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Foreword

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

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

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- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
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In the present document, certain modal verbs have the following meanings:

shall indicates a mandatory requirement to do something

shall not indicates an interdiction (prohibition) to do something

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

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

should indicates a recommendation to do something

should not indicates a recommendation not to do something

may indicates permission to do something

need not indicates permission not to do something

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

can indicates that something is possible

cannot indicates that something is impossible

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

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

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

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

In addition:

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

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

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

1 Scope

The present document specifies use cases, requirements and procedures for management capabilities of 5G networks.

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 28.532: "Management and orchestration; Generic management services".
- [3] 3GPP TS 28.533: " Management and orchestration; Architecture framework".
- [4] 3GPP TS 28.552: "Management and orchestration; 5G performance measurements".
- [5] 3GPP TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)".
- [6] 3GPP TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management".
- [7] 3GPP TS 32.404: "Telecommunication management; Performance Management (PM); Performance measurements; Definitions and template".
- [8] 3GPP TS 32.423: "Telecommunication management; Subscriber and equipment trace: Trace data definition and management".
- [9] 3GPP TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS) ".
- [10] 3GPP TS 28.623: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions".
- [11] 3GPP TS 28.111: "Management and orchestration; Fault Management (FM)".

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].

Trace metrics: This term is defined in TS 32.422 [6].

3.2 Symbols

Void.

3.3 Abbreviations

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

MnS Management Service

4 Heartbeat

4.1 Overview

The communication between Management Service (MnS) producers and MnS consumers shall be monitored, and communication link breaks between them shall be discovered by MnS consumers as early as possible. The behaviour of the MnS consumers, after detection of communication failure, is outside the scope of the present document.

4.2 Specification level requirements

4.2.1 Use cases

4.2.1.1 Configuring heartbeat notification periodicity

Use case stage	Evolution/Specification	<<Uses>> Related use
Goal	To configure the periodicity at which the management service producer shall emit heartbeat notifications to its authorized management service consumer.	
Actors and Roles	An authorized consumer of the management service.	
Telecom resources	The management service producer.	
Assumptions	N/A	
Pre-conditions	The periodicity requested by the management service consumer has a valid value.	
Begins when	The management service consumer sends a request to the management service producer to set the periodicity at which it shall emit heartbeat notifications.	
Step 1	The management service producer receives the request and sets its internal countdown timer to a value (which can be zero) equal to the periodicity requested by the management service consumer.	
Step 2	The management service producer sends a heartbeat notification to all authorized management service consumer(s), provided they previously subscribed to heartbeat notifications.	
Ends when	All the steps identified above are successfully completed.	
Exceptions	One of the steps identified above fails.	
Post-conditions	The notification periodicity has been configured according to the management service consumer request. A heartbeat notification is sent out to all authorized management service consumer(s).	
Traceability	REQ-HB-CTRL-2.	

4.2.1.2 Requesting immediate heartbeat notification

Use case stage	Evolution/Specification	<<Uses>> Related use
Goal	To trigger the emission of an immediate heartbeat notification by the management service producer.	
Actors and Roles	An authorized consumer of the management service.	
Telecom resources	The management service producer.	
Assumptions	N/A	
Pre-conditions	N/A	
Begins when	The soliciting management service consumer sends a request to the management service producer to emit immediately a heartbeat notification.	
Step 1	The management service producer receives the request and sends immediately a heartbeat notification to all authorized management service consumer(s) who had previously subscribed to heartbeat notifications. The management service producer countdown timer is not impacted.	
Ends when	All the steps identified above are successfully completed.	
Exceptions	One of the steps identified above fails.	
Post-conditions	The immediate heartbeat notification has been emitted according to the soliciting management service consumer request.	
Traceability	REQ-HB-CTRL-3, REQ-HB-NOTIF-2.	

4.2.1.3 Emitting periodic heartbeat notifications

Use case stage	Evolution/Specification	<<Uses>> Related use
Goal	To send periodic heartbeat notifications at the periodicity requested by the management service consumer.	
Actors and Roles	An authorized producer of the management service.	
Telecom resources	The management service consumer.	
Assumptions	The heartbeat notification periodicity has been configured according to the management service consumer request.	Configuring heartbeat notification periodicity
Pre-conditions	N/A	
Begins when	The internal countdown timer managed by the management service producer has reached the value 0.	
Step 1	The management service producer sends a heartbeat notification to all authorized management service consumer(s), provided they previously subscribed to heartbeat notifications.	
Step 2	The management service producer resets its internal countdown timer to the value of the heartbeat notification periodicity.	Configuring heartbeat notification periodicity
Ends when	All the steps identified above are successfully completed.	
Exceptions	One of the steps identified above fails.	
Post-conditions	The periodic heartbeat notification has been emitted to all authorized management service consumer(s) at the requested periodicity.	
Traceability	REQ-HB-NOTIF-1.	

4.2.2 Requirements

4.2.2.1 Requirements for controlling heartbeat

REQ-HB-CTRL-1: The management service producer shall have the capability to allow its authorized consumer to read the heartbeat period.

REQ-HB-CTRL-2: The management service producer shall have the capability to allow its authorized consumer to set the heartbeat period.

REQ-HB-CTRL-3: The management service producer shall have the capability to allow its authorized consumer to request the emission of an immediate heartbeat notification.

4.2.2.2 Requirements for notifying heartbeat

REQ-HB-NOTIF-1: The management service producer shall have the capability to send periodic heartbeat notifications to its authorized consumer at the frequency specified by the management service consumer.

REQ-HB-NOTIF-2: The management service producer shall have the capability to send immediate heartbeat notifications to its authorized consumer, upon request from the management service consumer.

4.3 Procedures for heartbeat

4.3.0 Procedure for subscribing to heartbeat notification

Figure 4.3.0-1 illustrates the procedure for subscribing to heartbeat notifications using operations and notifications of the provisioning MnS (see clause 11.1.1 of [2]). The HeartBeatControl instance is name contained by NtfSubscriptionControl instance, which includes attribute “notificationRecipientAddress” represent the address of Notification Receiver. The Notification Receiver can be the same entity as MnS consumer or different entity. Whenever the HeratbeatPeriodValue is set or modified, the MnS producer reinitialize its internal countdown timer and starts sending notifyHeartbeat notification with the specified period.

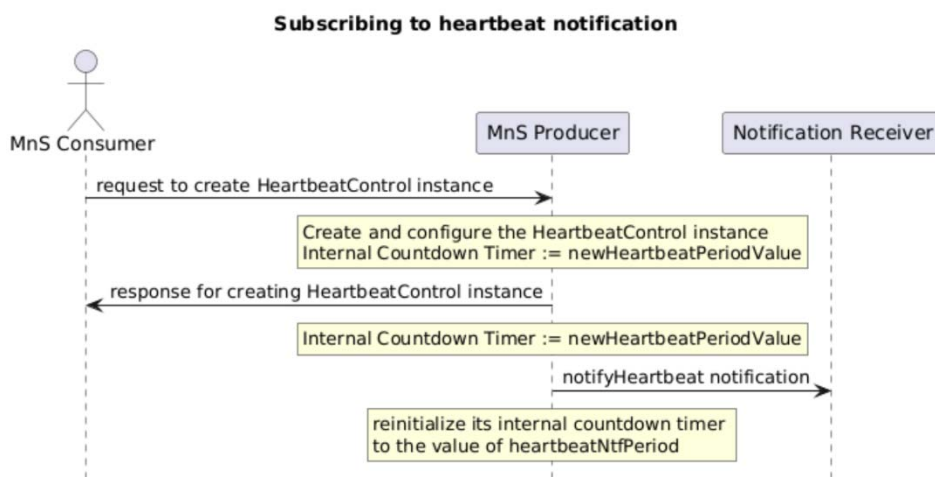


Figure 4.3.0-1: Procedure for subscribing to heartbeat notification

4.3.1 Void

4.3.2 Procedure for requesting immediate heartbeat notification

Figure 4.3.2-1 illustrates the procedure for requesting immediate heartbeat notification using operations and notifications of the provisioning MnS (see clause 11.1.1 of [2]).

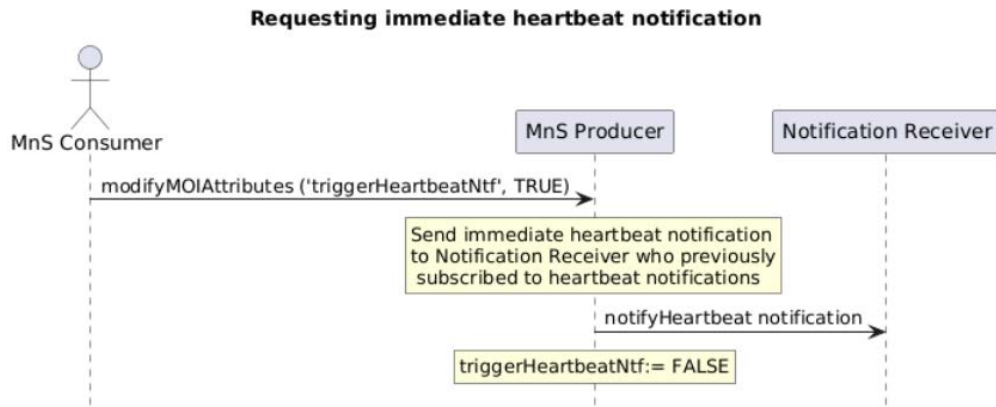


Figure 4.3.2-1: Procedure for requesting immediate heartbeat notification

4.3.3 Void

4.4 Solutions

4.4.1 Stage 2 definition

Following are the stage 2 definitions for controlling heartbeat:

- The operations and notifications of generic provisioning MnS defined in clause 11.1 in TS 28.532 [2].
- The Heartbeat notification control NRM fragment defined in clause 4.3.21 and clause 4.3.22 in TS 28.622 [9].

Following are the stage 2 definition for notifying heartbeat

- The Heartbeat notification defined in clause 11.4 in TS 28.532 [2].

4.4.2 Stage 3 definition

Following are the stage 3 definition for controlling heartbeat

- RESTful HTTP-based solution set
 - RESTful HTTP-based solution set for generic provisioning management service is defined in clause 12.1.1 in TS 28.532 [2]. Corresponding OpenAPI document "TS28532_ProvMnS.yaml" in clause A.1 in TS 28.532 [2].
 - OpenAPI document "TS28623_SubscriptionControlNrm.yaml" in clause 4.3 in TS 28.623 [10].
- YANG/Netconf-based solution set
 - YANG/Netconf-based solution set for generic provisioning management service is defined in clause 12.1.3 in TS 28.532 [2].
 - YANG model "_3gpp-common-subscription-control.yang" in clause 4.4. in TS 28.623 [10].

Following are the stage 3 definition for notifying heartbeat

- RESTful HTTP-based solution set for heartbeat notification is defined in clause 12.1.1 in TS 28.532 [2].
- OpenAPI document " TS28532_HeartbeatNtf.yaml " in clause A.5 in TS 28.532 [2].

5 Discovery of Management Services

5.1 Overview

To enable communication between MnS Consumers and MnS Producers, MnS Consumers need mechanisms to discover management service information available in the 3GPP management system, and their management capabilities. To this end, MnS Producers and their management capabilities need to be exposed in the 3GPP management system.

From management service perspective the following information can be exposed:

- Identifying data describing an MnS, e.g. name, version, type
- Capabilities of an MnS, e.g. supported operations, supported notifications

From MnS Consumer perspective such information can be used for different purposes, including:

- MnS Producer discovery: allows MnS Consumer to discover identifying information about an MnS Producer instance. In short, allows MnS Consumer to know which MnS Producers instances are exposed.
- MnS Producer Capabilities retrieval: allows MnS Consumer to retrieve capability information about an MnS Producer instance. In short, allows MnS Consumer to know what an MnS Producer instance is capable of.

In case an exposed MnS Producer instance's information changes the 3GPP management system needs to be updated.

MnS Consumers wishing to discover MnS Producer instances might have different questions. For example, an MnS Consumer may wish to know which MnS Producers manage a certain geographical area or civic location. Or, after receiving an alarm notification specifying that a specific NF is alarmed, they may wish to know the MnS Producers from which they can request management data from that NF or to retrieve the configuration of that NF.

5.2 Specification level requirements

5.2.1 Use cases

5.2.1.1 Adding a new management service producer to MnS registry

Use case stage	Evolution/Specification	<<Uses>> Related use
Goal	Add a MnS producer to a 3GPP management system.	
Actors and Roles	MnS Producer, MnS Registry	
Telecom resources	MnS producer. MnS discovery service producer.	
Assumptions	MnS producer is ready to be added to MnS registry.	
Pre-conditions	The MnS Producer is available.	
Begins when	There is a need for a MnS producer to be exposed via MnS registry.	
Step 1 (M)	The MnS producer is added to the MnS registry.	
Ends when	All the steps identified above are successfully completed.	
Exceptions	One of the mandatory steps fails.	
Post-conditions	MnS discovery service producer has stored the MnS information.	
Traceability	REQ-DMS-1	

5.2.1.2 Removing a management service producer from MnS registry

Use case stage	Evolution/Specification	<<Uses>> Related use
Goal	Remove a MnS producer from MnS registry..	
Actors and Roles	Network operator.	
Telecom resources	MnS producer.	
Assumptions	-	
Pre-conditions	The management service producer is no longer required in the MnS registry.	
Begins when	The management service is ready to be removed from MnS Registry.	
Step 1 (M)	The management service producer is removed from the MnS Registry.	
Ends when	All the steps identified above are successfully completed.	
Exceptions	One of the mandatory steps fails.	
Post-conditions	MnS discovery service producer has removed the MnS information related to the MnS Producer.	
Traceability	REQ-DMS-1	

5.2.1.3 MnS Consumer retrieves management service information from MnS registry

Use case stage	Evolution/Specification	<<Uses>> Related use
Goal	MnS consumer retrieves information from MnS registry.	
Actors and Roles	MnS Consumer	
Telecom resources	MnS registry	
Assumptions	MnS consumer is authorized to obtain the MnS information for the available management service(s) from MnS discovery service producer.	
Pre-conditions	MnS information exists in MnS registry.	
Begins when	MnS Consumer needs to access a specific MnS Producer(s).	
Step 1 (M)	MnS Consumer queries MnS Registry with filter criteria based on the management service(s) of interest.	
Step 2 (M)	MnS Consumer receives response with MnS Info for the management service(s) which match the criteria.	
Ends when	All the steps identified above are successfully completed.	
Exceptions	One of the mandatory steps fails.	
Post-conditions	MnS Consumer has basic information about the management service(s).	
Traceability	REQ-DMS-2, REQ-DMS-3, REQ-DMS-4, REQ-DMS-5	

NOTE: MnS information refer to the information used by the consumer to discover the producers of specific Management Services and to derive the addresses of the Management Service.

5.2.1.4 Providing detailed capabilities about management service

Use case stage	Evolution/Specification	<<Uses>> Related use
Goal	Management service detailed capabilities are exposed.	
Actors and Roles		
Telecom resources	-	
Assumptions	Management service detailed capabilities are available.	
Pre-conditions	Management service detailed capabilities are ready to be exposed.	
Begins when	MnS Producer wants to expose its detailed capabilities.	
Step 1 (M)	Management service detailed capabilities are exposed by MnS Producer.	
Post-conditions	Management services detailed capabilities have been exposed.	
Traceability		

5.2.1.5 MnS Consumer retrieves detailed capabilities about management service

Use case stage	Evolution/Specification	<<Uses>> Related use
Goal	MnS Consumer retrieves detailed capabilities for specific MnS Producer(s).	
Actors and Roles	MnS Consumer	
Telecom resources	-	
Assumptions	Management service has ability to expose its detailed capabilities.	
Pre-conditions	Authorized MnS Consumer knows location and method to retrieve detailed capabilities.	
Begins when	MnS Consumer requires to retrieve detailed capabilities of specific MnS Producer(s).	
Step 1 (M)	MnS Consumer reads detailed capabilities from MnS Producer of interest.	
Post-conditions	MnS Consumer has retrieved detailed capabilities of specific MnS Producer(s).	
Traceability		

5.2.2 Requirements

REQ-DMS-1: The 3GPP management system shall provide capabilities allowing MnS producers to register their management capabilities (including the endpoint address) at MnS discovery service producer for use by MnS consumers wishing to interact with these MnS producers.

REQ-DMS-2: The 3GPP management system shall provide capabilities allowing MnS consumers to retrieve the management capabilities registered at MnS discovery service producer by MnS producers.

REQ-DMS-3: The 3GPP management system shall provide capabilities allowing to discover MnS producers that are managing a specified managed entity.

REQ-DMS-4: The 3GPP management system shall provide capabilities allowing to discover the managed entities a MnS producer is responsible for.

REQ-DMS-5: The 3GPP management system shall provide capabilities allowing MnS consumers to retrieve the area information (geographical area or TAI) of the MnS instances.

REQ-DMS-6: The 3GPP management system shall provide capabilities allowing MnS producers to publish their MnS version in the MnS Registry.

5.2.3 Solutions

5.2.3.0 Overview

5.2.3.0.1 Introduction

The solution for Discovery of Management Services is based on the model driven approach. MnSRegistry NRM is configured by operators to control the behaviour of the management service discovery. Following are the functionalities for discovery of management services:

- Registration of Management Services
- Discovery of Management Services

5.2.3.0.2 Registration of Management Services

The Registration of Management Services functionalities allow a MnF to register MnS Information (i.e. MnSInfo) for a specific MnS instance that it produces to MnS Registry. When successful registration of an MnS instance, corresponding MnS information is stored in the MnS Registry and available for discovery by other authorized entities (as MnS consumer). Following are the list of concrete functionalities for Registration of Management Services:

- Register a new MnS instance

- Update a registered MnS instance
- Query a registered MnS instance
- Deregister a MnS instance

5.2.3.0.3 Discovery of Management Services

The Discovery of Management Services functionalities allow MnS consumer to retrieve MnS information on available MnS instances in the MnS Registry based on selection filter. MnSRegistry will verify the received MnS discovery request based on configured access control rules, and provide the MnS information of the available MnS instances based on selection filter. Following are the list of concrete functionalities for Discovery of Management Services:

- Query available MnS instances
- Subscribe/Unsubscribe changes on available MnS instances
- Notify changes on available MnS instances

5.2.3.1 Stage 2 definition

Following are the stage 2 definition for Discovery of Management Services:

- The operations and notifications of generic provisioning MnS defined in clause 11.1 in TS 28.532 [2].
- The MnSRegistry NRM fragment defined in clause 4.3.41 and clause 4.3.42 in TS 28.622 [9].

5.2.3.2 Stage 3 definition

Following are the stage 3 definition for Discovery of Management Services:

- RESTful HTTP-based solution set
 - RESTful HTTP-based solution set for generic provisioning management service is defined in clause 12.1.1 in TS 28.532 [2]. OpenAPI document "TS28532_ProvMnS.yaml" in clause A.1 in TS 28.532 [2].
 - OpenAPI document "TS28623_MnSRegistryNrm.yaml" in clause 4.3 in TS 28.623 [10].

Following are the detailed SS to support Registration and Discovery of Management Services based on Table 12.1.1.1.1-1 and Table 12.1.1.2.1-1 in TS 28.532 [2].

	Functionality	IS operations	HTTP Method	Resource URI
Registration of Management Services	Register a new MnS instance	createMOI operation	POST	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/MnsRegistry
	Update a registered MnS instance	modifyMOIAttributes operation	PUT PATCH	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/MnsRegistry/MnsInfo={id}
	Query a registered MnS instance	getMOIAttributes operation	GET	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/MnsRegistry/MnsInfo={id}
	Deregister a MnS instance	deleteMOI operation	DELETE	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/MnsRegistry/MnsInfo={id}
Discovery of Management Services	Query available MnS instances	getMOIAttributes operation	GET	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/MnsRegistry
	Subscribe changes on available MnS instances	createMOI operation	POST	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}
	Unsubscribe changes on available MnS instances	deleteMOI operation	DELETE	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/NtfSubscriptionControl={id}
	Notify changes on available MnS instances	notifyMOIAttributeValue Changes notification	POST	{notificationTarget}

Note: The MnSRegistry and MnSInfo resources are defined in "TS28623_MnSRegistryNrm.yaml", the NtfSubscriptionControl resource is defined in "TS28623_SubscriptionControlNrm.yaml".

- YANG/Netconf-based solution set

- YANG/Netconf-based solution set for generic provisioning management service is defined in clause 12.1.3 in 3GPP TS 28.532 [2].

- YANG model "3gpp-common-mnsregistry.yang" in clause 4.4 TS 28.623 [10].

5.3 Usage of MnS Registry for different deployment scenarios

Following are potential deployment scenarios for MnS Registry (i.e. act as discover MnS producer):

- Deployment scenario #1: Separate MnSRegistry. The MnS Registry and a concrete MnS producer are separate entities with a published interface between them. In this scenario, the MnS Registry is used to store the MnS information (i.e. MnSInfo) for MnS instances and management capability information for management data (i.e. MgmtDataInfo) provided by different MnFs, especially for different MnFs from different vendors. Following is one example, MnF_1 needs to register MnSInfo_1 and MgmtDataInfo_1 in the MnS Registry implemented in MnF_3, and MnF_2 needs to discover/retrieve the MnSInfo_1 and MgmtDataInfo_1 from MnF_3 to consume MnS_1 provided by MnF_1. In this scenario, MnS Registry needs to support both registry and discovery/retrieve capabilities.

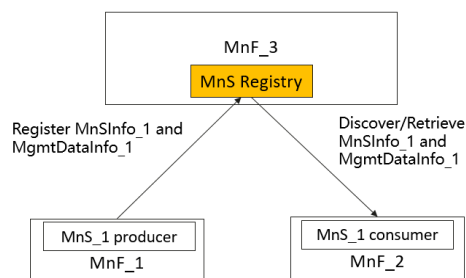


Figure 5.3-1 Example of Separate MnSRegistry deployment scenario

- Deployment scenario #2: Embedded MnSRegistry. The MnSRegistry and a concrete MnS producer are hosted by the same entity with an implementation specific interface between them. The MnS Registry is implemented in an MnF and used to store the MnS Information (i.e. MnSInfo) for MnS instances and management capability information for

management data (i.e. MgmtDataInfo) provided by the MnF itself. Following is one example, MnF_3 needs to retrieve/discover MnSInfo_1 and MgmtDataInfo_1 in the MnSRegistry implemented in MnF_1. In this scenario, MnS Registry supports discovery/retrieve capabilities only.

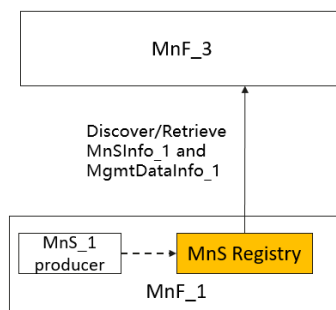


Figure 5.3-2 Example of Embedded MnSRegistry deployment scenario

5.4 MnS version publication

The MnS version is published in the MnS Registry NRM fragment [32] in support of MnS Discovery as defined in this specification.

6 Managing management data

6.1 Producing and reporting management data

6.1.1 Description

Management data is referring to data produced by radio access network functions, core network functions or management functions and used for management purposes. Management data specified by 3GPP for 5G management is classified into 5G performance measurements as defined by TS 28.552 [4], 5G end to end key performance indicators as defined by TS 28.554 [5] and Trace metrics as defined by TS 32.422 [6]. The combined performance measurements and key performance indicators are also called performance metrics.

Management data is produced on request. Therefore, the 3GPP management system needs to enable a data consumer to request management data to be produced. The data requester needs to specify the type of data to be produced as well as the radio access network functions, core network functions and management functions where the data shall be produced. The target managed object instances can be identified in multiple ways:

- The requester can specify the target managed object instances based on the managed object tree (as defined in the 3GPP Network Resource Models) representing the network and management functions. The simplest approach is to directly identify the managed object instances where data shall be produced. More sophisticated approaches allow to specify one or more subtrees where data shall be produced and may allow also to specify managed object classes to select only object instances of specific classes.
- The requester can specify one or multiple of the following selection criteria. The system needs to translate this information into the target managed object instances. The selection criteria need to be deterministic in such a way that the target node(s) can be selected unambiguously.
- Area of interest: In a big network, it makes sense to specify a limited area for which data shall be produced. The area of interest can be expressed for example with a geographical area, one or several cells or one or several tracking areas. The target managed object instances represent network functions serving that area of interest. Geographical areas can be expressed for example with multiple longitude-latitude pairs that define a convex polygon. In the radio domain the geographical area needs to be mapped to the coverage area of cells supported by RAN NE(s). The managed object instances (e.g. NRCellCU, GNBDFunction) providing service to these

cells can be identified as target managed object instances. Of course, the coverage area of the target cell(s) will usually not exactly map to the described shape of the geographical area because, on the one side, the coverage area of cell has no sharp borders due to fast fading effects, on the other side, the coverage area of cells may vary slightly e.g. due to adaptation of the antenna downtilt angle or beamforming configurations. For the mapping between the geographical area and the corresponding managed object instances the cell coverage status at the time of the request shall be used. Later changes affecting the cell coverage shall not be reflected for the mapping.

- Domain e.g RAN, CN: A consumer might only be interested in analysing and understanding the performance of a particular domain like RAN or Core e.g in case of recurrent issues, a consumer may want to have understanding of a particular domain only for further actions. In such a scenario, it should be possible to indicate the domain from where consumer wants measurements for its usage.
- Traffic type e.g user plane or control plane: 5G brings clear separation (CUPS) of user plane and control plane in a network, a consumer may leverage it to identify target managed object instances to have measurements from. For example, the measurement report may be expected from user plane nodes only.
- Slice type e.g eMBB, URLLC: Consumer may mention a particular slice type (eMBB, URLLC, mMTC, V2X, HMTTC) as the selection criteria. It may help in narrowing down the target managed object instances, which are part of provided slice type(s).

This MnS to request management data in a simple way shall not be exposed at any network function.

The management data can be requested according to a certain time scheduler. The consumer can e.g. specify a start and stop time or can request for data at specific days of a week or specific hours of a day.

The management data can be requested according to certain conditions, in this case, the management data shall be produced if corresponding conditions are satisfied. The consumer may specify different management data producing control parameters (e.g. producing period) in different management data requests, and each request related to a certain condition. For example, the condition may indicate a performance abnormal scenario when a performance metric crosses a specified threshold. Normally, if the condition is not satisfied, the management data may be produced in a higher period. However, in a performance abnormal scenario, the MnS producer may provide the management data more frequently to enable network optimization, such that it may report the management data produced before the anomaly with a lower period.

After production the data needs to be reported to the data consumers. Reporting can be based on multiple reporting methods such as file or streaming. Data reporting needs to be requested by the data consumer. The requestor needs to specify the control parameters for reporting such as the reporting method and the address the data shall be delivered to.

A data consumer which is unaware of specific managed objects (e.g. NRCellCU, NRCellDU), is able to obtain the management data without relying on the specific managed objects using area based KPIs (e.g. downlink weak coverage ratio or high DL PRB load ratio for the associated area). An area based KPI is a type of the management data which is not associated to specific managed objects. In this case, data requestor specifies the list of names or categories of the area based KPIs for the interested areas. Based on the request, data producer needs to report the area based KPIs to the data consumer. The area based KPIs can be associated with sub-areas of the interested areas.

Depending on access rights and security settings, data consumers may be subject to restrictions regarding the data they can access.

Data is always produced in some context. The data describing this context is called context data. Context data contains information on all interrelated conditions in which the management data is produced. This includes for example the configuration of the measured network functions, information on the network entity where the network function is running such as vendor name or software version, but also alarms associated to the network function or load conditions.

Data consumers processing management data in an effort to accomplish some task typically benefit when taking context data into account. For that reason, data consumers should be able to obtain the context data for the management data they obtain. However, access to certain management data does not automatically imply access to all context data. Access to management data and access to context data may be subject to different data security and data protection considerations.

6.1.2 Void

6.1.3 Requirements

REQ-MDM-PR-1: The 3GPP management system shall enable an authorized data consumer to request management data (specified by 3GPP) to be produced.

REQ-MDM-PR-2: The 3GPP management system shall enable an authorized data consumer to request management data specified by 3GPP to be produced by certain managed object instance(s) only. The selection criteria to determine the managed object instance(s) shall be deterministic in such a way that the target node(s) can be selected unambiguously. The managed object instances can be targeted based on:

- Area of interest (e.g. list of cells, list of tracking areas or geographical area).
- Domain (CN or RAN).
- User plane or control plane.
- Slice type (e.g. eMBB, URLLC, mMTC, V2X, HMTTC).

The MnS to request management data specified by 3GPP in a simple way shall not be exposed at any network function.

The mapping of geographical area to corresponding managed object instances reflects the cell coverage status at the time of the request.

REQ-MDM-PR-3: The 3GPP management system shall enable an authorized data consumer to request management data specified by 3GPP to be produced according to a certain time scheduler.

REQ-MDM-PR-4: The 3GPP management system shall enable an authorized data consumer to request management data (specified by 3GPP) to be reported to the requesting or another authorized data consumer.

REQ-MDM-PR-5: The 3GPP management system shall enable an authorized data consumer to obtain context data for management data. Access to management data does not imply access to context data. Different data privacy considerations may apply.

REQ-MDM-PR-6: The 3GPP management system shall support enabling an authorized data consumer to obtain management data which does not rely on specific managed objects.

REQ-MDM-PR-7: The 3GPP management system shall enable an authorized data consumer to request management data (specified by 3GPP) to be produced according to corresponding conditions.

NOTE: The term "management data specified by 3GPP" relates to

- 5G performance measurements as defined by TS 28.552 [4]
- 5G end to end key performance indicators as defined by TS 28.554 [5], and
- Trace metrics as defined by TS 32.422 [6].

6.1.4 Solutions

6.1.4.1 Stage 2 definition

Following are the stage 2 definition for producing and reporting management data.

- The operations and notifications of generic provisioning MnS defined in clause 11.1 in TS 28.532 [2].
- The ManagementDataCollection control NRM fragment defined in clause 4.3.47 in TS 28.622 [9].

6.1.4.2 Stage 3 definition

Following are the stage 3 definition for producing and reporting management data.

- RESTful HTTP-based solution set

- RESTful HTTP-based solution set for generic provisioning management service is defined in clause 12.1.1 in 3GPP TS 28.532 [2]. OpenAPI document "TS28532_ProvMnS.yaml" in clause A.1 in TS 28.532 [2].
- OpenAPI document " TS28623_ManagementDataCollectionNrm.yaml " in clause 4.3 in TS 28.623 [10].

Following are the detailed SS to support management data collection based on Table 12.1.1.1.1-1 and Table 12.1.1.2.1-1 in TS 28.532 [2].

Table 6.1.4.2-1: SS to support management data collection

	Functionality	IS operations	HTTP Method	Resource URI
Management Data Collection	Management data collection request	createMOI operation	POST	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/ManagementDataCollection
	Management data collection deletion	deleteMOI operation	DELETE	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/ManagementDataCollection={id}
	Management data collection status query	getMOIAttributes operation	GET	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/ManagementDataCollection={id}

Note: The ManagementDataCollection resource is defined in " TS28623_ManagementDataCollectionNrm.yaml ".

- YANG/Netconf-based solution set

- YANG/Netconf-based solution set for generic provisioning management service is defined in clause 12.1.3 in 3GPP TS 28.532 [2].

- YANG model "_3gpp-common-managementdatacollection.yang " in clause 4.4 in TS 28.623 [10].

6.2 Coordinating management data production

6.2.1 Description

Many consumers can request network or management functions to produce management data. In this context it is beneficial to coordinate data requests at the management level to optimize management data production.

6.2.2 Void

6.2.3 Requirements

REQ-MDM-C-1: The 3GPP management system shall coordinate requests from several data consumers to avoid producing multiple times the same data at a certain point of time.

NOTE: The definition of "same data" is not addressed in the current document.

6.3 Storing management data

6.3.1 Description

Storing management data enables reuse of management data for multiple management purposes.

For example, AI/ML models need input data collected over a certain period of time for training purposes. A specific set of collected data may serve different purposes and can therefore be input to multiple AI/ML services. For example, management data collected in a geographical area may be used also for another geographical area when the scenarios in the areas are statistically similar.

Another use case for storing produced data is related to the fact that multiple sets of training data from similar scenarios are typically required. For example, one set of data produced for the rush hour in a subway station on a single weekday is typically not enough for profiling. Many sets produced on many workdays are required.

Stored data is useful when management functions can discover which data has been produced and stored in the past to check if the currently needed data is already available.

6.3.2 Void

6.3.3 Requirements

REQ-MDM-S-1: The 3GPP management system shall support the storing of produced management data.

REQ-MDM-S-2: The 3GPP management system shall enable an authorized data consumer to discover stored management data.

REQ-MDM-S-3: The 3GPP management system shall enable an authorized data consumer to retrieve stored management data.

6.4 Managing external management data

6.4.1 Description

Management data which is specified by 3GPP (clause 6.1.1) can be enriched by additional data not specified by 3GPP. This so-called external management data can be produced by data sources of different nature (e.g. sensors) with different formats.

Note that management data that is not defined by 3GPP but specified based on 3GPP defined management data definition templates and frameworks (such as the measurement definition template in TS 32.404 [7]) is not considered as external management data.

External management data can be used for example as additional input for network optimization and prediction.

The management system should be able to manage this kind of data. That means data consumers should be able to request external management data to be produced and reported. The management system should provide support for storing it.

The definition of external data sources and the data formats they use is out of scope of this specification. This functionality is supported based on the assumption that the connection between the 3GPP external entities and 3GPP management system is set up enabling the 3GPP management system to obtain and store the external management data. The mechanism for setting up the connection between the 3GPP management system and external data sources and collection of the external management data is out of scope of this specification. This functionality focuses on the external management data discovery, request and delivery between MnS producer and MnS consumer. Following is an example to illustrate the framework for managing external management data.

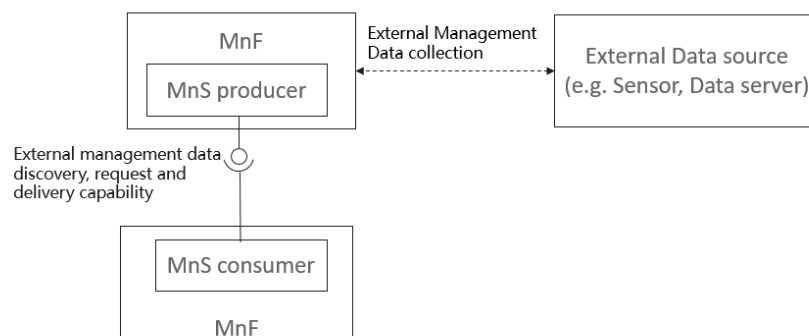


Figure 6.4.1-1 Example to illustrate the framework for managing external management data.

The present document defines generic management mechanisms for external management data discovery, request and delivery, which can cope with any kind of external data sources and data formats.

6.4.2 Void

6.4.3 Requirements

REQ-MDM-ED-1: Void.

REQ-MDM-ED-2: The 3GPP management system shall enable an authorized data consumer to request external management data to be reported to the requesting or another authorized data consumer.

REQ-MDM-ED-3: The 3GPP management system shall support the storing of produced external management data.

REQ-MDM-ED-4: The 3GPP management system shall enable an authorized data consumer to discover stored external management data.

REQ-MDM-ED-5: The 3GPP management system shall enable an authorized data consumer to retrieve stored external management data.

NOTE: The term "external management data" relates to data not specified by 3GPP.

6.4.4 Solutions

6.4.4.1 Stage 2 definition

Following are the stage 2 definition for management of external management data:

- The operations and notifications of generic provisioning MnS defined in clause 11.1 in TS 28.532 [2].
- The External data type NRM fragment (including ExternalDataType IOC) defined in clause 4.3.73 in TS 28.622 [9].

6.4.4.2 Stage 3 definition

Following are the stage 3 definition for managing external management data:

- RESTful HTTP-based solution set
 - RESTful HTTP-based solution set for generic provisioning management service is defined in clause 12.1.1 in TS 28.532 [2]. OpenAPI document "TS28532_ProvMnS.yaml" in clause A.1 in TS 28.532 [2].
 - OpenAPI document "TS28623_ExternalDataMgmtNrm.yaml" in clause 4.3 in TS 28.623 [10].

Following are the detailed SS to support managing external management data based on Table 12.1.1.1.1-1 and Table 12.1.1.2.1-1 in TS 28.532 [2].

Table 6.4.4.2-1 SS to support managing external management data

	Functionality	IS operations	HTTP Method	Resource URI
Discovery of external management data types	Query available external management data types	getMOIAttributes operation	GET	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/SubNetwork={id}
	Subscribe changes on available external management data types	createMOI operation	POST	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/SubNetwork={id}
	Unsubscribe changes on available external management data types	deleteMOI operation	DELETE	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/SubNetwork={id}/NtfSubscriptionControl={id}
	Notify changes on available external management data types	notifyMOIAttributeValueChanges notification	POST	{notificationTarget}
Request and retrieve external management data	Request external management data	getMOIAttributes operation	GET	MnSRoot}/ProvMnS/{MnSVersion}/SubNetwork={id}/{ExternalDataType}=id

Note: The ExternalDataType resource is defined in "TS28623_ExternalDataMgmtNrm.yaml", the NtfSubscriptionControl resource is defined in "TS28623_SubscriptionControlNrm.yaml".

6.5 Discovery of management data

6.5.1 Description

Discovery of management data mechanism allows MnS consumers to discover what management data can be produced by the 3GPP management system without direct involvement of those MnS services producing the data, which can be time and resource consuming process.

For this mechanism to work MnS producers as entities producing data, need to register what data they can produce by adding a corresponding record in the 3GPP management system. The MnS consumer needs to discover or retrieve what management data (represented by management data name) or what type of management data (represented by management data category) can be produced by MnS producer. In addition, the MnS consumer needs to know what reporting methods are supported for the specified management data.

NOTE: The term "management data produced by 3GPP management system" relates to

- 5G performance measurements as defined by TS 28.552 [4]
- 5G end to end key performance indicators as defined by TS 28.554 [5], and
- Trace metrics as defined by TS 32.422 [6].

6.5.2 Void

6.5.3 Requirements

REQ-MDM-DIS-1: The 3GPP management system shall enable an authorized data consumer to discover what management data can be produced by 3GPP management system.

REQ-MDM-DIS-2: The 3GPP management system shall enable an authorized data consumer to discover what category of management data can be produced by 3GPP management system.

REQ-MDM-DIS-3: The 3GPP management system shall enable an authorized data consumer to obtain the reporting methods that are supported for the management data which can be produced by 3GPP management system.

6.5.4 Solutions

6.5.4.1 Stage 2 definition

Following are the stage 2 definition for discovery of management data:

- The operations and notifications of generic provisioning MnS defined in clause 11.1 in TS 28.532 [2].
- The NRM fragments related to management data discovery (including MnsRegistry IOC, MgmtDataInfo IOC and MnsInfo) defined in clause 4.3.41, clause 4.3.42, and clause 4.3.75 in TS 28.622 [9].

6.5.4.2 Stage 3 definition

Following are the stage 3 definition for discovery of management data:

- RESTful HTTP-based solution set
- RESTful HTTP-based solution set for generic provisioning management service is defined in clause 12.1.1 in TS 28.532 [2]. OpenAPI document "TS28532_ProvMnS.yaml" in clause A.1 in TS 28.532 [2].
- OpenAPI document "TS28623_MnSRegistryNrm.yaml" in clause 4.3 in TS 28.623 [10].

Following are the detailed SS to support discovery of management data based on Table 12.1.1.1.1-1 and Table 12.1.1.1.2.1-1 in TS 28.532 [2].

Table 6.1.4.2-2: SS to support management data collection

	Functionality	IS operations	HTTP Method	Resource URI
Management Data Registration	Register the management capability information for a set of management data	createMOI operation	POST	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/MnsRegistry
	Update the management capability information for a set of management data	modifyMOIAttributes operation	PUT PATCH	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/MnsRegistry/MgmtDataInfo={id}
	Query a registered management capability information for a set of management data	getMOIAttributes operation	GET	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/MnsRegistry/MgmtDataInfo={id}
	Deregister the management capability information for a set of management data	deleteMOI operation	DELETE	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/MnsRegistry/MgmtDataInfo={id}
Management Data Discovery	Query available management capabilities for a set of management data	getMOIAttributes operation	GET	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/MnsRegistry
	Subscribe changes on available management capabilities for a set of management data	createMOI operation	POST	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}
	Unsubscribe changes on available management capabilities for a set of management data	deleteMOI operation	DELETE	{MnSRoot}/ProvMnS/{MnSVersion}/{URI-LDN-first-part}/NtfSubscriptionControl={id}
	Notify changes changes on available management capabilities for a set of management data	notifyMOIAttributeV alueChanges notification	POST	{notificationTarget}

Note: The MnSRegistry and MgmtDataInfo resources are defined in "TS28623_MnSRegistryNrm.yaml", the NtfSubscriptionControl resource is defined in "TS28623_SubscriptionControlNrm.yaml".

7 File management

7.1 File transfer

7.1.1 Description

File management deals with transferring files between MnS producers and MnS consumers.

Existing file transfer protocols are used. These protocols need to comply to requirements specified in this clause.

7.1.2 Void

7.1.3 Requirements

REQ-FM-G-1: The file transfer protocol shall preserve the formatting of the file during exchange.

REQ-FM-G-2: The file transfer protocol shall preserve the encoding of the file during exchange.

REQ-FM-G-3: The MnS producer shall support at least one of the following file transfer protocols: SFTP, FTPES, HTTPS.

REQ-FM-G-4: The MnS consumer shall use the file transfer protocol supported by the MnS producer.

7.2 File retrieval from a MnS producer by a MnS consumer

7.2.1 Description

File retrieval is when the MnS consumer retrieves (gets) a file from the MnS producer. Either the MnS consumer retrieves a file from the MnS producer because the MnS consumer receives a file ready notification from the MnS producer or the MnS consumer reads the list of available (ready) files on the MnS producer and decides to retrieve an available file.

7.2.2 Void

7.2.3 Requirements

REQ-FM-R-1: The MnS producer shall support the capability allowing a MnS consumer to retrieve (get) a file from the MnS producer.

REQ-FM-R-2: The MnS producer shall support the capability allowing a MnS consumer to retrieve the list of files available for transfer from the MnS producer.

REQ-FM-R-3: The MnS producer shall support the capability to inform a MnS consumer about files that are available for retrieval.

REQ-FM-R-4: The MnS producer shall support the capability to inform a MnS consumer about errors that occurred during the preparation of a file.

REQ-FM-R-5: The information transferred to a MnS consumer about an available file shall allow associating the file to the process on the MnS producer that generated the file, if any such process exists and has an identifier.

REQ-FM-R-6: The MnS producer shall support the capability allowing a MnS consumer to indicate to the MnS producer, that the MnS consumer does not need a file anymore, such that the MnS producer hides the file in responses to subsequent read requests or decide to delete it altogether.

7.2.4 Solutions

7.2.4.1 Stage 2 definition

Following are the stage 2 definition for File retrieval from a MnS producer by a MnS consumer.

- The operations and notifications of generic provisioning MnS defined in clause 11.1 in 3GPP TS 28.532 [2].
- The File retrieval NRM fragment defined in TS 28.622 [9].

7.2.4.1 Stage 3 definition

Following are the stage 3 definition for File retrieval from a MnS producer by a MnS consumer.

- RESTful HTTP-based solution set
 - RESTful HTTP-based solution set for generic provisioning management service is defined in clause 12.1.1 in 3GPP TS 28.532 [2]. Corresponding OpenAPI document "TS28532_ProvMnS.yaml" in clause A.1 in TS 28.532 [2].
 - OpenAPI document " TS28623_FileManagementNrm.yaml " in clause 4.3 in TS 28.623 [10].
- YANG/Netconf-based solution set
 - YANG/Netconf-based solution set for generic provisioning management service is defined in clause 12.1.3 in 3GPP TS 28.532 [2].
 - YANG model "_3gpp-common-files.yang " in clause 4.4 TS 28.623 [10].

7.3 File push from a MnS producer to a MnS consumer

7.3.1 Description

For file push, the MnS producer pushes a file to the MnS consumer or a designated file server. The MnS consumer configures the MnS Producer to push a file based on an event occurring on the MnS producer, such as the availability of a file.

7.3.2 Void

7.3.3 Requirements

REQ-FM-P-1: void

REQ-FM-P-2: void

REQ-FM-P-3: void

REQ-FM-P-4: The MnS producer shall support the capability to push a file to the MnS consumer or a designated file server when configured by a MnS consumer.

REQ-FM-P-5: The MnS producer shall support the capability for a MnS consumer to configure the MnS producer to push a file to the MnS consumer or a designated file server based on an event occurring on the MnS producer.

REQ-FM-P-6: The MnS producer shall support the capability to inform the MnS consumer, that has configured a file push, or any other MnS consumer about the completion of that file push.

7.4 File download from a MnS consumer to a MnS producer

7.4.1 Description

File download is when the MnS producer gets a file from the MnS consumer or a designated file server because the MnS consumer requests the MnS producer to download the file.

7.4.2 Void

7.4.3 Requirements

REQ-FM-D-1: The MnS producer shall support the capability to download a file from a MnS consumer or a designated file server when triggered by a MnS consumer.

REQ-FM-D-2: The MnS producer shall support the capability allowing a MnS consumer to trigger the MnS producer to download a file from the MnS consumer or a designated file server.

REQ-FM-D-3: The MnS producer shall support the capability to inform the MnS consumer that has triggered a file download, or any other consumer about the progress of that file download.

7.4.4 Solutions

7.4.4.1 Stage 2 definition

Following are the stage 2 definition for File download from a MnS consumer to a MnS producer.

- The operations and notifications of generic provisioning MnS defined in clause 11.1 in 3GPP TS 28.532 [2].
- The File download NRM fragment defined in clause 4.3.46 in TS 28.622 [9].

7.4.4.2 Stage 3 definition

Following are the stage 3 definition for File download from a MnS consumer to a MnS producer.

- RESTful HTTP-based solution set
 - RESTful HTTP-based solution set for generic provisioning management service is defined in clause 12.1.1 in 3GPP TS 28.532 [2]. Corresponding OpenAPI document "TS28532_ProvMnS.yaml" in clause A.1 in TS 28.532 [2].
 - OpenAPI document " TS28623_FileManagementNrm.yaml " in clause 4.3 in TS 28.623 [10].
- YANG/Netconf-based solution set
 - YANG/Netconf-based solution set for generic provisioning management service is defined in clause 12.1.3 in 3GPP TS 28.532 [2].
 - YANG model "_3gpp-common-filemanagement.yang" in clause 4.4 in TS 28.623 [10].

8 Notification support

8.1 Overview

Management functionality requires the ability for the MnS producer to send unsolicited information messages – notifications - to the MnS consumer. Notifications are needed for many areas of management including fault management, performance management, configuration management etc. The MnS consumer shall control the sending

and reception of notifications by subscribing to notifications. The subscription may include filters to select specific types of notifications or notifications carrying specific data.

The "reliable notification transfer" feature ensures that missing information in notifications that:

- could not be prepared by the MnS producer,
- that are lost in transmission or
- temporarily could not be received by the consumer
- can be detected to be missing and can be recovered.

8.2 Requirements

8.2.1 General notification requirements

REQ-NOTIF-1: The management service producer shall have the capability to send unsolicited information messages – notifications - to the MnS consumer.

REQ-NOTIF-2: The management service producer shall provide the capability for the MnS consumer to subscribe to notifications. If, and only if, MnS consumer subscribes to notifications, the MnS producer shall send subscribed notifications to the consumer.

REQ-NOTIF-3: Filters based on notification type and notification content should be available in the subscription.

8.2.2 Requirements for reliable notification transfer

REQ-REL-NOTIF-1: Producer shall provide a mechanism for the consumer that allows it to discover missing or out-of-order notifications.

REQ- REL-NOTIF-2: Producer shall store all generated notifications up to an implementation specific limit.

REQ-REL-NOTIF-3: Producer shall provide a mechanism for the consumer that allows it to retrieve the stored notifications from the producer.

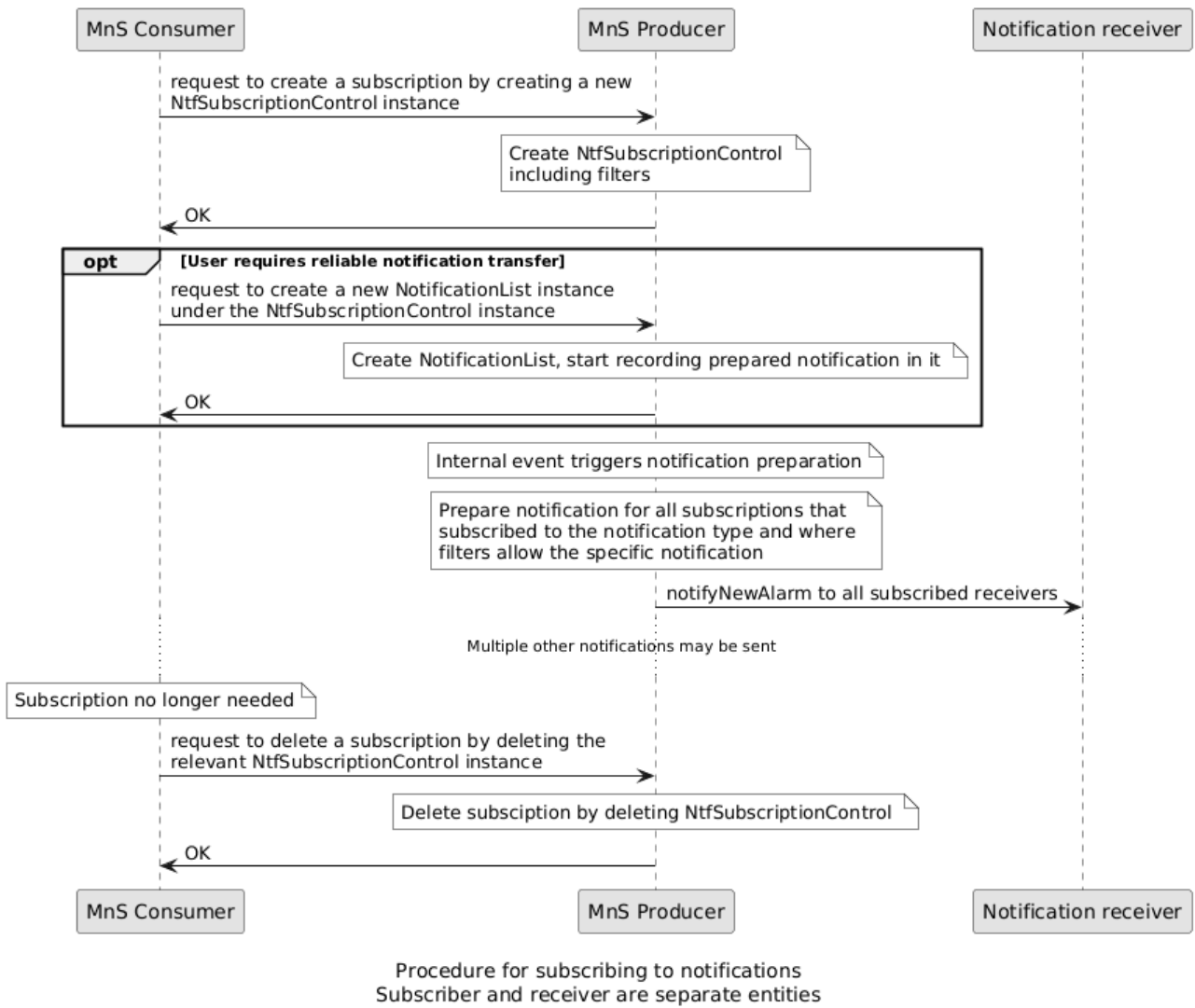
REQ-REL-NOTIF-4: Producer shall inform the consumer if the producer did not succeed to properly send one or more notifications that should have been sent according to the subscription.

8.3 Procedures for notification support

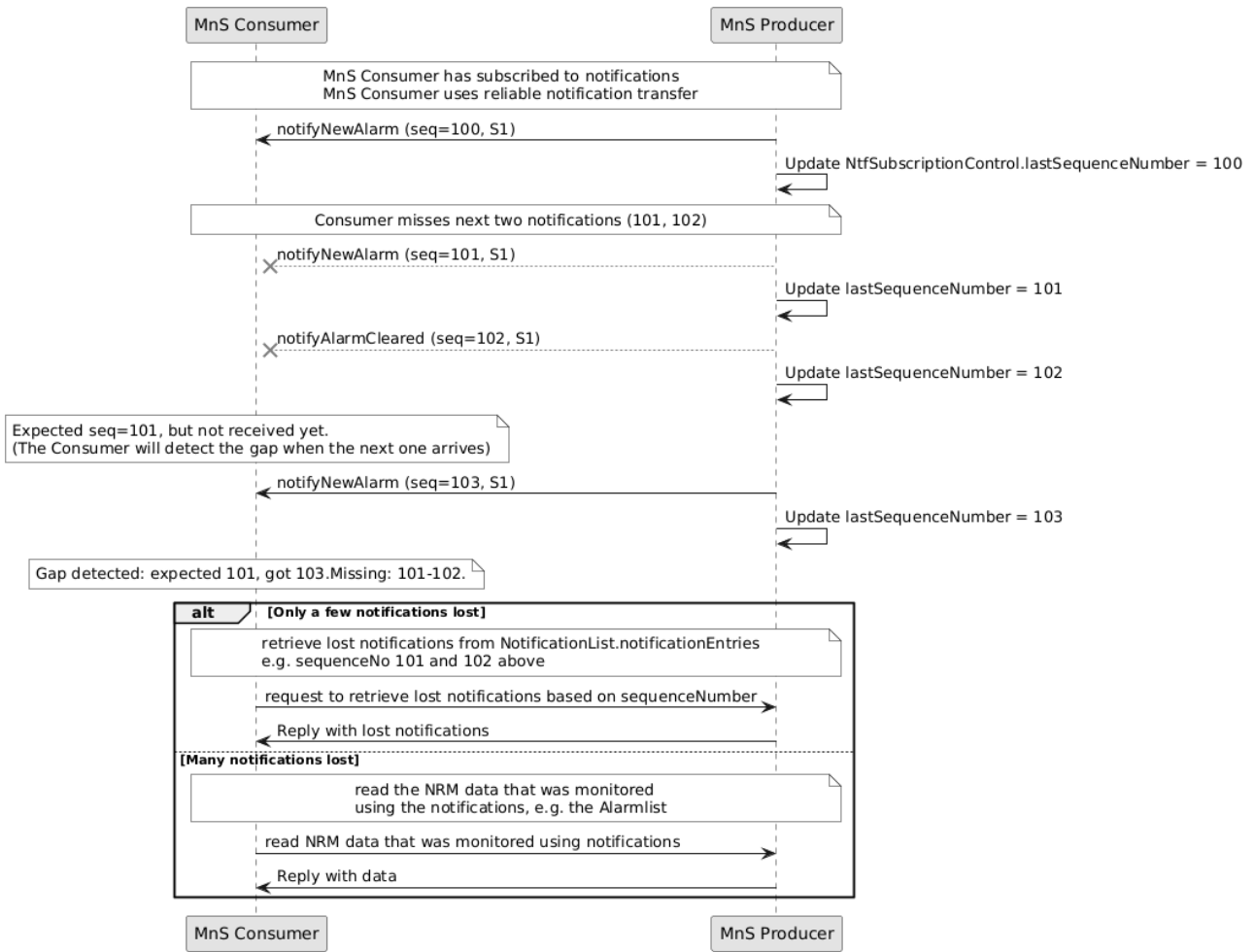
8.3.1 Introduction

The procedures below are examples of subscription support. Depending on the notification subscription different notification types may be used. The MnS consumer and the recipient of the notifications may or may not be the same entity.

8.3.2 Procedure for subscribing to notifications

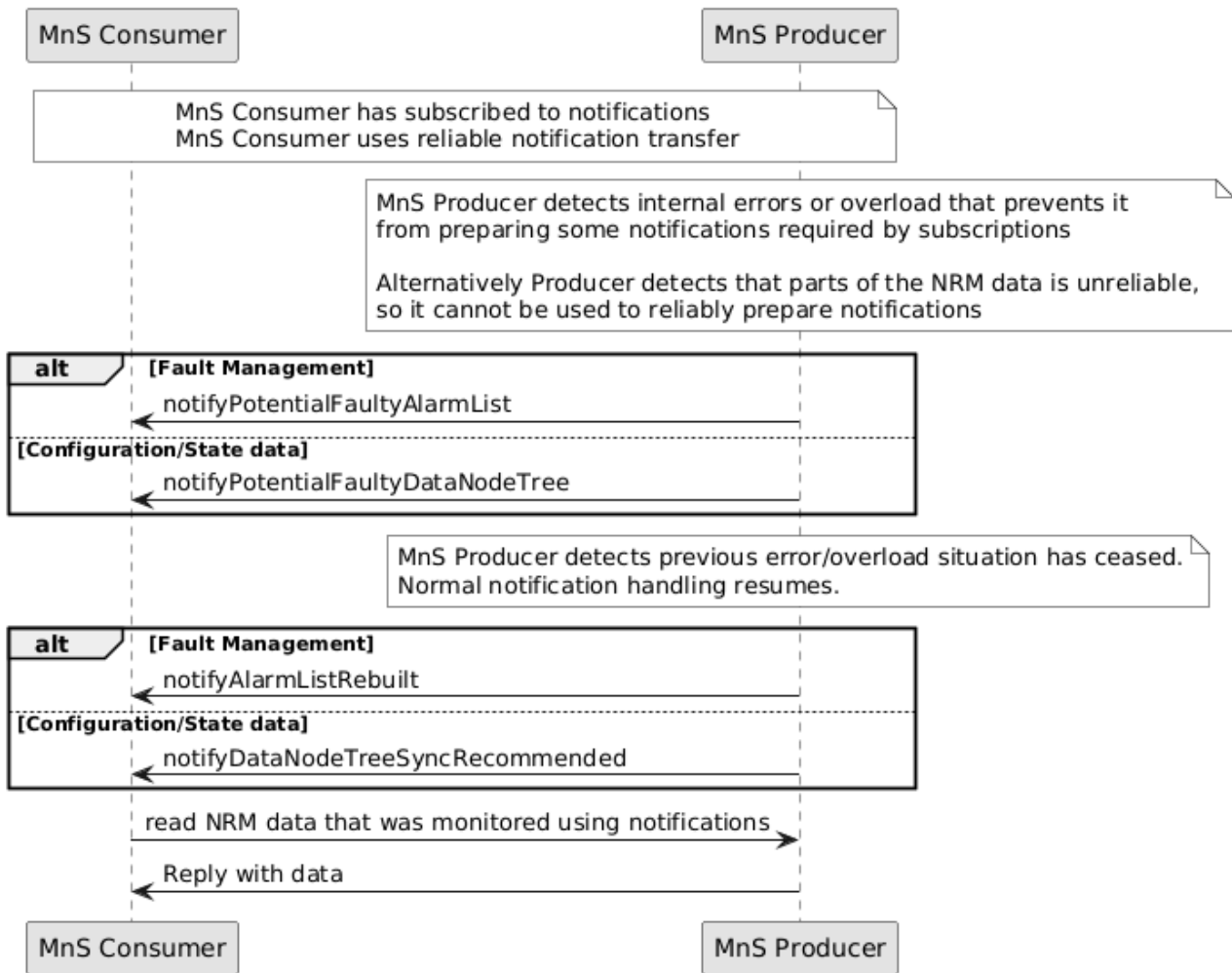


8.3.3 Procedure for detecting and recovering lost notifications



Procedure for detecting and recovering lost notifications
Subscriber and receiver are the same

8.3.4 Procedure for detecting not prepared notifications and recovering the data



Procedure for detecting not prepared notifications and recovering the data
Subscriber and receiver are the same

8.4 Solutions

8.4.1 Stage 2 definition

Following are the stage 2 definitions for notification support:

- The common notification header is defined in clause 11.0.2 in TS 28.532 [2].
- Individual notification types are defined in clause 11 and 12 in TS 28.532 [2] and in clause 8 in TS 28.111 [11]. Other specification or vendors may define additional notification types.
- The notification subscription NRM fragment is defined in clause 4.3.22 in TS 28.622 [9].
- The NRM fragment used to recover lost notifications is defined in clause 4.3.81 in TS 28.622 [9].
- The NRM fragment describing notification types supported by an MnS producer is defined in clause 4.3.61 in TS 28.622 [9].

8.4.2 Stage 3 definition

Following are the stage 3 definition for controlling heartbeat

- RESTful HTTP-based solution set:

- RESTful HTTP-based solution set for generic provisioning management service is defined in clause 12.1.1 in TS 28.532 [2]. Corresponding OpenAPI document "TS28532_ProvMnS.yaml" in clause A.1 in TS 28.532 [2].
- OpenAPI document "TS28623_SubscriptionControlNrm.yaml" and "TS28623_GenericNrm.yaml" in clause 4.3 in TS 28.623 [10].
- YANG/Netconf-based solution set:
 - YANG/Netconf-based solution set for generic provisioning management service is defined in clause 12.1.3 in TS 28.532 [2].
 - YANG model "_3gpp-common-subscription-control.yang" in clause 4.4. in TS 28.623 [10].

Annex A (informative): Heartbeat PlantUML source code

A.0 Procedure for subscribing to heartbeat notification

The following PlantUML source code is used to describe the procedure for subscribing to heartbeat notifications, as depicted by Figure 4.3.0-1:

```
@startuml
title "Subscribing to heartbeat notification"
actor "MnS Consumer" as CONS
participant "MnS Producer" as PROV
participant "Notification Receiver" as Receiver
CONS -> PROV: request to create HeartbeatControl instance
rnote over PROV
  Create and configure the HeartbeatControl instance
  Internal Countdown Timer := newHeartbeatPeriodValue
endnote
PROV -> CONS: response for creating HeartbeatControl instance
rnote over PROV
  Internal Countdown Timer := newHeartbeatPeriodValue
endnote
PROV -> Receiver: notifyHeartbeat notification
rnote over PROV
  reinitialize its internal countdown timer
  to the value of heartbeatNtfPeriod
endnote
hide footbox
@enduml
```

A.1 Void

A.2 Procedure for requesting immediate heartbeat notification

The following PlantUML source code is used to describe the procedure for requesting immediate heartbeat notification, as depicted by Figure 4.3.2-1:

```
@startuml
title "Requesting immediate heartbeat notification"
actor "MnS Consumer" as CONS
participant "MnS Producer" as PROV
participant "Notification Receiver" as Receiver
CONS -> PROV: modifyMOIAttributes ('triggerHeartbeatNtf', TRUE)
rnote over PROV
  Send immediate heartbeat notification
  to Notification Receiver who previously
  subscribed to heartbeat notifications
endnote
PROV -> Receiver: notifyHeartbeat notification
rnote over PROV
  triggerHeartbeatNtf:= FALSE
endnote
hide footbox
@enduml
```

A.3 Void

A.4 Procedures for notification support

```

@startuml
caption \nProcedure for subscribing to notifications\nSubscriber and receiver are separate entities
skinparam monochrome true

participant "MnS Consumer" as CON
participant "MnS Producer" as PROD
participant "Notification receiver" as RCV

CON -> PROD : request to create a subscription by creating a new\nNtfSubscriptionControl instance
note over PROD
  Create NtfSubscriptionControl
  including filters
end note
CON <- PROD : OK

opt User requires reliable notification transfer
  CON -> PROD : request to create a new NotificationList instance \nunder the NtfSubscriptionControl
  instance
  note over PROD
    Create NotificationList, start recording prepared notification in it
  end note
  CON <- PROD : OK
end

note over PROD : Internal event triggers notification preparation
note over PROD
  Prepare notification for all subscriptions that
  subscribed to the notification type and where
  filters allow the specific notification
end note

PROD -> RCV : notifyNewAlarm to all subscribed receivers

... Multiple other notifications may be sent ...

note over CON : Subscription no longer needed
CON -> PROD : request to delete a subscription by deleting the\nrelevant NtfSubscriptionControl
instance
note over PROD
  Delete subscription by deleting NtfSubscriptionControl
end note
CON <- PROD : OK

@enduml

```

```

@startuml
caption \nProcedure for detecting and recovering lost notifications\nSubscriber and receiver are the
same
skinparam monochrome true

participant "MnS Consumer" as CON
participant "MnS Producer" as PROD

note over PROD, CON
  MnS Consumer has subscribed to notifications
  MnS Consumer uses reliable notification transfer
end note

PROD -> CON : notifyNewAlarm (seq=100, S1)
PROD -> PROD : Update NtfSubscriptionControl.lastSequenceNumber = 100

note over PROD, CON

```

```

Consumer misses next two notifications (101, 102)
end note

PROD -[#gray,dashed]>x CON : notifyNewAlarm (seq=101, S1)
PROD -> PROD : Update lastSequenceNumber = 101

PROD -[#gray,dashed]>x CON : notifyAlarmCleared (seq=102, S1)
PROD -> PROD : Update lastSequenceNumber = 102

note over CON
Expected seq=101, but not received yet.
(The Consumer will detect the gap when the next one arrives)
end note

' --- Next received notification ---
PROD -> CON : notifyNewAlarm (seq=103, S1)
PROD -> PROD : Update lastSequenceNumber = 103

note over CON : Gap detected: expected 101, got 103.Missing: 101-102.

alt Only a few notifications lost
  note over PROD, CON
    retrieve lost notifications from NotificationList.notificationEntries
    e.g. sequenceNo 101 and 102 above
  end note
CON -> PROD : request to retrieve lost notifications based on sequenceNumber
CON <- PROD : Reply with lost notifications
else Many notifications lost
  note over PROD, CON
    read the NRM data that was monitored
    using the notifications, e.g. the Alarmlist
  end note
CON -> PROD : read NRM data that was monitored using notifications
CON <- PROD : Reply with data
end

@enduml

```

```

@startuml
caption \nProcedure for detecting not prepared notifications and recovering the data\nSubscriber and
receiver are the same
skinparam monochrome true

participant "MnS Consumer" as CON
participant "MnS Producer" as PROD

note over PROD, CON
  MnS Consumer has subscribed to notifications
  MnS Consumer uses reliable notification transfer
end note

note over PROD
  MnS Producer detects internal errors or overload that prevents it
  from preparing some notifications required by subscriptions

  Alternatively Producer detects that parts of the NRM data is unreliable,
  so it cannot be used to reliably prepare notifications
end note
alt Fault Management
  PROD -> CON : notifyPotentialFaultyAlarmList
else Configuration/State data
  PROD -> CON : notifyPotentialFaultyDataNodeTree
end

note over PROD
  MnS Producer detects previous error/overload situation has ceased.
  Normal notification handling resumes.
end note

alt Fault Management
  PROD -> CON : notifyAlarmListRebuilt
else Configuration/State data
  PROD -> CON : notifyDataNodeTreeSyncRecommended
end

```

```
CON -> PROD : read NRM data that was monitored using notifications
CON <- PROD : Reply with data
@enduml
```

Annex B (informative): Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2020-03	SA#87-e					Upgrade to changecontrol version	16.0.0
2021-03	SA#91e	SP-210152	0003	-	B	Add use cases for discovery of management services	17.0.0
2021-09	SA#93e	SP-210864	0004	1	C	Add support for discovery of management services	17.1.0
2021-09	SA#93e	SP-210876	0005	-	B	Add requirements for data management	17.1.0
2021-09	SA#93e	SP-210875	0006	-	B	Add requirements for file management	17.1.0
2021-12	SA#94e	SP-211467	0007	1	C	Clarifications into existing use cases	17.2.0
2021-12	SA#94e	SP-211467	0008	-	C	Clarifications into existing requirements	17.2.0
2022-06	SA#96	SP-220564	0009	1	F	Editorial Corrections	17.3.0
2022-06	SA#96	SP-220505	0010	-	B	Add requirements for management data collection and discovery	17.3.0
2023-12	SA#102	SP-231452	0013	1	F	Clarify management service discovery use cases	17.4.0
2024-04	-	-	-	-	-	Update to Rel-18 version (MCC)	18.0.0
2024-04	SA#104	SP-240804	0015	-	A	Rel-18 CR TS 28.537 Remove unsatisfied requirements related to file push triggered by MnS consumer	18.1.0
2024-04	SA#104	SP-240804	0020	-	A	Rel-18 CR TS 28.537 Remove undefined use case clause	18.1.0
2024-09	SA#105	SP-241162	0022	-	A	Rel-18 CR TS 28.537 Correction on file push requirement	18.2.0
2024-12	SA#106	SP-241640	0027	-	F	Rel-19 CR 28.537 Clarification of external management data	19.0.0
2024-12	SA#106	SP-241640	0028	-	D	Rel-19 CR 28.537 Correction of requirement labels	19.0.0
2024-12	SA#106	SP-241640	0029	-	F	Rel-19 CR 28.537 Introduce missing definition of term "trace metrics"	19.0.0
2025-03	SA#107	SP-250160	0030	2	B	Rel-19 TS 28.537 Usage of MnS Registry NRM fragment for MnS Registry and Discovery for different deployment scenarios	19.1.0
2025-03	SA#107	SP-250160	0032	1	B	Rel-19 CR TS 28.537 Change MnS provider to MnS producer	19.1.0
2025-03	SA#107	SP-250149	0033	1	F	Rel 19 CR TS 28.537 Remove editors notes	19.1.0
2025-03	SA#107	SP-250149	0034	1	D	Rel-19 CR TS 28.537 Add reference for solution description (NRM fragment) for each management capability	19.1.0
2025-06	SA#108	SP-250553	0031	3	B	Rel-19 CR TS 28537 Add requirements for discovering management capabilities of MnS instances based on area of interest	19.2.0
2025-06	SA#108	SP-250558	0035	2	F	Rel-19 CR TS 28.537 Correct procedures for heartbeat	19.2.0
2025-06	SA#108	SP-250538	0039		B	Rel-19 CR TS28.537	19.2.0
2025-06	SA#108					MCC: correction of a reference.	19.2.1
2025-09	SA#109	SP-251080	0040	1	B	Rel19 CR TS 28.537 Add missing solution description for discovery of management services	19.3.0
2025-09	SA#109	SP-251088	0042	-	F	Rel-19 CR TS 28.537 Update reference for trace metric	19.3.0
2025-09	SA#109	SP-251080	0043	1	B	Rel-19 CR 28.537 Add details for MnS component versioning	19.3.0
2025-12	SA#110	SP-251393	0041	3	F	Rel-19 CR TS 28.537 Add missing functionality and solution description for managing external management data	19.4.0
2025-12	SA#110	SP-251399	0048		A	Rel-19 CR 28.537 Remove requirement that does not have any solution.	19.4.0
2025-12	SA#110	SP-251393	0049	1	F	Rel-19 CR TS 28.537 Add missing RESTFUL implementation description for management data collection and discovery	19.4.0
2026-03	SA#111	SP-260070	0050	1	F	Add missing notification requirements	19.5.0

History

Version	Date	Status
V19.4.0	February 2026	Publication
V19.5.0	April 2026	Publication