **Description** |
| Alarm Incident Identifier | The alarm incident id or name for correlated alarms and performance measurements, e.g., NgU transmission alarm incident, Xn transmission alarm incident. |
| List of Correlated AlarmInfo | List of Alarm name or alarm ID, e.g., alarm of NgU setup, alarm of user plane link failure, alarm of user plane failure, alarm of cell outage. |
| List of Correlated performance measurements info | Performance measurements and the corresponding value, e.g., NgU handover failure rate, NgU setup failure rate. |
| Location | The geographical area or the cells where the alarm incident exists |
| Start Time | The start time of alarm incident |
| Stop Time | The end time of alarm incident |
| Affected objects | The MOIs, e.g., the MOIs of cells or subnetworks or network slices affected by the alarm incident |
| Root cause or Root alarm | Root alarm identified or predicted by root cause decision model, e.g. alarm of NgU setup, alarm of virtualized resource failure. |
| Severity level | The severity level (e.g., critical, medium, not important) of the alarm incident |
| Recommended actions | The recommend actions to clear the alarm incident. The recommended actions could be to replace the hardware unit, reconfigure the protocol, e.g., Xn application protocol |

### 6.4.2 Fault prediction analysis

#### 6.4.2.1 Use case

In 5G network, millions of alarms are generated every day. The causes of these alarms are usually the faults or abnormal states of the network. The current treatment method is generally based on the alarm information analysis, to find out the cause of the faults or abnormal states, and then determine the fault repair method and solve the problems, so as to eliminate the alarms. Because the amount of alarms is so large, it is a big challenge to deal with these alarms in a timely and efficient manner.

One the other hand, when we look at it the other way, if the network can be maintained very well so that it has fewer faults and abnormal states, then there will be fewer alarms. This requires the system to be able to predict the potential faults or abnormal states before they occur, and to recommend appropriate handling actions to prevent the fault or abnormal state really occur. In 5G network, MDAS is adopted, which is in conjunction with AI and ML techniques. The MDAS producer may train the ML model of the MDAS by using the historical alarms, performance measurements, configuration data and network topology information to obtain the basic health maintenance knowledges (e.g. the relationship between the faults or potential faults and the related maintenance actions).

The MDAS producer monitors and analyses the performance measurements and KPIs continuously, and provides the analytics report which includes the predictive information of potential faults or abnormal states and corresponding recommendation of maintenance actions to prevent the fault or abnormal state really occur, so that the MDAS consumer can execute the recommended actions accordingly or by taking the recommended actions into account.

The MDAS producer is informed when the recommended actions are taken by the MDAS consumer to maintain the network health, so that the MDAS producer can evaluate the result of the executed actions and update its basic health maintenance knowledges.

The MDAS producer also periodically does the ML training based on the new collected alarms, performance measurements and KPIs, configuration data, and updates its basic health maintenance knowledges.

#### 6.4.2.2 Potential requirements

**REQ-HEALTH\_MDA-01**: The MDAS producer shall have a capability to provide the analytics report describing the fault prediction analysis results.

**REQ-HEALTH\_MDA-02**: The analytics report describing the results from the fault prediction analysis should include the detailed advice on how to eliminate the cause of potential fault(s).

Note: The detailed advice described in the fault prediction analytics report may include but not limited the follows:

* List of potential faults and severity levels
* Affected objects
* Recommended actions

#### 6.4.2.3 Possible solutions

##### 6.4.2.3.1 Solution description

The MDAS producer analyses the management data described in the following subclauses to identify the potential faults or abnormal states and corresponding recommended actions. The required data can be from RAN domain or CN domain or both.

As the table in 6.4.2.3.4 shows, the analytics report is able to be provided by the MDAS producer to describe the analytics result and recommendations of network health maintenance. It can be a domain specific or cross domain analytics report. This procedure may be triggered by the request or periodically.

##### 6.4.2.3.2 Data required for fault prediction analysis for RAN domain

Following table shows the potential data required to perform the fault prediction analysis for RAN domain.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | RAN related performance measurements and KPIs, see TS 28.552 [8] and TS 28.554[7];  The detailed types of performance measurements and KPIs are FFS |
| Configuration Data | The execution data including the changes or the configuration of the MOIs. |
| Network topology | The topology of the network deployment. |

Note: The above parameters may not be the complete list.

##### 6.4.2.3.3 Data required for fault prediction analysis for CN domain

Following table shows the potential data required to perform the fault prediction analysis for CN domain.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | CN related performance measurements and KPIs, see TS 28.552 [8] and TS 28.554[7];  The detailed types of performance measurements and KPIs are FFS |
| Configuration Data | The execution data including the changes or the configuration of the MOIs. |
| Network topology | The topology of the network deployment. |

Note: The above parameters may not be the complete list.

##### 6.4.2.3.4 Analytics report for fault prediction analysis

Following table shows the potential information carried in the analytics report of fault prediction analysis.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of fault prediction** | **Attribute Name** | **Description** |
| Fault prediction analytics report identifier | The identifier of the fault prediction analytics report |
| List of potential faults | List of potential faults, including:   * Fault type * Location * Severity level * Affected objects |
| Recommended actions | The recommend actions to eliminate the causes of the potential faults |

Note: The above parameters carried in the analytics report may not be the complete list.

## 6.5 Mobility management related issues

### 6.5.1 Handover optimization

#### 6.5.1.1 Use case

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 MDAS (Management data analytic service) 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 report containing the current and future/predicted resource consumption, resources capabilities and other KPIs’ status for the available target gNB(s). The analytics report 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 report, 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.

#### 6.5.1.2 Potential requirements

**REQ-HO\_OPT\_CON-1** The MDAS producer should have a capability to provide the analytics report describing the resource consumption to authorized consumers based on the current and future virtual resource consumption of gNB.

**REQ-HO\_OPT\_CON-2** The MDAS producer should have a capability to provide the analytics report describing the resource consumption to authorized consumers based on the current and future radio resource consumption of gNB.

**REQ-HO\_OPT\_CON-3** The analytics report describing the resource consumption should contain the following information describing the current and future resource consumption:

- Assigned virtual, radio, and transport resources for target gNB.

- Consumed virtual, radio, and transport resources for target gNB.

- Projected virtual, radio and transport resource usage in near future for target gNB.

- 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.

**REQ-HO\_OPT\_CON-4** The MDAS producer should have a capability to provide an analytics report indicating a selection priority for the target cell, among a set of candidate inter-frequency cells.

**REQ-HO\_OPT\_CON-5** The MDAS producer should have a capability to provide an analytics report indicating a list of target cells to spare, i.e. avoid, a handover for an indicated time period.

**REQ-HO\_OPT\_CON-6** The analytics report describing inter-frequency target cell selection for handover may provide 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.

**REQ-HO\_OPT\_CON-7** The analytics report describing inter-frequency target cell selection for handover should provide indication of current and expected QoE (for the UE) at the current and target gNB.

#### 6.5.1.3 Possible solutions

##### 6.5.1.3.1 Solution description

The solution considers resource consumption both in terms of virtual and radio resource for the target gNB. The current resource consumption is analysed with the future/predicative resource consumption to decide if the target gNB is optimal for handover or not.

The MDAS producer can correlate and analyze the ongoing and/or potential handover optimization issues based on the current and historical performance data related to handover performance considering intra-gNB and inter-gNB handover measurements as well as other performance measurements including network load, E2E latency, retainability and radio conditions, UE measurements including MDT, location and QoE for the network or network slices. The MDAS producer can provide the analytics report as defined in Clause 6.5.1.3.3 related with resource utilization analytics triggered by an event or periodically.

##### 6.5.1.3.2 Data required

The following data is required to do the required analysis.

Table 6.5.1.3.2-1: Potential data required for handover optimization

|  |  |
| --- | --- |
| **Data category** | **Required data** |
| Performance Measurements | Average/distribution of UE reported RSRPs/RSRQs/SINRs of each neighbour cell;  Packet delay related to neighbour cells as defined in clause 5.1.1.1/5.1.3.3, TS 28.552 [8];  IP Latency to neighbour cells as defined in clause 5.1.3.4, TS 28.552 [8];  Round-trip GTP Data Packet Delay to neighbour cells as defined in clause 5.4.1.9, TS 28.552 [8];  End-to-end Latency of 5G Network to neighbour cells as defined in clause 6.3.1, TS 28.554 [7];  CQI related measurements: The distribution of Wideband CQI reported by UEs, clause 5.1.1.11 of TS 28.552 [8];  Intra-gNB handovers: Number of failed handovers in terms of handover preparation/resource allocation/execution and the mean time of handover execution, clause 5.1.1.6 of TS 28.552 [8];  Inter-gNB handovers: Number of failed handovers in terms of handover preparation/resource preparation clause 5.1.1.6.2, TS 28.552 [8];  Frequency Priority Information (i.e., based on deployment) set by the MNOs: Absolute priorities for different NR frequencies or inter-RAT frequencies, clause 5.2.4.1, TS 38.304 [21];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, clause 6.3.4/6.3.5 of TS 28.554 [7];  Data packet loss: Data volume of outgoing GTP data packets per QoS level on the N3 interface, from UPF to (R)AN and via versa clause 5.4.1.6 TS 28.552 [8] |
| Allocated Virtual Resource | Allocated Compute: This describes the number of vCPUs allocated to the virtual machine on which the gNB VNF is hosted.  Allocated Memory: This describes the number of vMemory allocated to the virtual machine on which the gNB VNF is hosted.  Allocated Storage: This describes the number of vStorage allocated to the virtual machine on which the gNB VNF is hosted. |
| Consumed Virtual Resource | Consumed Compute: This describes the number of total aggregated compute resource consumption at a particular point of time.  Consumed Memory: This describes the number of total aggregated memory consumption at a particular point of time.  Consumed Storage: This describes the number of total aggregated storage consumption at a particular point of time. |
| Consumed Radio Resource | Radio resource utilization: The physical radio resource utilization of the target gNB, see clause 5.1.1.2 of TS 28.552[8]; |
| MDT Data | UE measurements related to RSRP, RSRQ, SINR (serving cell and neighbour cells) and UE location information, TS 37.320 [12]. |
| UE location reports | UE location information provided by the LCS with the anonymous ID, which can be used to correlate with MDT reports. |
| QoE Data | Detailed measurements are FFS. |
| S-NSSAI | S-NSSAI as defined in clause 5.15.2, TS 23.501 [13]. MDAS uses this information to identify target gNBs or inter-RAT cells associated with a network slice performing handover optimization and may derive resource utilization and network performance analytics. |
| Configuration Data | Resource configuration data including RAN and virtualized NFs.  The current policy configured in the RAN related to the handover optimization. |

##### 6.5.1.3.3 Analytics report on gNB resource consumption

The resource analytics report contains the following information per gNB.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of gNB resource consumption** | **Attribute Name** | **Description** |
| Allocated Virtual Resource | Allocated Compute: This describes the number of vCPUs allocated to the virtual machine on which the gNB VNF is hosted.  Allocated Memory: This describes the number of virtual vMemory allocated to the virtual machine on which the gNB VNF is hosted.  Allocated Storage: This describes the number of vStorage allocated to the virtual machine on which the gNB VNF is hosted. |
| Consumed Virtual Resource | Consumed Compute: This describes the number of total aggregated compute resource consumption at a particular point of time.  Consumed Memory: This describes the number of total aggregated memory consumption at a particular point of time.  Consumed Storage: This describes the number of total aggregated storage consumption at a particular point of time. |
| Projected Virtual Resource consumption | Projected Compute: This describes the number of total projected compute resource consumption at a particular point of time.  Projected Memory: This describes the number of total projected memory consumption at a particular point of time.  Projected Storage: This describes the number of total projected storage consumption at a particular point of time.  Timestamp: Time for which the projection is made. |
| Assigned radio resources | The physical radio resource assignment to the target gNB. |
| Consumed radio resource | The physical radio resource utilization of the target gNB. |
| Projected radio resource | The physical radio resource projected utilization of the target gNB. |
| isOptimal | Indication on whether the target gNB is optimal for handover. This will include:  isOptimal: TRUE/FALSE indication if it is optimal.  Network slice Identifier: Indication of the target slice (or same slice type) at the target gNB. |
| isFutureOptimal | Indication on whether the target gNB is optimal for handover at a future point of time (Timestamp). This will include:  isFutureOptimal: TRUE/FALSE indication if it is optimal.  TimeStamp: Indicating the timestamp at which the target gNB will be optimal  Network slice Identifier: Indication of the target slice (or same slice type) at the target gNB. |
| Priority | Priority of the target gNB for optimal HO, in case of multiple targets. |
| Remedial Action | Recommendation for gNB modification in order to make it optimal for handover e.g., scale-out gNB, increase radio resource. |

### 6.5.2 Inter-gNB Beam Selection Optimization

#### 6.5.2.1 Use case

The handover procedure specified in 5G is triggered based on UE measurements, specifically considering the cell level radio quality of the source and target cell(s). In case of beamformed access, one cell can make use of several 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 target cell provides RACH resources to the UE, which are linked with specific beams. Currently, the target cell can do this, based on beam level measurements performed and reported by the UE. Picking the wrong beam for performing RACH on the target cell could easily result in RLF for the UE and should be avoided.

To address this beam level handover optimization issue, it is desirable to use MDAS to prioritize and/or select a beam in case of handover for a specific target cell, in order to minimize or even avoid RLF.

The MDAS producer provides a beam level HO optimization analytics report considering information about the handover performance of different beam combinations between specific source and target cell pairs. In particular, the MDAS producer considers the beam of the current cell and the selected beam (out of several available beams) of the target cell to keep statistics regarding the handover performance in order to avoid RLF. Beams of the target cell with a successful handover are preferred in the selection.

In other words, the analytics report also provides recommended actions to optimize the beam selection at the target gNB as a function of serving beam on the source cell side. Based on the recommended actions, the MDAS 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 analytics report may also be used to aid the target cell to allocate RACH resources in a way that ensures HO success.

#### 6.5.2.2 Potential requirements

**REQ-HO\_BEAM\_OPT\_CON-1**  The MDAS producer should have a capability to provide the analytics report describing the handover performance of beam combinations between cell pairs to authorized consumers based on previously recorded HOs.

**REQ-HO\_BEAM\_OPT\_CON-2**  The analytics report describing the performance of beam combinations between cell pairs should contain the following information:

- Number of successful HOs between a given beam pair

- Number of failed HOs between a given beam pair

- Indication if a beam pair is to be prioritized or down prioritized

#### 6.5.2.3 Possible solutions

##### 6.5.2.3.1 Solution description

The MDAS producer can analyze the ongoing and/or potential beam handover optimization based on the current and historical beam selection success/failure rate for an inter-gNB handover. The MDAS producer can provide the analytics report as defined in Clause 6.5.2.3.3 triggered by an event or periodically.

##### 6.5.2.3.2 Data required

The following data is required to do the required analysis.

|  |  |
| --- | --- |
| **Data category** | **Required data** |
| Performance Measurements | Inter-gNB handover: Number of success/failed handovers in terms of handover preparation/resource preparation;  Beam level measurements: CSI-RS, SSB beam related measurements clause 5.1.1.28, TS 28.552 [8];  Success/failure handover rate per beam pair, i.e. serving beam Id in source gNB and selected beam Id in target gNB. |
| MDT Data | UE measurements related to radio conditions and UE location information. |
| Beam selection policy | The current policy configured in the RAN related to beam selection for inter-gNB handover optimization. |

##### 6.5.2.3.3 Analytics report

The gNB resource analytics report contains the following information.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of gNB resource consumption** | **Attribute Name** | **Description** |
| Beam level Inter-gNB Handover performance | Handover success rate per beam ID pair. This can be quantified as high, medium or low success rate. |
| Time period | Time period, in the future, for the handover success rate per beam ID pair |
| List of gNBs | Objects involved: gNB(s) and cells of gNBs, |

### 6.5.3 Load Balancing optimization

#### 6.5.3.1 Use case

The rapid traffic growth and multiple frequency bands utilized in a commercial network make it challenging to steer the traffic in a balanced distribution. To address the problem, load balancing had been proposed. The objective of load sharing and load balancing is to distribute cell load evenly among cells or to transfer part of the traffic from congested cell, or to offload users from one cell or carrier or RAT to improve the network resource utilization efficiency and achieve network energy saving. This can be done by means of optimization of cell reselection/handover parameters and handover actions.

To ensure the service performance and user experience, the load balancing action based on handovers highly depends on the measurement report (MR) from the UE. For example, the inter-frequency scenarios with the deployment of multiple different frequency bands, the MR configuration and UE MR reports may cause amount of signalling overhead over Uu interface. The frequent inter-frequency measurement will cause huge UE power consumption and severely impact on running service by the data interruption for inter-frequency measurement gap, e.g. the gap time in LTE is number of frequency\*60ms per 480ms period and the gap time in NR also depends on SMTC period. The gap assistant inter-frequency measurements mechanism will bring delay of the measurement and decrease the data transmission rate. Solutions are desired to improve the effectiveness of the MR configuration and report, which may help to greatly reduce the MR signalling overhead, UE power consumption and data interruption of running service, and improve the convergence speed of the load balancing.

The MDA can help to predict the measurement results of cell on neighboring frequencies for each UE without the GAP assisted measurement. Via analyzing the historical intra-frequency and inter-frequency measurement from both the serving cell and the neighbour cell, the MDA can construct the network “radio finger print”, which characterize the network intra-frequency and inter-frequency coverage quality. The “radio finger print” information is composed of multiple virtual grid. The grid index is to identify a specific virtual grid and this index consists of cell ID and corresponding coverage quality, e.g., RSRP, of at least three intra-frequency cells. The attributes of the grid are used to describe the wireless characteristics of the grid, such as coverage of inter-frequency neighbor cells, including RSRP, reference signal receiving quality (RSRQ), received signal strength indication (RSSI), channel quality indicator (CQI), modulation and coding scheme (MCS), beam ID, etc.

The MDA producer provides the analytics report on “radio finger print” information to the gNB, gNB can directly predict the measurement values of cells on neighboring frequencies for each UE based on the well-constructed “radio finger print” and the real-time intra-frequency measurement. In this case, the GAP assisted inter-frequency measurement is avoided, and the gNB can make proper load balancing actions based on the predictions, which helps to reduce the data interruption of running services and improve the load balancing speed.

The MDA producer may also provide the traffic load prediction report to the authorized consumers, e.g., gNB, to enable the proactive load balancing actions. This would help to prevent the user experience degradation in advance compared to the reactive optimizations based on the delayed load information measurement and exchange.

#### 6.5.3.2 Potential requirements

**REQ-MLB\_OPT\_CON-1** The MDAS producer should have a capability to provide the analytics report describing the radio measurement information to authorized consumers , e.g., gNB.

**REQ-MLB\_OPT\_CON-2** The analytics report describing the radio measurement information should contain the following information:

- the applied cell ID;

- the time period(s) of the original data used for deriving the analytics report;

- the serving cell and its inter-frequency/intra-frequency neighboring cell’s cell ID and corresponding radio measurement information, e.g., CSI-RSRP, SS-RSRP, etc;

- Indication on whether the gNB is suitable to be selected as the target gNB for the MLB based handover based on the radio signal qualities.

**REQ-MLB\_OPT\_CON-3** The analytics report describing the predicted resource utilization status of gNB should contain the following information:

- predicted virtual, radio, and transport resources utilizations for potential MLB source and target gNBs in the near future;

- Indication on whether the gNB is needed to activate the MLB operation;

- Indication on whether the gNB is suitable to be selected as the target gNB for the MLB based handover.

#### 6.5.3.3 Possible solutions

TBD

### 6.5.4 Mobility performance analysis

#### 6.5.4.1 Use case

The mobility performance related problems may be resulted from different causes, e.g., too long mobility interruption time for latency sensitive services, low handover successful rate due to poor coverage of the cell-edge, handover failure due to lack of handover resources, too-early/too-late/pingpong handovers due to [inappropriate](javascript:;) handover parameters.

In addition, there are different handover mechanisms, e.g. Dual Active Protocol Stack (DAPS) to reduce service interruption time during handover, Conditional Handover (CHO) to improve handover robustness, RACH-less handover to reduce handover latency etc. SON MRO solutions can handle multiple handover robustness issues such as too early handover, too late handover, handover to a wrong cell etc. Furthermore, handover mechanisms are also related with NSA and SA deployment architecture. In different scenarios, handover solutions will have different impacts on the mobility performance. The analytics report to identify the most optimal handover mechanism may be provided by MDAS producer. For example, to satisfy the requirements of 0ms mobility interruption time for some URLLC services, MDAS may propose to prioritize the usage of DAPS. If handover successful rate is low due to coverage issue in the cell edge, MDAS may recommend CHO instead of gNB triggered handover mechanisms. To provide optimal handover mechanisms and the corresponding handover related parameters, MDAS may consider multiple factors, e.g. radio conditions, cell load, service requirements, handover successful rate, history performance data around handover, UE RF finger prints etc. MDAS may compare performance of different handover mechanisms and propose optimal handover mechanisms, e.g. the prioritization of different handover mechanisms in different conditions.

MDAS can be used to analyse service experience and network performance during handover period in different mobility scenarios. It may also be able to provide the recommendations of optimal handover parameters, resource configurations and mobility related policies. Mobility performance analysis should cover the following aspects:

- Mobility scenarios in NSA and SA deployment architectures;

- Optimal handover mechanisms, e.g. DAPS, CHO, RACH-less handover etc;

- Optimal handover parameter and resource configurations;

- Coordination with SON MRO mechanisms to improve handover robustness;

- Mechanisms for fast handover failure recovery;

The MDAS producer is able to, from the perspective of the management aspects, provide the mobility performance analytics report. This analytics report can be considered as an input to support SLS assurance to perform further evaluation.

#### 6.5.4.2 Potential requirements

**REQ-MOB\_PMF\_CON-1** The MDAS producer should have a capability to provide the analytics report of mobility performance.

**REQ-MOB\_PMF\_CON-2** The analytics report describing the mobility performance should contain the following information describing the mobility related performance aspects:

- Optimal handover mechanism and the corresponding parameters for DAPS, CHO, RACH-less handover and NR SON MRO scenarios etc.

#### 6.5.4.3 Possible solutions

##### 6.5.4.3.1 Solution description

The MDAS producer correlates and analyses the management data described in the following subclause to provide optimal handover mechanisms and the corresponding configurations regarding parameters and resources. As the table in 6.5.4.3.3 shows, the analytics report is able to be provided by the MDAS producer to describe the optimal handover mechanisms. This procedure may be triggered by the request or periodically.

##### 6.5.4.3.2 Data required for mobility performance analysis

Following table shows the potential data required to analyse the mobility performance.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | sNSSAIList;  Inter-gNB handovers: see clause 5.1.1.6.1 of TS 28.552[8];  Intra-gNB handovers: see clause 5.1.1.6.2 of TS 28.552[8];  Handovers between 5GS and EPS: see clause 5.1.1.6.3 of TS 28.552[8];  RRC Connection Re-establishment: see clause 5.1.1.17 of TS 28.552[8];  Inter-AMF handovers: see clause 5.2.5.1 of TS 28.552[8];  Handovers from 5GS to EPS: see clause 5.2.5.3 of TS 28.552[8];  Handovers from EPS to 5GS: see clause 5.2.5.4 of TS 28.552[8];  Number of handover events, Number of HO failures, Number of too early HO failures, Number of too late HO failures, Number of HO failures to wrong cell, Number of unnecessary HOs to another RAT: see clause 4.3.5 of TS 28.628[y];  Radio resource utilization: The usage of physical radio resource utilization of the network, see clause 5.1.1.2 of TS 28.552[8];  RAN UE throughput: A KPI that shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [7];  Throughput at N3 interface: Upstream/Downstream GTP data throughput at N3 interface, see clause 6.3.4 and clause 6.3.5 of TS 28.554 [7];  NWDAF analytical data: UE mobility analytics, UE Communication Analytics; see 6.7.2 and 6.7.3 of TS 23.288 [y]; |
| MDT Data | UE measurements related to RSRP, RSRQ, SINR and UE location information. |
| QoE Data | The details information of QoE data required by this case is FFS. |
| Configuration Data | The execution data including the changes or the configuration of the MOIs related with RAN user plane congestion. |

Note: The above parameters may not be the complete list.

##### 6.5.4.3.3 Analytics report for mobility performance analysis

Following table shows the potential information carried in the analytics report of mobility performance analysis.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of mobility performance** | **Attribute Name** | **Description** |
| Mobility performance issue identifier | The identifier of the mobility performance issue analysis; |
| Root cause of mobility performance issue | The root cause of mobility performance issues, e.g., too long mobility interruption time for latency sensitive services, low handover successful rate due to poor coverage of the cell-edge, too-early/too-late/pingpong handovers due to [inappropriate](javascript:;) handover parameters |
| Recommended handover mechanisms | Recommended handover mechanisms according to network conditions, e.g., DAPS, CHO, RACH-less handover;  Note: The DAPS and CHO mechanism are mutually exclusive. |
| Recommended handover related parameters | Corresponding configurations of handover related parameters, e.g., the range of handover offset. |
| Time duration | The time duration the identified handover mechanism or handover related parameters are recommended to apply. |
| Location | The geographical area or the cells where the identified handover mechanism and handover related parameters are applied. |

### 6.5.5 Handover optimization based on UE trajectory

#### 6.5.5.1 Use case

Handover optimization can benefit from knowledge about the trajectory on which the user may be moving. A trajectory here is a sequence of location coordinates, i.e. a vector that captures the sequences of coordinates within a certain time interval, derived from historical UE location data, that identifies the different directions which users may take starting at a given point. At a city junction, for example, the probability of a handover success for a user moving straight through the junction may be different from that for a user who is turning left or turning right. So, at that junction, the straight, left and right direction indicate three possible trajectories. The MDAS producer should be able to analyse historical handover performance data in combination with historical UE location and the radio characteristics like RSRP and SINR considering the possible user trajectories to identify the optimal handover configurations and target cell prioritization.

#### 6.5.5.2 Potential requirements

REQ-HO\_OPT\_TR\_CON-1 The MDAS producer should have a capability to provide an analytics report indicating the possible candidate user trajectories across the cell boundaries and provide radio configuration and target gNB selection specific to each trajectory.

#### 6.5.5.3 Possible solutions

##### 6.5.5.3.1 Solution description

The solution considers UE trajectories and radio conditions for selecting the target gNB. The current resource consumption is analysed with the future/predicative resource consumption to decide if the target gNB is optimal for handover or not.

##### 6.5.5.3.2 Data required

The following data is required to do the required analysis.

|  |  |
| --- | --- |
| **Data category** | **Required data** |
| Consumed Radio Resource | Radio resource utilization: The physical radio resource utilization of the target gNB, see clause 5.1.1.2 of TS 28.552[8]; |
| MDT data | UE measurements related to RSRP, RSRQ, SINR time-stamped and annotated with UE location information. |

##### 6.5.5.3.3 Analytics report on user trajectory-based handover optimization

The gNB trajectory-based handover optimization analytics report contains the following information.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of user trajectory-based handover** | **Attribute Name** | **Description** |
| User trajectory | The predicted UE location that identifies a trajectory across a cell boundary. |
| Radio characteristics on user trajectory | Radio parameters e.g. RSRP, SINR, on the predicted user trajectory across a cell boundary. |
| Recommended actions | Recommendation for optimal gNB configuration and/or target gNB selection/prioritization based on the user trajectory information. |

## 6.6 Energy efficiency related issues

### 6.6.1 MDA assisted energy saving

#### 6.6.1.1 Use case

Energy saving is a critical issue for the 5G operators. Energy saving is achieved by activating the energy saving mode of the NR capacity booster cell or 5GC NF (e.g. UPF etc.), and the energy saving activation decision making may be based on the various information such as load information of the related cells and the energy saving policies set by operators as specified in TS 28.310 [14].

As the conclusion from clause 7.2 of the TR 21.866 [15], “The EE Control and Coordination Function: a self-managed automated process to control and coordinate system wide power saving operations including the access networks, core network, backhaul/fronthaul transmission networks, backbone networks and other subsystems”, the management system has the overall view of network load information and it could also take the inputs from the control plane analysis (e.g. the analytics provided by NWDAF). The management system may provide the network wide analytics and cooperate with Core and RAN domains and decide on which network element should move into energy saving mode in a coordinated manner.

There are various information could be used as inputs for management energy saving analysis. For example, the MDAS provides the analytics report to assist energy saving based on the EE related performance measurements, (e.g. PDCP data volume, PNF temperature, and PNF power consumption etc.) from the gNBs.

The composition of the traffic load could be also considered as inputs for energy saving analysis. (e.g., the percentage of high-value traffic in the traffic load). The variation of traffic load may be related to the network data (e.g., historical handover information of the UEs or network congestion status). Collecting and analysing the network data with machine learning tools may provide predictions related to the trends of traffic load. The composition and the trend of the traffic load may be used as references for making decision on energy saving.

MDAS may also obtain NF location or other resource information including virtual resource consumption, while analyzing historical network information. Based on the collected information, MDAS provides analysis and give suggestions to network management in optimization suggestion for 5G Core NF deployment options in high-value traffic region (e.g. location of VNF in context of energy saving). The information from control plane data analysis from NWDAF may also be used as input for energy saving analysis and decision.

The decision of core NF and RAN node energy saving should be coordinated by management system to guarantee the overall network and service performance are not affected as much as possible.

To achieve an optimized balance between the energy consumed and the serviced performance provided by the network, MDAS can be used to provide an analytic report by analyzing the above information comprehensively to assist the energy saving related decision making.

#### 6.6.1.2 Potential requirements

TBD

#### 6.6.1.3 Possible solutions

##### 6.6.1.3.1 Solution description

The MDAS producer correlates and analyses the management data described in the following subclause to assist the management energy saving function to make energy efficiency decisions. As the table in 6.6.1.3.3 shows, the analytics report is able to be provided by the MDAS producer to describe the analytics result and recommendations of energy saving. This procedure may be triggered by the request or periodically.

Energy saving activation decision making may be based on the various information such as load information. The prediction result of these information can be used by operators to make energy-saving policies. There are many prediction models which may use ML algorithms for predicting these information, such as energy-saving scenarios prediction models and traffic load prediction models.

The prediction models are trained to be able to produce the expected training output from the training input. The data for models training may include RRC connection number, PRB utilization, energy consumption, service experience, etc. After the training process, the pre-trained models for predicting information used to make energy-saving policies can be obtained.

The more accurate the information prediction results are, the better the energy-saving policies based on the information prediction results will be. According to the result of information prediction and the energy-saving benefit, the MDA service can assist the energy saving policy decision making by recommending the optimal information prediction models which can provide more accurate information prediction results for consumers.

For example, the MDA service may take base station energy saving scenarios prediction model and the traffic load prediction model together as input. Based on the results of energy saving scenarios prediction and traffic load prediction, the MDA service may use the ML algorithms to calculate the energy-saving benefit based on base station related information (e.g., service experience changes), the traffic load changes as well as the prediction of the energy saving scenarios. And by maximizing the expected sum of energy-saving benefits, the MDA service may provide the optimal prediction models for making recommendation of base station energy saving policies accordingly.

##### 6.6.1.3.2 Data required for MDA assisted energy saving

Following table shows the potential data required to analyse the energy saving issue.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | PNF Power Consumption: Power consumed over the measurement period, see clause 5.1.1.19.2 of TS 28.552 [8];  PNF Energy consumption: The energy consumed, see clause 5.1.1.19.3 of TS 28.552[8];  PNF Energy Temperature: The temperature over the measurement period, see clause 5.1.1.19.4 of TS 28.552[8];  PNF Voltage: The voltage, see clause 5.1.1.19.5 of TS 28.552[8];  PNF Current: The current, see clause 5.1.1.19.6 of TS 28.552[8];  PNF humidity consumption: The percentage of humidity during the measurement period, see clause 5.1.1.19.7 of TS 28.552[8];  PDCP Data Volume: The transmitted PDCP data volume, see clause 5.1.2.1 and 5.1.3.6 of TS 28.552 [8];  Virtual resource usage of NF: The resource usage of virtual network functions, see clause 5.7.1 of TS 28.552 [8]. |
| QoE Data | The measurements that are collected are DASH [16] and MTSI [17] measurements. The detailed information of QoE data required by this case is FFS. |
| Analytics Data | The control plane analysis result from the NWDAF defined in TS 23.288 [18], e.g., observed service experience related network data analytics.  The additional required analysis result is FFS. |
| Pre-trained Prediction Models | The pre-trained models, which may be based on ML algorithms and trained to be able to produce the expected training output for consumers, e.g., pre-trained base station energy-saving scenarios prediction models, pre-trained traffic load prediction models.  The detailed information about where to obtain the pre-trained prediction models is FFS. |

Note: The above parameters may not be the complete list.

##### 6.6.1.3.3 Analytics report for MDA assist energy saving

Following table shows the potential information carried in the analytics report of MDA assist energy saving.

|  |  |  |
| --- | --- | --- |
| **Analytics Report of MDA assisted energy saving** | **Attribute Name** | **Description** |
| Energy efficiency issue identifier | The identifier of the MDA assisted energy saving |
| Location | The geographical area or the cells where the unreasonable energy consumption exists |
| Root cause | The root cause of the part of the energy consumption that may be conserved, e.g., ultra-low traffic load area with energy consumption, excessive energy consumption |
| Recommended prediction models | The optimal prediction models which can provide more accurate information prediction results to assist the energy saving related decision making. |

## 6.7 Paging performance related issues

### 6.7.1 Paging optimization

#### 6.7.1.1 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 comes in the coverage and reacts 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 analytical report containing the user(s) paging analytics indicating the time window at which the user is OOC on a regular basis at the particular location and hence will not be able to respond on a network-initiated paging. Based on the report 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.

#### 6.7.1.2 Potential Requirements

**REQ-PA\_OPT\_CON-1:** The MDAS producer should have a capability allowing the authorized consumer to get the paging analytics report describing paging results for a particular user or a group of users.

**REQ-PA\_OPT\_CON-2:** The MDAS producer should have a capability to provide the paging analytics report describing the paging results based on successful and un-successful paging attempts at a particular time and duration.

**REQ-PA\_OPT\_CON-3:** The paging analytics report describing the paging results should contain the following information:

- User Identification: Identification of the user or a group of users.

- Daily-OOC-Duration: Identifying the time window during which UE is out-of-coverage every day.

- Daily-OOC-Location: Identifying the last known location before UE going out-of-coverage every day.

- Recommended Action: The recommendation may suggest stopping paging the UE for Daily-OOC-Duration at Daily-OOC-Location.

#### 6.7.1.3 Possible Solutions

##### 6.7.1.3.1 Solution description

The solution requires MDAS producer to collect various data and provide the paging analytics report. Daily-OOC-Duration and Daily-OOC-Location will be included in the Paging Analytics Report mentioning the time window during which UE is out-of-coverage every day at a particular location. The paging is not initiated for the UE during the period provided as Daily-OOC-Duration if the last know UE location is the location identified by Daily-OOC-Location.

##### 6.7.1.3.2 Data required

The consumer (e.g. AMF) can subscribe to obtain the paging analytics report for a user or a group of the user from MDAS producer. The subscription request may include identification for the target user or a group of the user, reporting interval etc. The MDAS producer collects the following per UE per day data from various sources.

|  |  |
| --- | --- |
| **Data category** | **Required data** |
| UE Paging Measurements | Number of successful paging attempt. |
| Successful Timestamp: The timestamp for each successful paging attempt. |
| Successful Location: Last known location of UE. |
| Number of un-successful paging attempt: Total number of un-successful paging attempt. |
| Un-Successful Timestamp: The timestamp for each un-successful paging attempt. |
| Un-Successful Location: Last known location of UE. |

##### 6.7.1.3.3 Analytics report

The paging analytics report contains the following information

|  |  |  |
| --- | --- | --- |
| **Paging Analytics Report** | **Attribute Name** | **Description** |
| User Identification | Identification of the user or a group of users. |
| Daily-OOC-Duration | Identifying the time window during which UE is out-of-coverage every day. This will be provided per UE. |
| Daily-OOC-Location | Identifying the last known location before UE going out-of-coverage every day. This will be provided per UE. |
| Recommended Action | The recommendation may suggest stopping paging the UE for Daily-OOC-Duration at Daily-OOC-Location. This will be provided per UE. |

Based on the report and the recommendation, the consumer decides whether to change the paging strategy for a particular UE or a group of UE. If the paging policy needs to be changed, the AMF may decide whether, when and where to page the UE. The AMF may not page the UE during the period provided as Daily-OOC-Duration if the last know UE location is the location identified by Daily-OOC-Location.

Editor’s Note: This use may require MDAS to know UE Identifier. How that will be done is FFS.

## 6.8 Software management related issues

### 6.8.1 RAN Node Software Upgrade

#### 6.8.1.1 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. The software upgrade should be automatically initiated by the OAM system, once configured, at the time 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 for software upgrade.

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

#### 6.8.1.2 Potential Requirements

**REQ-SW\_UPG\_CON-1:** The MDAS producer should have a capability allowing the authorized consumer to get the DRB info analytics report describing the DRBs info at a particular RAN Node(s).

**REQ-SW\_UPG\_CON-2:** The MDAS producer should have a capability to provide the DRB info analytics report describing the DRB info based on DRB characteristics including GBR/non-GBR, state, modification count, handover etc.

**REQ-SW\_UPG\_CON-3:** The DRB info analytics report describing the DRB info should contain the following information:

- Timestamp: Time at which the report is generated

- CurrentUpgradeOptimal: Whether RAN Node is optimal for upgrade at present

- DRB status: Total number of GBR and non-GBR DRBs at present

- FutureUpgradeOptimal: Whether RAN Node will be optimal for upgrade at a future point of time. This will also provide a future timestamp.

- DRB status: Total number of GBR and non-GBR DRBs at future point of time. This will also provide a future timestamp.

#### 6.8.1.3 Possible Solutions

##### 6.8.1.3.1 Solution description

The solution requires MDAS producer to collect current DRB info as defined in clause 6.8.1.3.2 and produce the report, as defined in clause 6.8.1.3.3, providing the optimal time for software upgrade i.e. the time at which the impact is minimal.

##### 6.8.1.3.2 Data required

The following table shows the data required to generate the DRB info analytics report. The data is collected per DRB from gNB.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Bearer Statistics | QCI: Indicates resource bearer type (GBR, non-GBR). |
| Radio bearer State: Radio bearer State (Idle, Active)  *The state indicates the status of bearer connection. The state will be used to deduce total number of idle/active connection. Based on the number of idle/active connections probable time for SW Upgrade can be decided.* |
| Bearer Modification Count: This count indicates number of times, this bearer has gone for modification since its creation.  *This count will be used to detect how frequent this session has undergone bearer modification. With history database, if this session is vulnerable to many bearer modifications, the upgrade can be differed.* |
| Handover In Progress: This flag indicates whether the bearer is undergoing handover or not.  *This flag will help to deduce number of sessions which are undergoing handover. MDAS may choose to defer SW upgrade based on number of sessions which are undergoing handover. The best practise is to go for SW upgrade, when active handovers are minimum.* |
| GTP Error Indication: This flag indicates GTP Path has gone to error state and system is waiting for recovery.  *This flag will help to deduce number of sessions which are recovering due to error in GTP Path. MDAS may choose to defer SW upgrade based on number of sessions which are in error state. The best practise is to go for SW upgrade, when number of sessions suffering from this error are minimal.* |
| Timestamp: This parameter indicates timestamp during which this information has been collected |

Editor’s Note: Additional Input may be required, which are FFS.

##### 6.8.1.3.3 Analytics report

The DRB info analytics report shall contain the following

|  |  |  |
| --- | --- | --- |
| **DRB info Analytics Report** | **Attribute Name** | **Description** |
| Timestamp | Time at which the report is generated |
| CurrentUpgradeOptimal | Boolean attribute indicating whether RAN Node can be upgrade at present. |
| No. of GBR DRB | Total number of GBR bearer |
| No. of Non-GBR DRB | Total number of non-GBR bearer |
| FutureUpgradeOptimal | Boolean attribute indicating whether RAN Node can be upgrade in future. This will provide the time duration in future. |
| No. of GBR DRB | Total number of GBR bearer |
| No. of Non-GBR DRB | Total number of non-GBR bearer |

## 6.9 MDA assisted SON coordination

### 6.9.1 SON conflict prevention and resolution

#### 6.9.1.1 Use case

Some SON functions, such as the MRO function and the MLB function, may modify the same parameters of an NR cell and potentially cause conflict. For instance, the MRO function may need to modify the HO parameters causing a handover to occur later (i.e., when the signal strength of the neighbour cell become stronger). However, the MLB function may need to modify the same HO parameters causing the HO to occur sooner, in order to offload some traffic towards the same neighbour cell. Similarly, the conflict may arise between a SON function and a non-SON function (e.g., eMIMO).

The potential SON conflict (which could be between SON functions or between a SON function and a non-SON function) should be prevented from happening as much as possible, and if the conflict happens it should be resolved as soon as possible. The SON conflict prevention and resolution can be assisted by MDA.

The MDA could analyse the following data for identifying the potential SON conflict or detecting whether a SON conflict occurred:

- historical and the most recent changes made by the SON functions and non-SON functions;

- the current network configurations;

- historical and current network performance data related to the SON function(s) and the relevant non-SON functions. For instance, load information of the NR cells, handover performance measurements (too early HOs, too late HOs, etc.);

- Policies and targets for the SON functions.

- historical and current MDT/RLF data.

- for a SON function or a non-SON function, considering potential affected parameters.

If a potential SON conflict is identified, the MDAS producer provides an analytics report to describe the potential conflict and the recommended actions to prevent such conflicts from happening.

If a SON conflict is defected, the MDAS producer provides an analytics report to describe the conflict including the recommended actions to resolve it.

The recommended actions for SON conflict prevention and resolution may be one or more of the following:

- modify the policies and targets for the SON function(s);

- change the priority of the SON function(s);

- set or change the range of the attributes value that the SON function(s) are allowed to modify;

- update the attributes value to correct the conflict (if already occurred);

- temporarily switch off one or more SON function(s) ;

- undo the most recent configuration undertaken by the SON function;

- provide a report that describes how SON function(s) can potentially affect the common parameters.

#### 6.9.1.2 Potential requirements

**REQ-MDA\_SONCO-CON-1** The MDAS producer should have a capability to provide the analytics report describing the identified potential conflict between SON functions or between a SON function and a non-SON function with recommended actions to prevent the conflict from happening.

**REQ-MDA\_SONCO-CON-2** The MDAS producer should have a capability to provide the analytics report describing the detected conflict between SON functions or between a SON function and a non-SON function with recommended actions to resolve the conflict.

**REQ-MDA\_SONCO-CON-3** The MDAS producer should have a capability to provide the analytics report that describes the relations (i.e. whether certain conditions trigger conflicts) between observed conflicts and observed conditions.

##### 6.9.1.3 Possible solutions 6.9.1.3.1 Solution description

The MDAS producer correlates and analyzes the data described in the following subclause within a time period on a regular basis or trigged by events (e.g., the RLF report) to identify a potential SON conflict or a SON conflict already occurred.

Once a potential or already occurred SON conflict is identified, the MDAS producer provides the analytics report to describe the SON conflict as shown in subclause 6.9.1.3.3.

##### 6.9.1.3.2 Data required for SON conflict analysis

The following table describes the data required for SON conflict analysis:

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements | Radio Measurements for gNB: RRC connection, see clause 5.1, TS 28.552[8], e.g., RRC connection number, RRC connection establishment, RRC connection re-establishment, RRC connection resuming;  RAN UE throughput: A KPI that shows how NG-RAN impacts the service quality provided to an end-user, see clause 6.3.6 of TS 28.554 [7].  Throughput for network slice instance: Upstream/Downstream throughput for network and Network Slice Instance, see clause 6.3.2 and clause 6.3.3 of TS 28.554 [7];  Performance measurements related to the SON functions, see TS 28.313 [19]. |
| CM notification | Notifications of the NRM updates made by SON functions and non-SON functions.  The notification needs to include the Id (e.g., DN) of the SON function or non-SON function who made the NRM updates. |
| MDT/RLF Data | UE measurements related to RLF containing RSRP, RSRQ, of the serving cell and neighbour cells, SINR with anonymous id (e.g., C-RNTI) and UE location information. |
| QoE Data | The details information of QoE data required by this case is FFS. |
| Configuration Data (NRM) | The execution data including the changes or the configuration of the MOIs. This should include historical UE configurations  The attributes of the MOIs to be analysed, see TS 28.541 [20].  The policy and targets of the SON functions, see TS 28.313 [19]. |
| Potential affected parameters | SON functions parameters affected including the degree of impact (low, medium, high). |

Note: The above parameters may not be the complete list.

##### 6.9.1.3.3 Analytics report SON conflict prevention and resolution

Following table provides the potential contents of the analytics report for SON conflict prevention and resolution:

|  |  |  |
| --- | --- | --- |
| **Analytics Report of SON conflict prevention and resolution** | **Attribute Name** | **Description** |
| Conflicting Functions Id | Indicates the Id of the conflicting SON functions or non-SON functions. |
| Conflict type | Indicates the conflict is a potential conflict or an already occurred conflict. |
| Conflicting attributes | The MOI and attributes where the conflict occurred or is potentially to occur. |
| Conflict reason | The description of the reason for the conflict. |
| Conflicting metrics | The performance measurements and KPI(s) over which the SON or non-SON Functions conflict. |
| Attribute conflict status | The relative level (low, medium, high) of impact of each conflicting attribute on the SON or non-SON functions. |
| Recommended actions | The MOI and attributes recommended to be configured/changed:  - The policy and targets of the SON functions, see TS 28.313 [19];  - The range of attributes value each conflicting SON function can change;  - The priority of each conflicting SON function;  - Value of the attributes of the affected MOIs (e.g., NRCellCU) where the conflict already occurred;  - Switch off the conflicting SON functions, see TS 28.313 [19]. |

## 6.10 Security related issues

### 6.10.1 Security risk assessment

#### 6.10.1.1 Use case

Security risk assessment can detect anomalies in managed objects, e.g. NF, identify potential security risks and propose countermeasures to mitigate them. Security risks may originate from a variety of different sources and target distinct network objects resulting in different abnormal behaviours, e.g. sudden increase in computing and storage in a virtualization environment, sudden increase of load in network links, abnormal communication patterns between NFs, excessive latency in accessing a NF, relocating a NF in an unexpected location or interrupting the relocation of a NF.

To assess security risks, the management plane can leverage the benefits of MDAS. An MDAS producer can identify a security risk issue by correlating different performance measurements and alarms, i.e. performing a root cause analysis to locate the malicious source and the network objects affected. Such activity can be triggered when certain performance measurements and KPIs indicate an abnormal network behaviour, which is not related to another known faults.

The MDAS producer should correlate the usage, e.g. considering the NF procedures for supporting a number of UEs or other events, with the corresponding resource usage, e.g. in terms of CPU, storage and disk. If no other fault alarms indicate another reason, an unexpected resource usage should trigger a security risk analysis to identify the issue based on a private security risk database that resides on the MDAS producer. The MDAS producer can notify the MDAS consumer, e.g. MnF or NE, and provide recommendations to mitigate the identified security risk. The MDAS consumer based on the recommendations can isolate the malicious network objects, e.g. NF, and can also provide recommendations to harden the network in order to avoid similar security risks in the future.

#### 6.10.1.2 Potential requirements

**REQ-SEC\_CON-1** The MDAS producer should have a capability to provide the analytics report describing the security risk to authorized consumers based on the correlation of current and predicted performance measurements and alarms.

**REQ-SEC\_CON-2** The analytics report describing the security issue should contain the following information describing the current and future security risk issue:

- Identify the type of security risk.

- Location and network objects affected by the security risk.

- Root cause analysis of the security risk issue.

- Recommended action to isolate and/or restrict the security risk issue and harden the network security.

#### 6.10.1.3 Possible solutions

##### 6.10.1.3.1 Solution description

The solution considers security risk assessment related to network. The MDAS producer correlates and analyzes performance measurements and alarm data considering the network topology and configuration data related to statistics or predictions to identify the type of security risk.

##### 6.10.1.3.2 Data required

The following data is required to perform the corresponding security risk assessment analysis.

|  |  |
| --- | --- |
| **Data category** | **Required data** |
| **Alarm Data** | Alarm information - types of alarms |
| **Service Data** | S-NSSAI as defined in clause 5.15.2, TS 23.501 [13]. MDAS may derive network topology information |
| **Performance Measurements** | Failures and disruptions:  - Number of abnormal releases: DRB, QoS flows, PDU sessions, UE context in serving cells as per TS 28.552 [8]  - Disruption measurements: CQI/MCS as per TS 28.552 [8]  - Excessive delay in accessing NFs (e.g. AMF or SMF)  - NF abnormal and excessive communication, e.g. AMF uses a different SMF without performing the expected selection process or it overloads an SMF unexpectedly.  - Intra/inter-gNB handover: failures - long handover time as per TS 28.552 [8]  Virtualized resources/behaviour:  - Virtual resource usage of NF: The resource usage of virtual network functions, see clause 5.7.1 of TS 28.552 [8]  - Virtual NF Re-location: Timing/duration and success rate  - Frequency of virtual NF Re-location: Rate of relocation  - Virtual NF location: NF location with respect to a data network  NF context information as per TS 28.552 [8]:  - Number of UEs/periodic registration updates (AMF)  - Number of PDU sessions/modifications, QoS flows (SMF)  - N4/N6/N9 measurements or packet delay, traffic volume, link usage, packet loss (UPF)  - Number of application trigger requests rejected (NEF)  - Number of failed NF service registration/update, discoveries due to unauthorized NF/error (NRF) |
| **Configuration Data** | NRM attributes affecting the location and virtual NF resource allocation and configuration  NRM update reports (notification and log) containing the creation or changes of the MOIs affecting the virtual NFs |
| **Network Topology** | Topology of the network |

##### 6.10.1.3.3 Analytics report

The MDAS producer offers a new Security Analytics service to the MDAS consumer, which supports security risk assessment related providing the following analytics results:

|  |  |  |
| --- | --- | --- |
| **Analytics Report of Security risk assessment** | **Attribute Name** | **Description** |
| **Security Incident Identifier** | Identifier that indicates the security risk (e.g. DDoS, malicious NF, etc.) |
| **Type of Analytics** | Statistics or Prediction of security risks |
| **Location** | Geographical location that the security risk affects |
| **Affected Objects** | NF, PDU session, QoS Flow, Slice |
| **Start/Stop Time** | Starts/stop time of the security risk issue |
| **Root Cause** | The originator of security issue to isolate fast the problem. |
| **Severity Level** | The severity level (e.g. critical, medium, not important) of the security risk issue |
| **Recommended Actions** | Recommendation actions to resolve the security risk issue:  - Isolate/terminate NF, terminate PDU session, throttle signalling from NF or UE, block UE, etc.  - Harden security on specific NF, firewall update, scaling resources, load balancing, admission control, etc. |

### 6.11 Traffic projection

### 6.11.1 Network slice traffic projection

#### 6.11.1.1 Use case

Some of the requirements captured in SliceProfile need to be translated into configurable parameter for various network entities including entities in 5G Core Network (5GC), Radio Access Network (RAN) and Transport Network. One of the example would be: the GST attribute Downlink throughput per slice (dLThptPerSlice) can be translated into maximum downlink throughput per slice (maxDlThptPerSlice) as a configuration parameter, for UPF. However, as one slice may have multiple UPF instances, dividing the total quota available among each UPF instance is critical. The given requirements can be divided among all the targeted NF instance based on the slice traffic analytics. The value for a particular configurable parameter (translated from a particular ServiceProfile attribute) for a particular NF is crucial, especially if multiple instance of that NFs is available in the network slice instance.

It is desirable to use uses MDAS to get the network slice traffic projections including individual traffic projections on each of the constituent network functions instances present in the slice. The individual traffic projections can be used to divide total available quota among the constituent network functions instances which can then be configured for network function(s), as required. For example, MDAS can provide total number of projected terminal or subscription for each AMF instance in the slice. Based on the projections the total available quota can be divided among the multiple AMF instances in the slice. The AMF instance serving more users or require to serve more users in future will have more quota then other AMF instances in the slice.

#### 6.11.1.2 Potential Requirements

**REQ-TRA\_CON\_CON-1:** The MDAS producer should have a capability allowing the authorized consumer to request the slice traffic analytics report describing traffic projection of the slice including its constituent network functions.

**REQ-TRA\_CON\_CON -2:** The MDAS producer should have a capability to provide the slice traffic analytics report describing the traffic projections for each constituent network function instance in the slice.

**REQ-TRA\_CON\_CON -3:** The slice traffic analytics report providing traffic projection for the slice may include the following information:

- Projected uplink and downlink throughput requirement on each User Plane Function instance (UPF) present in the slice.

- Projected number of Packet Data Unit (PDU) session for each Session Management Function (SMF) instance present in the slice.

- Projected number of UE or Registered subscriptions for each AMF instance present in the slice.

- Projected maximum packet size for each UPF instance present in the slice.

- Projected UE uplink and downlink throughput requirement per slice on each gNodeB (gNB) instance present in the slice.

#### 6.11.1.3 Possible Solutions

##### 6.11.1.3.1 Solution description

The solution requires MDAS producer to produce slice traffic analytics report providing traffic projections on NFs involved in the slice. Based on the report, configuration for the NFs can be decided.

##### 6.11.1.3.2 Data required

The following table shows the data required to generate the traffic analytics report.

|  |  |
| --- | --- |
| **Data Category** | **Required Data** |
| Performance Measurements/KPIs |  |
| From each UPF instance in the slice  - Current Uplink throughput. See 5.4.1.3 in TS 28.552.  - Current Downlink throughput. See 5.4.1.4 TS 28.552  - Current Maximum packet size |
| From each gNB instance in the slice  - Current Uplink UE throughput. See 5.1.1.3 in TS 28.552.  - Current Downlink UE throughput. See 5.1.1.3 in TS 28.552. |
| From each SMF instance in the slice  - Current Number of PDU session. See 5.2.1 in TS 28.552. |
| From each AMF instance in the slice  - Current Number of registered subscriptions. See 5.2.1 in TS 28.552. |

##### 6.11.1.3.3 Analytics report

The slice traffic analytics report shall contain the following:

|  |  |  |
| --- | --- | --- |
| **Analytics Report of slice traffic projection** | **Attribute Name** | **Description** |
| Slice Identifier | Identifier of the slice for which the report is provided |
| Projection Timestamp | Provide a particular time stamp for which the projections are provided |
| Projection Duration | Provides a time duration during which the average projections are provided |
| For each UPF in the slice | Projected Uplink throughput |
| Projected Downlink throughput |
| Projected Maximum packet size |
| For each gNB in the slice | Projected Uplink UE throughput. |
| Projected Downlink UE throughput |
| For each SMF in the slice | Projected Number of PDU session |
| For each AMF in the slice | Projected Number of registered subscriptions |

## 6.99 MDA management aspects

Editor’s Note: This sub-clause will be put to the end of clause 6 to separate from other categories of issues. The sub-clause number will be revisited before sending the TR for approval.

### 6.99.1 ML model training for MDA

#### 6.99.1.1 Use case

The MDA process may rely on ML technologies. To optimize the accuracy of MDA result, the ML model of the MDA process may need to be trained.

For training the ML model of the MDA process, the consumer provides the training data including training input and the desired output to the MDAS producer. The MDAS producer classifies the training data and uses the training input and the desired output to train the ML model, i.e., to train the algorithm of the ML model to be able to provide the desired output by analysis of the training input. The MDAS producer provides an ML model training report as one kind of output data to the consumer.

With a trained ML model for MDA, the MDAS producer can analyze the analytics input and generate the analytics report as output data of the analysis to the consumer.

The consumer may validate the output data provided by the MDAS producer. The output data to be validated may be the analytics report and/or the ML model training report as described above. The consumer may provide the validation data as feedback to the MDAS producer, and the MDAS producer will use the validation data for further ML model training for MDA with the historical data that are used to generate the validated output data.

#### 6.99.1.2 Potential requirements

**REQ-MDA\_MGMT-CON-1** The MDAS producer should have a capability allowing the consumer to train the ML model for MDA.

**REQ-MDA\_MGMT-CON-2** The MDAS producer should have a capability to provide ML model training report to the consumer.

**REQ-MDA\_MGMT-CON-3** The MDAS producer should have a capability to receive the validation data from the consumer and train the ML model for MDA based on the received validation data.

### 6.99.2 Subscription to Management Data Analytics Reports

#### 6.99.2.1 Use case

MDAS Producer may provide several management data analysis reports. Multiple users may wish to receive a selection of these reports.

The user submits a request to MDAS to subscribe to an MDA report. This request may include a filter to specify which subset of management data should be analysed. MDA activates the data collection if it is not already active.

For all reports, MDA collects data, analyses the data, and generates an analysis report.

MDA notifies to subscribers when a new or updated analysis report is available. The notification may contain the analytics report, or the notification may contain a link to a location where the report may be retrieved.

The user may send a request to MDAS to unsubscribe from an MDA report. If no subscribers remain for an MDA report, MDA may decide to deactivate data collection for this report.

#### 6.99.2.2 Potential requirements

**REQ-MDA\_SUB-1** The MDAS producer should have a capability to allow an MDAS consumer to subscribe to an analytics report. The subscription request should optionally allow the MDAS consumer to filter the scope of data in the analytics report.

**REQ-MDA\_SUB-2** The MDAS producer should have a capability to provide the analytics report to subscribed consumers.

**REQ-MDA\_SUB-3** The MDAS producer should have a capability to allow an MDAS consumer to unsubscribe to an analytics report.

#### 6.99.2.3 Possible solutions

Figure 6.99.2.3-1 shows a possible solution.

Figure 6.99.2.3-1: Management data analytics subscribe/unsubscribe

### 6.99.3 Request for Management Data Analytics Reports

#### 6.99.3.1 Use case

MDA may provide several management data analysis reports. A user may wish to receive one of these reports.

The user submits a request to MDAS to receive an MDA report. This request may include a filter to specify which subset of management data should be analysed.

MDA collects data, analyses the data, and sends an analysis report to the user.

#### 6.99.3.2 Potential requirements

**REQ-MDA\_REQ-1** The MDAS producer should have a capability to allow an MDAS consumer to request an analytics report. The request should optionally allow the MDAS consumer to filter the scope of data in the analytics report.

**REQ-MDA\_REQ-2** The MDAS producer should have a capability to provide the analytics report to the MDAS consumer.

#### 6.99.3.3 Possible solutions

Figure 6.99.3.3-1 shows a possible solution.

Figure 6.99.3.3-1: Network management data analytics request

## 6.99.4 Confidence indicator in analysis results

A consumer of MDAS should treat the results of Management Data Analytics with caution. A decision based on analytics should take into account the degree of confidence of the analysis result, especially in the case when multiple analysis results are based on different models or different source data.

Therefore it is proposed that the result of Management Data Analytics should contain an attribute which indicates the degree of confidence of the analysis.

NOTE: How to evaluate a degree of confidence and how it should be expressed as an attribute are not addressed in this study. More work is needed in this area.

# 7 Conclusions and recommendations

Annex <X> (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2019-09 | SA5#127 | n/a | - | - | - | Initial skeleton | 0.0.0 |
| 2019-10 | SA5#127 | S5-196752 | - | - | - | pCR Add skeleton of draft TR 28.809 | 0.1.0 |
| 2019-10 | SA5#127 | S5-196812 | - | - | - | pCR Add overview for MDA | 0.1.0 |
| 2019-10 | SA5#127 | S5-196877 | - | - | - | pCR Add UC on coverage issue analysis | 0.1.0 |
| 2019-10 | SA5#127 | S5-196876 | - | - | - | pCR Add use case of MDAS assisted user data congestion analysis | 0.1.0 |
| 2019-12 | SA5#128 | S5-197807 | - | - | - | pCR on MDA role in management loop | 0.2.0 |
| 2019-12 | SA5#128 | S5-197710 | - | - | - | pCR on possible solution for coverage issue analysis | 0.2.0 |
| 2019-12 | SA5#128 | S5-197711 | - | - | - | pCR Add UC on resource utilization optimization | 0.2.0 |
| 2019-12 | SA5#128 | S5-197707 | - | - | - | pCR Update the overview descriptions of MDAS | 0.2.0 |
| 2019-12 | SA5#128 | S5-197709 | - | - | - | pCR on RAN user plane congestion | 0.2.0 |
| 2019-12 | SA5#128 | S5-197714 | - | - | - | pCR on E2E latency analysis as one of the SLS assurance related issues | 0.2.0 |
| 2019-12 | SA5#128 | S5-197808 | - | - | - | pCR on alarm incident analysis as one of the fault management related issues | 0.2.0 |
| 2019-12 | SA5#128 | S5-197809 | - | - | - | pCR Add UC on handover optimization | 0.2.0 |
| 2019-12 | SA5#128 | S5-197810 | - | - | - | pCR Add UC on MDA assisted energy saving | 0.2.0 |
| 2019-12 | SA5#128 | S5-197832 | - | - | - | pCR Add management interaction with NWDAF | 0.2.0 |
| 2020-03 | SA5#129e | S5-201315 | - | - | - | pCR Use case and potential solutions of MDA assisted EE | 0.3.0 |
| 2020-03 | SA5#129e | S5-201491 | - | - | - | pCR Add gNB as the consumer of MDAS | 0.3.0 |
| 2020-03 | SA5#129e | S5-201492 | - | - | - | pCR Add the use cases related to SLA assurance | 0.3.0 |
| 2020-03 | SA5#129e | S5-201327 | - | - | - | pCR Addition of resource utilization analysis solution | 0.3.0 |
| 2020-06 | SA5#131e | S5-203441 | - | - | - | pCR on MDA process | 0.4.0 |
| 2020-06 | SA5#131e | S5-203442 | - | - | - | pCR Add UC on MDA process training | 0.4.0 |
| 2020-06 | SA5#131e | S5-203443 | - | - | - | Clarify fault management use case | 0.4.0 |
| 2020-06 | SA5#131e | S5-203453 | - | - | - | Enhancing the Handover optimization use case in subclause 6.5 | 0.4.0 |
| 2020-06 | SA5#131e | S5-203206 | - | - | - | pCR solution for handover optimizaion | 0.4.0 |
| 2020-06 | SA5#131e | S5-203444 | - | - | - | Add use case and potential solutions of network slice throughput analysis | 0.4.0 |
| 2020-06 | SA5#131e | S5-203237 | - | - | - | Add use cases of UE uplink/downlink throughput analysis | 0.4.0 |
| 2020-06 | SA5#131e | S5-203148 | - | - | - | Update resource utilization use case | 0.4.0 |
| 2020-06 | SA5#131e | S5-203208 | - | - | - | pCR use case for paging optimization | 0.4.0 |
| 2020-06 | SA5#131e | S5-203209 | - | - | - | pCR use case RAN Node software upgrade | 0.4.0 |
| 2020-06 | SA5#131e | S5-203446 | - | - | - | pCR addition of network slice load analysis requirements and solution | 0.4.0 |
| 2020-06 | SA5#131e | S5-203447 | - | - | - | Add use case and potential solutions of cross-slice resource optimization analysis | 0.4.0 |
| 2020-06 | SA5#131e | S5-203448 | - | - | - | pCR Add UC on MDA assisted SON coordination | 0.4.0 |
| 2020-06 | SA5#131e | S5-203449 | - | - | - | New use case on Inter-gNB Beam Selection Optimization | 0.4.0 |
| 2020-06 | SA5#131e | S5-203450 | - | - | - | Add the use case for NAS level congestion control optimization | 0.4.0 |
| 2020-06 | SA5#131e | S5-203451 | - | - | - | Add use case and potential solutions of KPI anomaly analysis | 0.4.0 |
| 2020-06 | SA5#131e | S5-203445 | - | - | - | Modification of the resource utilization analysis use case | 0.4.0 |
| 2020-06 | SA5#131e | S5-203452 | - | - | - | Add use case of jitter analysis | 0.4.0 |
| 2020-08 | SA5#132e | S5-204559 | - | - | - | pCR Add solution on MDA assisted SON coordination | 0.5.0 |
| 2020-08 | SA5#132e | S5-204560 | - | - | - | pCR 28.809 Add load balancing optimization use case | 0.5.0 |
| 2020-08 | SA5#132e | S5-204561 | - | - | - | pCR 28.809 Add use case and potential requirements of mobility performance analysis | 0.5.0 |
| 2020-08 | SA5#132e | S5-204562 | - | - | - | Update of inter-gNB beam handover use case solution | 0.5.0 |
| 2020-08 | SA5#132e | S5-204563 | - | - | - | Update of Handover use case solution | 0.5.0 |
| 2020-08 | SA5#132e | S5-204564 | - | - | - | Update of Handover use case and solution considering user-trajectory info | 0.5.0 |
| 2020-08 | SA5#132e | S5-204565 | - | - | - | pCR 28.809 Update use case and potential solutions of resource utilization analysis | 0.5.0 |
| 2020-08 | SA5#132e | S5-204566 | - | - | - | pCR TR 28.809 Further clarifications relating to network resource allocation | 0.5.0 |
| 2020-08 | SA5#132e | S5-204567 | - | - | - | Update of KPI anomaly analysis use case and solution | 0.5.0 |
| 2020-08 | SA5#132e | S5-204568 | - | - | - | pCR Rel 17 Add description for analytics report | 0.5.0 |
| 2020-08 | SA5#132e | S5-204569 | - | - | - | pCR 28.809 Add Subscription to Management Data Analytics Reports | 0.5.0 |
| 2020-08 | SA5#132e | S5-204249 | - | - | - | pCR 28.809 Add Request for Management Data Analytics Reports | 0.5.0 |
| 2020-08 | SA5#132e | S5-[204247](http://www.3gpp.org/ftp/TSG_SA/WG5_TM/TSGS5_132e/Docs/S5-204247.zip) | - | - | - | pCR 28.809 Editorial improvements | 0.5.0 |
| 2020-08 | SA5#132e | S5-204570 | - | - | - | pCR 28.809 Add missing abbreviations | 0.5.0 |
| 2020-08 | SA5#132e | S5-204571 | - | - | - | pCR 28.809 Use case and potential solutions of fault prediction analysis | 0.5.0 |
| 2020-08 | SA5#132e | S5-204254 | - | - | - | pCR 28.809 updating fault analysis use case | 0.5.0 |
| 2020-08 | SA5#132e | S5-204572 | - | - | - | pCR 28.809 updating E2E latency analysis use case | 0.5.0 |
| 2020-08 | SA5#132e | S5-204573 | - | - | - | pCR 28.809 updating network slice throughput analysis use case | 0.5.0 |
| 2020-08 | SA5#132e | S5-204574 | - | - | - | pCR 28.809 Update use case and potential requirements of network slice load analysis | 0.5.0 |
| 2020-08 | SA5#132e | S5-204575 | - | - | - | pCR 28.809 Solution for Paging Optimization | 0.5.0 |
| 2020-08 | SA5#132e | S5-204576 | - | - | - | pCR 28.809 solution for RAN Node software upgrade | 0.5.0 |
| 2020-08 | SA5#132e | S5-204577 | - | - | - | pCR 28.809 MDAS Analysis confidence levels | 0.5.0 |
| 2020-08 | SA5#132e | S5-204578 | - | - | - | pCR 28.809 Add overview of MDA functionality | 0.5.0 |
| 2020-08 | SA5#132e | S5-204251 | - | - | - | pCR 28.809 Add possible solution for NAS congestion control | 0.5.0 |
| 2020-08 | SA5#132e | S5-204579 | - | - | - | pCR 28.809 Add the potential requirements and solutions for service experience related analysis | 0.5.0 |
| 2020-08 | SA5#132e | S5-204580 | - | - | - | Security risk assessment analytics use case | 0.5.0 |
| 2020-08 | SA5#132e | S5-204581 | - | - | - | MDAS assisted network slice traffic projections | 0.5.0 |
| 2020-08 | SA5#132e | S5-204587 | - | - | - | Add potential solutions for the MDA assisted energy saving analysis | 0.5.0 |
| 2020-08 | SA5#132e | S5-204505 | - | - | - | pCR 28.809 Add CN related KPI anomaly analysis | 0.5.0 |
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