

ETSI TS 132 160 V16.6.0 (2023-01)



**LTE;
5G;
Management and orchestration;
Management service template
(3GPP TS 32.160 version 16.6.0 Release 16)**



Reference

RTS/TSGS-0532160vg60

Keywords

5G,LTE

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Important notice

The present document can be downloaded from:

<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommitteeSupportStaff.aspx>

If you find a security vulnerability in the present document, please report it through our
Coordinated Vulnerability Disclosure Program:

<https://www.etsi.org/standards/coordinated-vulnerability-disclosure>

Notice of disclaimer & limitation of liability

The information provided in the present deliverable is directed solely to professionals who have the appropriate degree of experience to understand and interpret its content in accordance with generally accepted engineering or other professional standard and applicable regulations.

No recommendation as to products and services or vendors is made or should be implied.

No representation or warranty is made that this deliverable is technically accurate or sufficient or conforms to any law and/or governmental rule and/or regulation and further, no representation or warranty is made of merchantability or fitness for any particular purpose or against infringement of intellectual property rights.

In no event shall ETSI be held liable for loss of profits or any other incidental or consequential damages.

Any software contained in this deliverable is provided "AS IS" with no warranties, express or implied, including but not limited to, the warranties of merchantability, fitness for a particular purpose and non-infringement of intellectual property rights and ETSI shall not be held liable in any event for any damages whatsoever (including, without limitation, damages for loss of profits, business interruption, loss of information, or any other pecuniary loss) arising out of or related to the use of or inability to use the software.

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2023.
All rights reserved.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM®** and the GSM logo are trademarks registered and owned by the GSM Association.

Legal Notice

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

The present document may refer to technical specifications or reports using their 3GPP identities. These shall be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between 3GPP and ETSI identities can be found under <http://webapp.etsi.org/key/queryform.asp>.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Intellectual Property Rights	2
Legal Notice	2
Modal verbs terminology.....	2
Foreword.....	6
1 Scope	8
2 References	8
3 Definitions of terms, symbols and abbreviations	9
3.1 Terms.....	9
3.2 Symbols.....	9
3.3 Abbreviations	9
4 Management service template (stage 1)	9
4.1 General	9
4.2 Template for high-level requirement specifications	9
4.3 Template for Management service specific requirement specifications	10
5 Management service template (stage 2)	11
5.1 General	11
5.1.1 General.....	11
5.1.2 Management service components	11
5.2 Template for NRM	11
5.3 Template for Management service operations and notifications	17
6 NRM Stage 3 definition rules.....	22
6.1 Mappings from stage 2 artefacts to stage 3 JSON schema	22
6.1.1 Usage of JSON schema.....	22
6.1.2 Concrete NRM classes.....	22
6.1.3 Abstract classes.....	23
6.1.4 Name containment	23
6.1.5 Recursive name containment	25
6.1.6 Inheritance	25
6.1.7 NRM class naming attribute "id"	26
6.1.8 NRM class attributes.....	26
6.1.9 Vendor specific extensions	26
6.1.10 Attribute support qualifier	27
6.1.11 Attribute properties	27
6.1.11.1 Introduction	27
6.1.11.2 Attribute property "multiplicity"	27
6.1.11.3 Attribute property "isUnique"	27
6.1.11.4 Attribute property "isOrdered"	27
6.1.11.5 Attribute property "defaultValue"	28
6.1.11.6 Attribute property "isNullable"	28
6.1.11.7 Attribute property "isInvariant".....	28
6.1.11.8 Attribute property "isReadable" and "isWritable"	28
6.1.11.9 Attribute property "isNotifiable"	28
6.1.11.10 Attribute property "allowedValues"	28
6.2 Stage 3 YANG style and example.....	29
6.2.1 General Modeling Rules	29
6.2.1.1 Modeling Resources.....	29
6.2.1.2 Unique YANG Module names	29
6.2.1.3 Unique YANG Namespace	29
6.2.1.4 Unique YANG Module Prefixes	29
6.2.1.5 Use YANG Version 1.1	29
6.2.1.6 YANG Constructs Not to be Used – Not needed	29
6.2.1.7 Reuse Standards from Other Standard Organizations	30

6.2.1.8	Vendor Specific Model Changes.....	30
6.2.1.9	Model Correctness, checking	30
6.2.1.10	YANG modules in technical specifications	30
6.2.1.11	Module header statements.....	30
6.2.1.12	Provide description and reference statements	31
6.2.1.13	YANG module revisions.....	31
6.2.1.14	Don't use YANG statements with their default meaning.....	31
6.2.1.15	Formatting YANG modules/submodules.....	31
6.2.2	InformationObjectClass – abstract.....	32
6.2.2.1	Introduction.....	32
6.2.2.2	YANG mapping	32
6.2.3	Naming attribute	32
6.2.3.1	Introduction.....	32
6.2.3.2	Yang mapping.....	32
6.2.4	InformationObjectClass – concrete.....	32
6.2.4.0	Introduction.....	32
6.2.4.1	YANG mapping	32
6.2.5	Generalization relationship - inheritance from another class.....	33
6.2.5.1	Introduction.....	33
6.2.5.2	YANG mapping	33
6.2.6	Name containment	33
6.2.6.1	Introduction.....	33
6.2.6.2	YANG mapping	34
6.2.7	Recursive containment - reference based solution.....	34
6.2.8	Multi-root management tree	36
6.2.9	Alternative containment.....	36
6.2.10	Attribute – simple, single value	36
6.2.10.1	Introduction.....	36
6.2.10.2	YANG Mapping.....	36
6.2.11	Attribute – simple, multivalue	36
6.2.11.1	Introduction.....	36
6.2.11.2	YANG mapping	37
6.2.12	Attribute, structured.....	37
6.2.12.0	Introduction.....	37
6.2.12.1	YANG Mapping.....	37
6.2.13	defaultValue.....	38
6.2.13.1	Introduction.....	38
6.2.13.2	YANG mapping	38
6.2.14	multiplicity and cardinality.....	38
6.2.14.0	Introduction.....	38
6.2.14.1	YANG mapping	38
6.2.15	isNullable.....	39
6.2.15.0	Introduction.....	39
6.2.15.1	YANG mapping	39
6.2.16	dataType	39
6.2.16.0	Introduction.....	39
6.2.16.1	YANG mapping	39
6.2.17	enumeration	39
6.2.17.0	Introduction.....	39
6.2.17.1	YANG mapping	39
6.2.18	choice.....	39
6.2.18.0	Introduction.....	39
6.2.18.1	YANG mapping	40
6.2.19	isInvariant on attribute.....	40
6.2.19.1	YANG mapping	40
6.2.20	isReadable/isWritable	40
6.2.20.1	YANG mapping	40
6.2.21	isOrdered	40
6.2.21.1	YANG mapping	40
6.2.22	isUnique.....	40
6.2.22.1	YANG mapping	40
6.2.23	allowedValues.....	41

6.2.23.1	YANG mapping	41
6.2.24	Xor constraint	41
6.2.24.1	YANG mapping	41
6.2.25	ProxyClass	41
6.2.25.1	YANG mapping	41
6.2.26	SupportQualifier	41
6.2.26.1	Introduction	41
6.2.26.2	YANG mapping	41
6.2.27	isNotifiable.....	42
6.2.27.1	Introduction	42
6.2.27.2	YANG mapping	42
Annex A (informative):	Change history	43
History		44

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:

Version x.y.z

where:

- x the first digit:
 - 1 presented to TSG for information;
 - 2 presented to TSG for approval;
 - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, 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

The constructions "can" and "cannot" shall not to be used as substitutes for "may" and "need not".

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

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

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

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

In addition:

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

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

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

1 Scope

The present document contains the templates to be used for the production of Management service component specifications type A, type B and type C [2].

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 28.533: "Management and orchestration; Architecture framework".
- [3] 3GPP TS 32.156: "Telecommunication management; Fixed Mobile Convergence (FMC) Model Repertoire"
- [4] ITU-T Recommendation M.3020 (07/2017): "Management interface specification methodology".
- [5] 3GPP TR 21.801: "Specification drafting rules".
- [6] 3GPP TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".
- [7] 3GPP TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".
- [8] 3GPP TS 32.302: "Telecommunication management; Configuration Management (CM); Notification Integration Reference Point (IRP); Information Service (IS)".
- [9] 3GPP TS 32.300: "Telecommunication management; Configuration Management (CM); Name convention for Managed Objects".
- [10] ITU-T Recommendation M.3020 (07/2011): "Management interface specification methodology" – Annex E "Information type definitions – type repertoire".
- [11] IETF RFC 8407: "[Guidelines for Authors and Reviewers of Documents Containing YANG Data Models, October 2018](#)".
- [12] 3GPP TS 28.532: " Management and orchestration; Generic management services"
- [13] IETF RFC 8528: "YANG Schema mount "
- [14] OpenAPI: "OpenAPI 3.0.0 Specification", <https://github.com/OAI/OpenAPI-Specification/blob/master/versions/3.0.1.md>.
- [15] [draft-wright-json-schema-01 \(October 2017\): "JSON Schema: A Media Type for Describing JSON Documents"](#).
- [16] draft-wright-json-schema-validation-01 (October 2017: "JSON Schema Validation: A Vocabulary for Structural Validation of JSON".
- [17] draft-wright-json-schema-hyperschema-01 (October 2017): "JSON Hyper-Schema: A Vocabulary for Hypermedia Annotation of JSON.

[18] IETF RFC 9950: "The YANG 1.1 Data Modeling Language, August 2016".

3 Definitions of terms, symbols and abbreviations

3.1 Terms

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

3.2 Symbols

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].

C	Conditional
CM	Conditional Mandatory
CO	Conditional Optional
M	Mandatory
MnS	Management Service
NRM	Network Resource Model
O	Optional

4 Management service template (stage 1)

4.1 General

This template is mainly based on the requirements template (mainly Annex A) in the ITU-T M.3020 recommendation [4] and shall be used for the production of all requirement specifications for management and orchestration of 3GPP networks. The template contains two options: Option 1 specified in subclause 4.2, which shall be used for all high-level requirement specifications for management and orchestration of 3GPP networks, and option 2 specified in subclause 4.3, which shall be used for all Management Services (MnS) specific requirement specifications. When option 1 is selected for the production of high level requirement specifications, either the template for Business level requirements (R4.b), the template for Specification level requirements (R4.c) or both are used.

Instructions in *italics* below shall not be included in the requirements specifications.

The introductory clauses (from clause 1 to clause 3) for the requirements TS should be taken from the 3GPP TS template (i.e. not this requirements template).

Use the "Heading x" paragraph style for clause and sub-clauses in the Requirements TS.

Usage of fonts shall be according to the 3GPP drafting rules in TR 21.801 [5] for a TS (with some basic examples given in the 3GPP TS template).

4.2 Template for high-level requirement specifications

R4 Management service name

The Management service name above shall be replaced with the name of the Management Service (MnS) which is to be specified.

R4.a Concepts and background

For production of the contents of this clause, follow the template instructions in ITU-T M.3020 [4] subclause A.2, template clause "1 Concepts and background".

R4.b Business level requirements

For production of the contents of this subclause, follow the template instructions in ITU-T M.3020 [4] subclause A.2, template clause "2 Business level requirements".

Note on the Use case template: All occurrences of "()" in the first column "Use Case Stage" of the Use case template in table A.2, as well as the last row with a NOTE at the end of the table, shall not be included in the requirements TS as these are only template instructions to the TS author. For example, "Goal(*)" shall be converted to "Goal" in the TS. Likewise, for all occurrences of "(M|O)", a choice of M or O shall be made, leaving it as either "(M)" or "(O)" in the TS. For example, "Step n (M|O)" shall be converted to "Step n (M)" or "Step n (O)" in the TS.*

R4.c Specification level requirements

For production of the contents of this subclause, follow the template instructions in ITU-T M.3020 [4] subclause A.2, template clause "3 Specification level requirements".

Note on the Use case template: All occurrences of "()" in the first column "Use Case Stage" of the Use case template in table A.2, as well as the last row with a NOTE at the end of the table, shall not be included in the requirements TS as these are only template instructions to the TS author. For example, "Goal(*)" shall be converted to "Goal" in the TS. Likewise, for all occurrences of "(M|O)", a choice of M or O shall be made, leaving it as either "(M)" or "(O)" in the TS. For example, "Step n (M|O)" shall be converted to "Step n (M)" or "Step n (O)" in the TS.*

4.3 Template for Management service specific requirement specifications

R4 Management service name

The Management service name above shall be replaced with the name of the Management Service (MnS) which is to be specified.

R4.1 Concepts and background

For production of the contents of this clause, follow the template instructions in ITU-T M.3020 [4] subclause A.3, template clause "1 Concepts and background".

R4.2 Requirements

For production of the contents of this subclause, follow the template instructions in ITU-T M.3020 [4] subclause A.3, template clause "2 Requirements".

5 Management service template (stage 2)

5.1 General

5.1.1 General

The present document contains the templates to be used, for the production of all Management Service (MnS) specifications.

Clause 5.2 is applicable for specification of MnS component type B (NRM).

Clause 5.3 is applicable for specification of MnS component type A (operations and notifications) and type C (alarm and performance information).

The MnS template uses qualifiers M, O, CM, CO and C. The semantics of these qualifiers are defined in [3].

The MnS template uses type definition as one characteristic to describe class attributes and operation/notification parameters. The valid type definitions that can be used and their semantics are defined in [3].

Usage of fonts for the specific cases of class/attribute names etc., in addition to the general font requirements in the 3GPP drafting rules in 3GPP TR 21.801 [5], shall be according to the following table.

Table 5.1.1-1

Item	Font
Class names	Courier New
Attribute names	Courier New
Operation names	Courier New
Parameter names	Courier New
Assertion names	Courier New
Notification names	Courier New
Exception names	Courier New
State names	Arial
Matching Information	Courier New
Information Type	Courier New
Legal Values	Courier New
NOTE: These font requirements do not apply to UML diagrams.	

5.1.2 Management service components

A management service combines elements of management service components type A, B and C [1].

The template for NRM, see clause 5.2, applies to the specification of management service component type B.

The template for the Management service operations and notifications, see clause 5.3, applies to the specification of type A and type C.

5.2 Template for NRM

W4 Model

W4.1 Imported and associated information entities

W4.1.1 Imported information entities and local labels

This clause identifies a list of information entities (e.g. information object class, datatype, interface, attribute) that have been defined in other specifications and that are imported in the present (target) specification. All imported entities shall be treated as if they are defined locally in the target specification. One usage of import is for inheritance purpose.

Each element of this list is a pair (label reference, local label). The label reference contains the name of the original specification where the information entity is defined, the information entity type and its name. The local label contains the name of the information entity that appears in the target specification, and the entity name in the local label shall be kept identical to the name defined in the original specification. The local label may then be used throughout the target specification instead of that which appears in the label reference.

This information is provided in a table. An example of such a table is given here below:

Label reference	Local label
TS 28.622 [6], information object class, Top	Top
TS 28.541 [7] information object class NSI	NSI

W4.1.2 Associated information entities and local labels

This clause identifies a list of information entities (e.g. information object class, interface, attribute) that have been defined in other specifications and that are associated with the information entities defined in the present (target) specification. For the associated information entity, only its properties (e.g., DN (see TS 32.156 [3]), attribute (see TS 32.156 [3]) of an instance of the associated information entity) used as associated information needs to be supported locally in the target specification.

Each element of this list is a pair (label reference, local label). The label reference contains the name of the original specification where the information entity is defined, the information entity type and its name. The local label contains the name of the information entity that appears in the target specification. The local label may then be used throughout the target specification instead of that which appears in the label reference.

This information is provided in a table. An example of such a table is given here below:

Label reference	Local label
TS 28.541 [7], IOC, GNBDUFunction	GNBDUFunction

W4.2 Class diagram

W4.2.1 Relationships

This first set of diagrams represents all classes and datatypes defined in this MnS with all their relationships, including relationships with imported information entities (if any). These diagrams shall contain class cardinalities (for associations as well as containment relationships) and may also contain role names. These shall be UML compliant class diagrams (see also TS 32.156 [3]).

Characteristics (attributes, relationships) of imported information entities need not to be repeated in the diagrams. Allowable classes are specified in TS 32.156 [3].

Use this as the first paragraph: "This clause depicts the set of classes (e.g. IOCs) that encapsulates the information relevant for this MnS. This clause provides an overview of the relationships between relevant classes in UML. Subsequent clauses provide more detailed specification of various aspects of these classes."

W4.2.2 Inheritance

This second set of diagrams represents the inheritance hierarchy of all classes defined in this specification. These diagrams do not need to contain the complete inheritance hierarchy but shall at least contain the parent classes of all classes defined in the present document. By default, a class inherits from the class "top".

Characteristics (attributes, relationships) of imported classes need not to be repeated in the diagrams.

NOTE: some inheritance relationships presented in clause W4.2.2 may be repeated in clause W4.2.1 to enhance readability.

Use "This subclause depicts the inheritance relationships." as the first paragraph.

W4.3 Class definitions

Each class, with its stereotype name, is defined using the following structure.

Inherited items (attributes etc.) shall not be shown, as they are defined in the parent class(es) and thus valid for the subclass.

W4.3.a ClassName <<StereotypeName>>

StereotypeName is mandatory to be included in the clause header, except for the stereotype Information Object Class, for which it shall not be included in the clause header.

An example of a Class is *Subnetwork* of stereotype Information Object Class. The heading of sub-clause W4.3.a for *SubNetwork* would look as follows:

W4.3.a *SubNetwork*

An example of a Class is *SliceProfile* of stereotype data type. The heading of W4.3.a for *SliceProfile* would look as follows:

W4.3.a *SliceProfile* <<dataType>>

The various stereotypes can be found in TS 32.156 [3].

The "a" represents a number, starting at 1 and increasing by 1 with each new definition of a class.

W4.3.a.1 Definition

This clause is written in natural language. The <definition> clause refers to the class itself.

Optionally, information on traceability back to one or more requirements supported by this class may be defined here, in the following form:

Referenced TS	Requirement label	Comment
TS 28.xyz [xy]	REQ-SM-CON-23	Optional clarification
TS 28.xyz [xy]	REQ-SM-FUN-11	Optional clarification

W4.3.a.2 Attributes

This clause presents the list of attributes, which are the manageable properties of the class. Each attribute is characterised by some of the attribute properties (see TS 32.156 [3]), i.e. supportQualifier (abbreviated by S), isReadable, isWritable, isInvariant and isNotifiable.

The legal values and their semantics for attribute properties are defined in TS 32.156 [3].

This information is provided in a table.

An example below indicates

Attribute name	S	isReadable	isWritable	isInvariant	isNotifiable
eNodeBId	M	T	F	T	T

Another example below indicates that the attribute *password1* is not readable, is writable, is not an invariant and no *notifyAttributeValueChange* will be emitted when the attribute value is changed.

Attribute name	S	isReadabl e	isWritable	isInvariant	isNotifiable
password1	O	F	T	F	F

Another example below indicates that the attribute `password2` and `password1` (in example above) have the same qualifiers for the shown properties except that of `isReadable`. In the case of `password1`, the standard specification determines the qualifier to be `M`, i.e. it is readable. In the case of `password2`, the standard specification does not make a determination. The vendor would make the determination if the attribute is readable or not readable.

Attribute name	S	isReadable	isWritable	isInvariant	isNotifiable
<code>password2</code>	O	O	T	F	F

In case there is one or more attributes related to role (see clause 5.2.9 of TS 32.156 [3]), the attributes related to role shall be specified at the bottom of the table with a divider "Attribute related to role", as shown in the following example:

Attribute name	S	isReadable	isWritable	isInvariant	isNotifiable
<code>aTMChannelTerminationPointId</code>	M	T	F	T	T
...					
...					
Attribute related to role					
<code>theATMPATHTerminationPoint</code>	M	T	F	F	T
<code>theIubLink</code>	M	T	F	F	T

This clause shall state "None." when there is no attribute to define.

W4.3.a.3 Attribute constraints

This clause presents constraints for the attributes, and one use is to present the predicates for conditional qualifiers (CM/CO).

This information is provided in a table. An example of such a table is given here below:

Name	Definition
<code>configuredMaxTxPower</code> CM support qualifier	Condition: The sector-carrier has a downlink [4].
<code>sNSSAIIList</code> CM support qualifier	Condition: Network slicing feature is supported [4].

This clause shall state "None." when there is no attribute constraint to define.

W4.3.a.4 Notifications

This clause, for this class, presents one of the following options:

- The class defines (and independent from those inherited) the support of a set of notifications that is identical to that defined in clause W4.5. In such case, use "The common notifications defined in clause W4.5 are valid for this class, without exceptions or additions." as the lone sentence of this clause.
- The class defines (and independent from those inherited) the support of a set of notifications that is a superset of that defined in clause W4.5. In such case, use "The common notifications defined in clause W4.5 are valid for this IOC. In addition, the following set of notification is also valid." as the lone paragraph of this clause. Then, define the 'additional' notifications in a table. See clause W4.5 for the notification table format.
- The class defines (and independent from those inherited) the support of a set of notifications that is not identical to, nor a superset of, that defined in clause W4.5. In such case, use "The common notifications defined in clause W4.5 are not valid for this IOC. The set of notifications defined in the following table is valid." as the lone paragraph of this clause. Specify the set of notifications in a table. See clause W4.5 for the notification table format.
- The class does not define (and independent from those inherited) the support of any notification. In such case, use "There is no notification defined." as the lone sentence of this clause.

The notifications identified (i.e. option-a, option-b and option-c above) in this clause are notifications that may be emitted by the MnS producer, where the "object class" and "object instance" parameters of the notification header (see

note 2) of these notifications identifies an instance of the class (or its direct or indirect derived class) defined by the encapsulating clause (i.e. clause W4.3.a).

The notifications identified (i.e. option-a and option-b above) in this clause, may originate from implementation object(s) whose identifier may or may not be the same as that carried in the notification parameters "object class" and "object instance". Hence the identification of notifications in this clause does not imply nor identify those notifications as being originated from an instance of the class (or its direct or indirect derived class) defined by the encapsulating clause (i.e. clause W4.3.a).

This clause shall state "This class does not support any notification." (see option-c) when there is no notification defined for this class. (Note that if its parent class has defined some notifications, the implementation of this class is capable of emitting those inherited defined notifications.)

The notification header is defined in TS 32.302 [8].

The qualifier of a notification, specified in Notification Table, indicates if an implementation may generate a notification carrying the DN of the subject class. The qualifier of a notification, specified in an MnS producer interface, indicates if an implementation of the MnS may generate such notification in general.

An MnS consumer may receive notification-XYZ that carries DN (the "object class" and "object instance") of class-ABC instance if and only if:

- a) The class-ABC Notification Table defines the notification-XYZ and
- b) The class-ABC instance implementation supports this notification-XYZ and
- c) An MnS defines the notification-XYZ and
- d) The MnS implementation supports this notification-XYZ.

W4.3.a.5 State diagram

This subclause contains state diagrams. A state diagram of an information object class defines permitted states of this information object class and the transitions between those states. A state is expressed in terms of individual attribute values or a combination of attribute values or involvement in relationships of the information object class being defined. This shall be a UML compliant state diagram.

This subclause shall state "None." when there is no State diagram defined.

W4.5 Attribute definitions

W4.5.1 Attribute properties

It has a lone paragraph "The following table defines the properties of attributes that are specified in the present document. ".

Each information attribute is defined using the following structure.

Inherited attributes shall not be shown, as they are defined in the parent class(es) and thus valid for this class.

An attribute has properties (see TS 32.156 [3]). Some properties of an attribute are defined in W4.3.a.2 (e.g. Support Qualifier). The remaining properties of an attribute (e.g. documentation, default value) are defined here.

The information is provided in a table. In case a) attributes of the same name are specified in more than one class and b) the attributes have different properties, then the attribute names (first column) should be prefixed with the class name followed by a period.

An example is given below:

Attribute Name	Documentation and Allowed Values	Properties
xyzId	It identifies ... allowedValues: ...	type: Integer multiplicity: ... isOrdered: ... isUnique: ... defaultValue: ... isNullable: False
Abc.state	It indicates ... allowedValues: "ON": the state is on; "OFF": the state is off.	type: <<enumeration>> multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: False isNullable: False
Zyz.state	It indicates ... allowedValues: "HIGH": the state is high; "MEDIUM": the state is medium; "LOW": the state is low.	type: <<enumeration>> multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: False isNullable: False
abc	It defines... allowedValues: ...	type: ... multiplicity: ... isOrdered: ... isUnique: ... defaultValue: ... isNullable: ...

In case there is one or more attributes related to role (see clause 5.2.9 of TS 32.156 [3]), the attributes related to role shall be specified at the bottom of the table with a divider "Attribute related to role". See example below.

Attribute Name	Documentation and Allowed Values	Properties
abc	It defines... allowedValues: ...	type: PlmnlId multiplicity: ... isOrdered: ... isUnique: ... defaultValue: ... isNullable: ...
Attribute related to role		
aEnd	It defines... allowedValues: Values to be conformant to TS 32.300 [9] ...	type: DN multiplicity: ... isOrdered: ... isUnique: ... defaultValue: ... isNullable: False

This clause shall state "None." if there is no attribute to define.

W4.5.2 Constraints

This clause indicates whether there are any constraints affecting attributes. Each constraint is defined by a triplet (propertyName, affectedAttributes, propertyDefinition). PropertyDefinitions are expressed in natural language.

An example is given here below:

Name	Affected attribute(s)	Definition
inv_TimerConstra ints	ntfTimeTickTimer	The ntfTimeTickTimer is lower than or equal to ntfTimeTick.

This clause shall state "None." if there is no constraint.

W4.6 Common notifications

This clause presents notifications that may be referred to by any class defined in the specification. This information is provided in tables.

W4.6.1 Alarm notifications

The following quoted text shall be copied as the only paragraph of this clause.

"This clause presents a list of notifications, defined in TS 28.532 [12], that an MnS consumer may receive. The notification header attribute `objectClass/objectInstance`, defined in TS 28.541 [7], shall capture the DN of an instance of a class defined in the present document."

The information is provided in a table. The following is an example.

Name	S	Notes
notifyNewAlarm	M	--

W4.6.2 Configuration notifications

The following quoted text shall be copied as the only paragraph of this clause.

"This clause presents a list of notifications, defined in TS 28.532 [12], that an MnS consumer may receive. The notification header attribute `objectClass/objectInstance`, defined in TS 32.302 [8], shall capture the DN of an instance of a class defined in the present document."

The information is provided in a table. The following is an example.

Name	S	Notes
notifyMOIAttributeValueChange	O	--
notifyMOICreation	O	--
notifyMOIDeletion	O	--

W4.6.3 Threshold Crossing notifications

The following quoted text shall be copied as the only paragraph of this clause.

"This clause presents a list of notifications, defined in TS 28.532 [12], that an MnS consumer may receive. The notification header attribute `objectClass/objectInstance`, defined in TS 28.541 [7], shall capture the DN of an instance of a class defined in the present document."

The information is provided in a table. The following is an example.

Name	S	Notes
notifyThresholdCrossing	O	

5.3 Template for Management service operations and notifications

Y4 Overview

Yb Management service name

Management service name should be replaced with the name of the Management Service (MnS).

"b" represents a number, starting at 1 and increasing by 1 with each new definition of a Management Service.

Yb.1 Operations and notifications

Yb.1.a Operation OperationName

OperationName is the name of the operation followed by a qualifier indicating whether the operation is Mandatory (M), Optional (O), Conditional-Mandatory (CM), Conditional-Optional (CO), or SS-Conditional (C).

"a" represents a number, starting at 1 and increasing by 1 with each new definition of an operation.

Yb.1.a.1 Definition

Yb.1.a.1.1 Description

This subclause shall be written in natural language.

Information on traceability back to one or more requirements supported by this operation should also be defined here, in the following form:

Referenced TS	Requirement label	Comment
3GPP TS 32.xyz [xy]	REQ-SM-CON-23	Optional clarification
3GPP TS 32.xyz [xy]	REQ-SM-FUN-11	Optional clarification

Yb.1.a.1.2 Pre-condition

A pre-condition is a collection of assertions joined by AND, OR, and NOT logical operators. The pre-condition shall be true before the operation is invoked. An example is given here below:

*notificationCategoriesNotAllSubscribed OR
notificationCategoriesParameterAbsentAndNotAllSubscribed*

Each assertion is defined by a pair (propertyName, propertyDefinition). All assertions constituting the pre-condition are provided in a table. An example of such a table is given here below:

Assertion Name	Definition
notificationCategoriesNotAllSubscribed	At least one notificationCategory identified in the notificationCategories input parameter is supported by an MnS producer and is not a member of the ntfNotificationCategorySet attribute of an NtfSubscription which is involved in a subscription relationship with the NtfSubscriber identified by the managerReference input parameter.
notificationCategoriesParameterAbsentAndNotAllSubscribed	The notificationCategories input parameter is absent and at least one notificationCategory supported by MnS producer is not a member of the ntfNotificationCategorySet attribute of an ntfSubscription which is involved in a subscription relationship with the NtfSubscriber identified by the managerReference input parameter.

Yb.1.a.1.3 Post-condition

A post-condition is a collection of assertions joined by AND, OR, and NOT logical operators. The post-condition shall be true after the completion of the operation. When nothing is said in a post-condition regarding an information entity, the assumption is that this information entity has not changed compared to what is stated in the pre-condition. An example is given here below:

subscriptionDeleted OR allSubscriptionDeleted

Each assertion is defined by a pair (propertyName, propertyDefinition). All assertions constituting the post-condition shall be provided in a table. An example of such a table is given here below:

Assertion Name	Definition
subscriptionDeleted	The ntfsSubscription identified by subscriptionId input parameter is no more involved in a subscription relationship with the ntfsSubscriber identified by the managerReference input parameter and has been deleted. If this ntfsSubscriber has no more ntfsSubscription, it is deleted as well.
allSubscriptionDeleted	In the case subscriptionId input parameter was absent, the ntfsSubscriber identified by the managerReference input parameter is no more involved in any subscription relationship and is deleted, the corresponding ntfsSubscription have been deleted as well.

Yb.1.a.1.4 Exceptions

List of exceptions that can be raised by the operation. Each element shall be a tuple (exceptionName, condition, ReturnedInformation, exitState).

Yb.1.a.1.4.c exceptionName

ExceptionName is the name of an exception.

"c" represents a number, starting at 1 and increasing by 1 with each new definition of an exception.

This information shall be provided in a table. An example of such a table is given here below:

Exception Name	Definition
ope_failed_existing_subscription	Condition: (notificationCategoriesNotAllSubscribed OR notificationCategoriesParameterAbsentAndNotAllSubscribed) not verified. Returned information: output parameter status is set to OperationFailedExistingSubscription. Exit state: Entry State.

NOTE: An example of an exception can be a situation where an operation is raised and the required information between a consumer and producer cannot be conveyed via the input and output parameters.

Yb.1.a.2 Input parameters

List of input parameters of the operation. Each element shall be a tuple (Parameter Name, Support Qualifier, Information Type (see [10] and note 1) and an optional list of Legal Values supported by the parameter, Comment). Legal Values for the Support Qualifier are: Mandatory (M), Optional (O), Conditional-Mandatory (CM), Conditional-Optional (CO), or SS-Conditional (C).

This information shall be provided in a table. An example of such a table is given here below:

Parameter Name	S	Information Type / Legal Values	Comment
eventIdList	M	SET OF INTEGER / --	One or more event identifiers

NOTE: Information Type qualifies the parameter of Parameter Name. In the case where the Legal Values can be enumerated, each element is a pair (Legal Value Name, Legal Value Semantics), unless a Legal Value Semantics applies to several values in which case the definition can be provided only once. When the Legal Values cannot be enumerated, the list of Legal Values is defined by a single definition.

Yb.1.a.3 Output parameters

List of output parameters of the operation. Each element tuple (Parameter Name, Support Qualifier, Matching Information / Information Type (see [10]) (Note 1) and an optional list of Legal Values supported by the parameter, Comment). Legal Values for the Support Qualifier are: Mandatory (M), Optional (O), Conditional-Mandatory (CM), Conditional-Optional (CO), or SS-Conditional (C).

This information shall be provided in a table. An example of such a table is given here below:

Parameter Name	S	Matching Information / Information Type / Legal Values	Comment
eventTime	M	AlarmInformation.alarmRaisedTime / GeneralizedTime / --	The parameter carries the <ul style="list-style-type: none"> - alarmRaisedTime in case notificationType carries notifyNewAlarm, - alarmChangedTime in case notificationType carries notifyChangedAlarm, - alarmClearedTime in case notificationType carries notifyClearedAlarm.

NOTE: Information Type qualifies the parameter of Parameter Name. In the case where the Legal Values can be enumerated, each element is a pair (Legal Value Name, Legal Value Semantics), unless a Legal Value Semantics applies to several values in which case the definition can be provided only once. When the Legal Values cannot be enumerated, the list of Legal Values is defined by a single definition.

This table shall also include a special parameter 'status' to indicate the completion status of the operation (success, partial success, failure reason etc.).

Yb.1.a.4 Result

Yb.1.a.4,1 Error messages

This subclause presents error messages in case the operation is not successful.

This subclause does not need to be present when there are no error messages to define.

Yb.1.a.4,2 Constraints

This subclause presents constraints for the operation or its parameters.

This subclause does not need to be present when there are no constraints to define.

Yb.1.a Notification NotificationName

NotificationName shall be the name of the notification followed by a qualifier indicating whether the notification is Mandatory (M), Optional (O), Conditional-Mandatory (CM), Conditional-Optional (CO) or SS-Conditional (C).

"a" represents a number, starting at 1 and increasing by 1 with each new definition of a notification.

Yb.1.a.1 Definition

This subclause shall be written in natural language.

Information on traceability back to one or more requirements supported by this notification should also be defined here, in the following form:

Referenced TS	Requirement label	Comment
3GPP TS 32.xyz [xy]	REQ-SM-CON-23	Optional clarification
3GPP TS 32.xyz [xy]	REQ-SM-FUN-11	Optional clarification

Yb.1.a.2 Input parameters

List of input parameters of the notification. Each element is a tuple (Parameter Name, Qualifiers, Matching Information / Information Type (see [10]) (Note 1) and an optional list of Legal Values supported by the parameter, Comment).

The column "Qualifiers" contains the two qualifiers, Support Qualifier and Filtering Qualifier, separated by a comma. The Support Qualifier indicates whether the attribute is Mandatory (M), Optional (O), Conditional-Mandatory (CM), Conditional-Optional (CO), or SS-Conditional (C).

This information shall be provided in a table. An example of such a table is given here below:

Parameter Name	S	Matching Information / Information Type / Legal Values	Comment
managerReference	M	ntfSubscriber.ntfManagerReference / STRING / --	It specifies the reference of the consumer to which notifications shall be sent.
alarmType	M	AlarmInformation.eventType / ENUMERATED / "Communications Alarm": a communication error alarm. "Processing Error Alarm": a processing error alarm. "Environmental Alarm": an environmental violation alarm. "Quality Of Service Alarm": a quality of service violation alarm. "Equipment Alarm": an alarm related to equipment malfunction.	

NOTE: Information Type qualifies the parameter of Parameter Name. In the case where the Legal Values can be enumerated, each element is a pair (Legal Value Name, Legal Value Semantics), unless a Legal Value Semantics applies to several values in which case the definition can be provided only once. When the Legal Values cannot be enumerated, the list of Legal Values is defined by a single definition.

Yb.1.a.3 Triggering event

The triggering event for the notification to be sent is the transition from the information state defined by the "from state" subclause to the information state defined by the "to state" subclause.

Yb.1.a.3.1 From state

This subclause is a collection of assertions joined by AND, OR, and NOT logical operators. An example is given here below:

`alarmMatched AND alarmInformationNotCleared`

Each assertion is defined by a pair (propertyName, propertyDefinition). All assertions constituting the state "from state" are provided in a table. An example of such a table is given here below:

Assertion Name	Definition
alarmMatched	The matching-criteria-attributes of the newly generated network alarm has values that are identical (matches) with ones in one AlarmInformation in AlarmList.
alarmInformationNotCleared	The perceivedSeverity of the newly generated network alarm is not Cleared.

Yb.1.a.3.2 To state

This subclause contains a collection of assertions joined by AND, OR and NOT logical operators. When nothing is said in a to-state regarding an information entity, the assumption is that this information entity has not changed compared to what is stated in the from-state. An example is given here below:

`resetAcknowledgementInformation AND perceivedSeverityUpdated`

Each assertion is defined by a pair (propertyName, propertyDefinition). All assertions constituting the state "to state" are provided in a table. An example of such a table is given here below:

Assertion Name	Definition
resetAcknowledgementInformation	The matched AlarmInformation identified in inv_alarmMatched in pre-condition has been updated according to the following rule: ackTime, ackUserId and ackSystemId are updated to contain no information; ackState is updated to "unacknowledged".
perceivedSeverityUpdated	The perceivedSeverity attribute of matched AlarmInformation identified in inv_alarmMatched in pre-condition has been updated.

Yb.2 Managed information

6 NRM Stage 3 definition rules

6.1 Mappings from stage 2 artefacts to stage 3 JSON schema

6.1.1 Usage of JSON schema

JSON schema is used to describe a set of valid schema documents sent over the wire in HTTP request and response messages of the ProvMnS. JSON schema does not describe the concrete implementation of the NRM on the producer.

Definitions are written in YAML.

6.1.2 Concrete NRM classes

A NRM class (managed object class) is represented by a JSON object. The properties of the JSON object are the NRM class attributes and the name contained NRM classes.

YAML schema	YAML document example
<pre>type: object properties: {}</pre>	<pre>{}</pre>

In the following example the class contains an "attributeA" of type "string" and an "attributeB" of type "number".

YAML schema	YAML document example
<pre>type: object properties: attributeA: type: string attributeB: type: number</pre>	<pre>attributeA: ABC attributeB: 45</pre>

The JSON object representing the class instance is preceded by a key equal to the class name.

In the following example the class name is "classA". Attributes are omitted for the sake of simplicity.

YAML schema	YAML document example
<pre>type: object properties: classA: type: object properties: {}</pre>	<pre>classA: {}</pre>

Multiple managed object instances of the same class are represented using a JSON array, where each item of the array is a JSON object with a managed object class instance representation.

YAML schema	YAML document example
<pre>type: object properties: classA:</pre>	<pre>ClassA: - {} - {}</pre>

<pre> type: array items: type: object properties: {} </pre>	<pre> - {} </pre>
---	---------------------------

6.1.3 Abstract classes

Abstract classes shall be defined in a "definitions" object and referenced in the schema of the concrete class using the "\$ref" keyword.

In the following example the abstract class can be instantiated zero or one time..

YAML schema	YAML document example
<pre> definitions: ClassA-Abstract: type: object properties: {} type: object properties: ClassA: \$ref: '#/definitions/ClassA-Abstract' </pre>	<pre> ClassA: {} </pre>

In the following example the abstract class can be instantiated zero or more times.

YAML schema	YAML document example
<pre> definitions: ClassA-Abstract: type: object properties: {} type: object properties: ClassA: type: array items: \$ref: '#/definitions/ClassA-Abstract' </pre>	<pre> ClassA: - {} - {} - {} </pre>

Abstract classes can be defined as well in separate files. Assume a file with the name "myDefs.json" includes the "definitions" object with the definition of "ClassA-Abstract".

YAML schema	YAML document example
<pre> definitions: ClassA-Abstract: type: object properties: {} </pre>	

The definition of "ClassA-Abstract" is then referenced like

YAML schema	YAML document example
<pre> type: object properties: ClassA: type: array items: \$ref: 'myDefs.json#/definitions/ClassA-Abstract' </pre>	<pre> ClassA: - {} - {} - {} </pre>

6.1.4 Name containment

Name contained NRM class instances are modeled as property of the containing class. The name of the property is the class name. The value is an array with manged object class representations of that class. Cardinality of the name containment relationship is specified using the "minItems" and "maxItems" keywords.

If the maximum number of items is unbounded, the "maxItems" keyword shall be omitted. If the minimum number of items is 0, the "minItems" keyword can be omitted.

The contained class shall not be listed as required property. This allows omitting the property representing the contained class instances completely in a JSON document instead of having an empty array.

In the following example an instance of "classA" name contains 1...1000 instances of "classB".

YAML schema	YAML document example
<pre> type: object properties: ClassA: type: array items: type: object properties: ClassB: type: array minItems: 1 maxItems: 1000 items: type: object properties: {} </pre>	<pre> ClassA: - ClassB: - {} - {} </pre>

Managed objects class instances of more than one class can be name contained.

YAML schema	YAML document example
<pre> type: object properties: ClassA: type: array items: type: object properties: ClassB: type: array items: type: object properties: {} ClassC: type: array items: type: object properties: {} </pre>	<pre> ClassA: - ClassB: - {} - {} - ClassC: - {} - {} </pre>

The contained managed object classes may be defined as abstract classes first, and then referenced.

YAML schema	YAML document example
<pre> definitions: ClassB-SingleAbstract: type: object properties: {} ClassC-SingleAbstract: type: object properties: {} type: object properties: ClassA: type: array items: type: object properties: ClassB: type: array items: \$ref: '#/definitions/ClassB-SingleAbstract' ClassC: type: array items: \$ref: '#/definitions/ClassC-SingleAbstract' </pre>	<pre> ClassA: - ClassB: - {} - {} - ClassC: - {} - {} </pre>

or, when the abstract class is defined as an array, then

YAML schema	YAML document example
<pre> definitions: ClassB-MultipleAbstract: type: array items: type: object properties: {} ClassC-MultipleAbstract: type: array items: type: object properties: {} type: object properties: ClassA: type: array items: type: object properties: ClassB: \$ref: '#/definitions/ClassB-MultipleAbstract' ClassC: \$ref: '#/definitions/ClassC-MultipleAbstract' </pre>	<pre> ClassA: - ClassB: - {} - {} - ClassC: - {} - {} </pre>

6.1.5 Recursive name containment

Classes may name contain themselves. This shall be modeled in JSON schema with recursion. Recursion requires using a "definitions" object with the definition of an abstract class.

In the following example each instance of "classA" contains zero or one instance of "classA".

YAML schema	YAML document example
<pre> definitions: ClassA-Abstract: type: object properties: classA: \$ref: '#/definitions/ClassA-Abstract' type: object properties: ClassA: \$ref: '#/definitions/ClassA-Abstract' </pre>	<pre> ClassA: ClassA: ClassA: {} </pre>

In the following example each instance of "classA" contains zero or more instances of "classA".

YAML schema	YAML document example
<pre> definitions: ClassA-MultipleAbstract: type: array items: type: object properties: classA: \$ref: '#/definitions/ClassA-MultipleAbstract' type: object properties: ClassA: \$ref: '#/definitions/ClassA-MultipleAbstract' </pre>	<pre> ClassA: - ClassA: - {} - {} - ClassA: - ClassA: - {} </pre>

6.1.6 Inheritance

JSON schema does not have the concept of inheritance. Inheritance can be emulated by the composition of schemas with the "allOf" keyword.

In the following example the attribute "attrB" is added to the attribute "attrA" of "classA-Abstract" to construct "ClassB".

YAML schema	YAML document example
<pre> definitions: ClassA-Abstract: type: object properties: attrA: type: string type: object properties: ClassB: type: array items: allOf: - \$ref: '#/definitions/ClassA-Abstract' - type: object properties: attrB: type: number </pre>	<pre> ClassB: - attrA: ABC attrB: 5 - attrA: DEF attrB: 4 - attrA: GHI attrB: 23 </pre>

The other possibility is to specify the inherited attribute directly along with the added attributes, thus having no inheritance or any emulation thereof in NRM stage 3 definitions.

6.1.7 NRM class naming attribute "id"

The naming attribute "id" is mapped to a required property of the class object, where the key is "id" and the type is "string".

YAML schema	YAML document example
<pre> type: object properties: ClassA: type: array items: type: object properties: id: type: string required: - id </pre>	<pre> ClassA: - id: '1' - id: '2' - id: '3' </pre>

6.1.8 NRM class attributes

NRM class attributes other than the naming attribute "id" shall be carried as properties in an "attributes" object.

YAML schema	YAML document example
<pre> type: object properties: classA: type: array items: type: object properties: id: type: string attributes: type: object properties: {} required: - id </pre>	<pre> classA: - id: '1' attributes: {} - id: '2' attributes: {} - id: '3' attributes: {} </pre>

The class attributes are name/value pairs (properties) of the "attributes" object.

6.1.9 Vendor specific extensions

Vendor-specific attributes shall be added to standardized JSON schemas using the mechanism in clause 6.1.6 "Inheritance".

6.1.10 Attribute support qualifier

The attribute support qualifier is defined in clause 6 of TS 32.156 [3]. This qualifier specifies a requirement for the MnS producer.

Attributes may or may not be present in a JSON document carried in a HTTP request or response message, no matter what their support qualifier in the NRM is. For this reason, no qualification is required for attributes in the JSON schema for NRMs. By default, the properties defined by the "properties" keyword are not required and can be omitted in a document instance.

However, some attributes like the "id" naming attribute shall be always present when a managed object class instance is carried in a HTTP request or response. These attributes shall be listed as array items in the value of the "required" keyword.

YAML schema	YAML document example
<pre> type: object properties: classA: type: array items: type: object properties: id: type: string required: - id </pre>	<pre> classA: - id: '1' - id: '2' - id: '3' </pre>

6.1.11 Attribute properties

6.1.11.1 Introduction

The attribute properties are defined in clause 5.2.1.1 of TS 32.156 [3]. They reflect properties of the attributes exhibited by the MnS producer. Their purpose is not to specify requirements for the attribute when transferred over the wire. For this reason, care should be taken when mapping attribute properties to JSON schema keywords.

6.1.11.2 Attribute property "multiplicity"

Attributes of scalar type with multiplicity equal to "1" are mapped to a name/value pair whose value is either a number, a string or one of the literal names false, null or true.

Attributes of scalar type with multiplicity bigger than "1" are mapped to a name/value pair whose value is a JSON array, and the array items are either a number, a string or one of the literal names false, null or true.

Attributes of structured type with multiplicity equal to "1" are mapped to a single name/value pair whose value is a JSON object, whose properties are described by the structured data type.

Attributes of structured type with multiplicity greater than "1" are mapped to a name/value pair whose value is a JSON array, and the items are JSON objects, whose properties are described by the structured data type.

6.1.11.3 Attribute property "isUnique"

The semantics of his attribute property is mapped to the "uniqueItems" keyword with a value set to true.

```

properties:
  flower:
    type: array
    uniqueItems: true
    items:
      type: string

```

6.1.11.4 Attribute property "isOrdered"

This attribute property is a requirement for the MnS producer and not mapped to any JSON schema keyword.

6.1.11.5 Attribute property "defaultValue"

This attribute property is a requirement for the MnS producer and not mapped to any JSON schema keyword.

NOTE: The OpenApi Specification [14] defines the "default" keyword. This default value represents what would be assumed by the consumer of the input as the value of the schema if a value is not provided in the consumed JSON instance document. The semantics of default in the OpenApi Specification [14] is hence different from the semantics of default in TS 32.156 [3].

6.1.11.6 Attribute property "isNullable"

The semantics of this attribute property is mapped to the "nullable" keyword with a value set to true.

Example:

```
properties:
  flower:
    type: string
    nullable: true
```

NOTE: The "nullable" keyword is defined only in the OpenApi Specification [14]. JSON schema as defined in [15], [16], [17] does not specify this keyword.

6.1.11.7 Attribute property "isInvariant"

This attribute property is a requirement for the MnS producer and not mapped to any JSON schema keyword.

6.1.11.8 Attribute property "isReadable" and "isWritable"

The semantics of these properties are mapped to the "readOnly" and "writeOnly" keywords with the values set according to the following table. The default value of the "readOnly" and "writeOnly" keywords is boolean "false".

Stage 2 statement	Stage 2 semantic	Stage 3 statements	Stage 3 semantic
isReadable=True (default) isWritable=True (default)	Attribute can be read. Attribute can be written.	readOnly=False (default) writeOnly=False (default)	Attribute can be read. Attribute can be written.
isReadable=True (default) isWritable=False	Attribute can be read. Attribute cannot be written.	readOnly=True writeOnly=False (default)	Attribute can be read. Attribute cannot be written.
isReadable=False isWritable=True (default)	Attribute cannot be read. Attribute can be written.	readOnly=False (default) writeOnly=True	Attribute cannot be read. Attribute can be written.
isReadable=False isWritable=False	Attribute cannot be read. Attribute cannot be written.	readOnly=True writeOnly=True	Attribute cannot be read. Attribute cannot be written.

If "writeOnly" for an attribute has a value of boolean "true", it indicates that the attribute shall never be present in instance documents sent by the MnS producer to the MnS consumer.

If "readOnly" for an attribute has a value of boolean "true", it indicates that the attribute shall never be present in instance documents sent by the the MnS consumer to the MnS producer.

Example:

```
properties:
  flower:
    type: string
    readOnly: true
    writeOnly: false
```

6.1.11.9 Attribute property "isNotifiable"

This attribute property is a requirement for the MnS producer and not mapped to any JSON schema keyword.

6.1.11.10 Attribute property "allowedValues"

Allowed values for "string" are specified using the "minLength", "maxLength" and "pattern" keywords.

Allowed values for "number" and "integer" are specified using the "multipleOf", "maximum", "exclusiveMaximum", "minimum" and "exclusiveMinimum" keywords.

Allowed values of any type can be restricted by using the "enum" and "const" keywords.

6.2 Stage 3 YANG style and example

The next clause defines general rules for YANG modules. The following clauses specify how specific Stage to constructs should be mapped to YANG. Each clause may include the following clauses:

- The clause of Reference [3] for which mapping is specified.
- An example model that will be mapped.
- Mapping rules.
- An example of the resulting YANG statements.

6.2.1 General Modeling Rules

6.2.1.1 Modeling Resources

Resources shall be modeled as YANG data nodes (leaf, leaf-list, container, list) instead of Classes and Attributes. Specific operations shall be modelled as YANG actions.

6.2.1.2 Unique YANG Module names

The names of 3GPP YANG modules shall start with the "_3gpp" prefix.

6.2.1.3 Unique YANG Namespace

The namespace of a 3GPP YANG module's namespace shall have the following form:

```
urn:3gpp:saX:<module-name>
```

saX denotes the group creating the relevant YANG model e.g. "sa5"

Reference: <https://tools.ietf.org/html/rfc8407#section-4.9> [11].

6.2.1.4 Unique YANG Module Prefixes

3GPP YANG Modules shall use prefixes ending with "3gpp". Prefixes should be short preferably not longer than 10 characters.

e.g. prefix nrmttype -> prefix nrmttype3gpp

NOTE: To ensure that the prefix (in the yang prefix statement) is globally unique a prefix-suffix is used. While global uniqueness of prefixes is not mandatory most SW implementations have problems and need workarounds in case conflicting prefixes are found.

6.2.1.5 Use YANG Version 1.1

YANG version 1.1 shall be used.

6.2.1.6 YANG Constructs Not to be Used – Not needed

The following YANG constructs shall not be used in 3GPP YANG models as they are not available in the Stage 2 modeling terminology, thus not needed.

- Anydata

- AnyXml
- Rpc – use actions instead
- Deviation

6.2.1.7 Reuse Standards from Other Standard Organizations

Whenever there is a suitable existing standard from another standard organization or industry forum its usage should be preferred before defining a 3GPP model covering the same scope. E.g. ietf-types, ietf-inet-types

3GPP models shall link to and reference YANG models from other standard organizations/industry forum whenever applicable.

6.2.1.8 Vendor Specific Model Changes

Vendors shall not modify 3GPP YANG modules either by changing the original file or by adding vendor specific YANG modules that contain deviations targeting parts of a 3GPP module. Only the following exceptions are allowed from the above rule:

- Deviations that maintain backwards compatibility as defined in RFC 7950 [18] are allowed
- Marking as "not supported" any model element that is optional to support as defined by the 3GPP stage 2 supportQualifier is allowed.

Vendors extensions shall be done in separate YANG modules; they do not impact compliance.

6.2.1.9 Model Correctness, checking

3GPP YANG modules shall be checked with the pyang tool. See: [PYANG an extensible YANG validator and converter](#)

The "pyang --strict" command shall be run with no errors returned.

"pyang --lint" should also be run against all 3GPP YANG modules. Errors and warning produced by the "pyang --lint" checks should be removed. However, as these errors/warnings do not affect the correctness or functionality of the YANG module, and in some cases the changes needed to remove them would actually degrade readability, it is not a required to remove the errors/warnings produced by the "pyang --lint".

6.2.1.10 YANG modules in technical specifications

When YANG modules are listed in Technical specifications, they shall always be listed with their revisions in the format `_3gpp-module-xyz@2019-12-24.yang`.

If a module's text is included in a technical specification, each YANG module shall be contained in a separate clause. The clause's title shall not include the revision date of the module.

To facilitate automatic code extraction from the MS Word specification the module's first statement shall:

- start with the keyword "module" in the first place (no whitespace allowed before it on the line).
- followed by a single space.
- followed by the name of the module.
- followed by a single space and an opening curly bracket "{".

All following lines shall be indented at least with two spaces.

The modules last closing curly bracket "}" shall be in the first place (no whitespace allowed before it on the line) with nothing else on the same line.

6.2.1.11 Module header statements

A module's organization and description statements shall be present. The organization shall include the string "3GPP".

A module shall contain the following contact statement:

```
contact "https://www.3gpp.org/DynaReport/TSG-WG--S5--officials.htm?Itemid=464;"
```

6.2.1.12 Provide description and reference statements

A "description" statement should be present for each YANG schema node. As an exception: for individual leafs, leaf-lists, enums, case statements, typedef statements, where the schema node's name describes the node sufficiently, the "description" may be omitted.

A "reference" substatement to the module statement shall be present that specifies the technical specification where the YANG module is defined. In order to easily list with a "grep" command YANG modules belonging to a specific technical specification, the format of the first line of this reference statement shall start exactly with:

- new-line followed by
- the string ' reference "3GPP TS '
 - (that is 2 leading spaces + reference + 1 space + a double quote + 3GPP TS + 1 more space) followed by
- the number of the technical specification.

E.g. " reference "3GPP TS 28.622".

6.2.1.13 YANG module revisions

A separate "revision" statement shall be present for each published version of a module. The revision statement shall contain a reference substatement listing the numbers of all 3GPP change requests and any other documents that resulted in the creation of the new revision.

Example:

```
revision 1956-10-13 {
  reference "CR-0258, CR-0267";}
```

NOTE: Void.

If multiple change requests modify the new revision of a YANG module, the content of the reference substatements should be merged.

6.2.1.14 Don't use YANG statements with their default meaning

YANG statements config, mandatory, max-elements, min-elements, ordered-by, status, yin-element have a specific meaning even if they are absent. The default meaning for these statements should not be explicitly declared in a YANG Module.

E.g. if the mandatory statement is missing that is equivalent to the situation where "mandatory false" is specified; it does not change the meaning of the YANG module, it just makes it longer.

6.2.1.15 Formatting YANG modules/submodules

YANG modules are part of the end-user documentation so to enhance readability the following guidelines should be followed. The guidelines are important as YANG files are often compared and processed as simple text files by SW tools.

- YANG modules should not contain lines longer than 80 characters. (YANG files are often read by the end-users as-is, and reading files with long lines is problematic.)
- A line in a YANG should not contain whitespace (space, tab) immediately before the end of a line or at the end of the file after the last non-blank line. Additional whitespace will confuse tooling when comparing different versions of the YAM.

- Instead of tabs consecutive spaces (a.k.a. soft-tabs) should be used. As different editors use different length tabs (2,4,8 characters long) the indentation of the module might become messed up. Using mixed indentation (both hard-tabs and spaces) is especially problematic.
- In order to avoid long lines the normal indentation should be 2 spaces.
- YANG files should not use characters outside the US-ASCII character set unless there is a specific need for it.
- End-of-line separator SHALL use only a single Newline without a Carriage-Return character.

6.2.2 InformationObjectClass – abstract

6.2.2.1 Introduction

Reference [3] clause 5.4.2

6.2.2.2 YANG mapping

An abstract class shall be mapped to a "grouping". The name of the "grouping" will be <IocName>Grp. The "grouping" shall contain all attributes of the class. The naming attribute shall only be contained as a YANG comment, because all other attributes will be contained in a YANG "non-presence container" named "attributes", however the "key leaf" is contained immediately by the "list", it cannot be inside a child "container".

```
// abstract class MyClass_  
grouping MyClass_Grp {  
  // contains all contained attributes  
  // the leaf of the namingAttribute is either not included or  
  // included only as a comment not as a real definition  
  
  // leaf id {  
  //   type string;  
  //   description "naming attribute of the IOC";  
  // }  
  leaf attribute1 {..}  
  leaf-list attribute2 {..}  
}
```

6.2.3 Naming attribute

6.2.3.1 Introduction

Reference [3] clause 3.1

6.2.3.2 Yang mapping

The "leaf" that is mapped from the naming attribute shall be used in the YANG "key" statement. This is usually called "id" as defined in the Top_class in TS 28.620 Umbrella Information Model (UIM), clause 4.3.8.

6.2.4 InformationObjectClass – concrete

6.2.4.0 Introduction

Reference [3] clause 5.3.2

6.2.4.1 YANG mapping

A concrete class shall be mapped to a "list" that "uses" a "grouping". The "grouping" shall be named <IocName>Grp. It shall contain all attributes of the class in the same manner as the "grouping" for an abstract class. The "list" shall be

named <IocName>. The NamingAttribute shall be used as a key. All other attributes shall be placed inside a "container" named "attributes". The "container attributes" will facilitate asking for all attributes of an object instance with a simple subtree or XPath filter.

```
//concrete class
grouping MyConcreteClassGrp {
  // contains all attributes in the same manner as
  // a grouping for abstract class
}

list MyConcreteClass {
  key namingAttribute; // usually named 'id'
  leaf namingAttribute {...}
  container attributes {
    uses MyConcreteClassGrp ;
  }
  //YANG lists representing contained classes
}
```

6.2.5 Generalization relationship - inheritance from another class

6.2.5.1 Introduction

Reference [3] clause 5.2.5

Example model: Class MyManagedFunction inherits from class ManagedFunction.

6.2.5.2 YANG mapping

Generalization/Inheritance relationships are mapped to the inheriting class using the "grouping" of the inherited class in its own "grouping".

```
// Inheritance

grouping ManagedFunctionGrp {
  // Attributes of ManagedFunction
}

grouping MyManagedFunctionGrp {
  uses ManagedFunctionGrp;
  //additional attributes
}

list MyManagedFunction {
  key id;
  leaf id {}
  container attributes {
    uses MyManagedFunctionGrp;
  }
}
```

6.2.6 Name containment

6.2.6.1 Introduction

Reference [3] clause 5.2.4 - Composite aggregation association relationship

Example model: The classes ManagedElement and MyClass are defined in YANG module TS1. According to the stage2 definition ManagedElement contains MyClass. Another YANG module (TS2) defines class GnodeB. According to the stage2 definition ManagedElement contains GnodeB.

6.2.6.2 YANG mapping

The containment of classes defined in the same YANG module is mapped as embedded "lists".

Containment of classes defined in different YANG modules is mapped using the "augment" statement.

```
// Class containment
module TS1 {
  grouping MyClassGrp {
    // subnetwork attributes
  }
  grouping ManagedElementGrp {
    // managedElement attributes
  }

  list ManagedElement {
    key id;
    leaf id {}
    attributes {
      use ManagedElementGrp;
    }
    list MyClass {
      key id;
      leaf id {}
      attributes {
        uses MyClassGrp;
      }
    }
  }
  // place to insert/augment managedFunctions e.g. EnodeB
}

module TS2 {
  import _TS1 { prefix ts1; };
  grouping GNodeBGrp {
    // GNodeB attributes
  }
  augment /ts1:ManagedElement {
    list GNodeB {
      key id;
      leaf id {}
      attributes {
        uses GNodeBGrp;
      }
    }
    // lists representing child classes in the same module
  }
}
}
```

6.2.7 Recursive containment - reference based solution

The NRM information object class stage 2 definition contains one case where a class contains itself (so called recursive containment): the It is the SubNetwork class.

The name containment that a class has with itself in the stage 2 definition shall be modeled using a pair of "leaf-list" references between the instances of the class. The references shall be named "leaf-list parents {...}" and "leaf-list containedChildren {...}". Note the 2 reference "leaf-lists" should be defined directly under the "list" defining the class not in its "grouping" because the "path" statements are specific to each class, so the "leaf-lists" must not be inherited.

```

list SubNetwork {
  key id;
  leaf id {...}

  container attributes {
    uses SubNetworkGrp;
    leaf-list parents {
      description "Reference to all containing SubNetwork instances
        in strict order from the root subnetwork down to the immediate
        parent subnetwork.
        If subnetworks form a containment hierarchy this is
        modeled using references between the child SubNetwork and the parent
        SubNetworks.
        This reference MUST NOT be present for the top level SubNetwork and
        MUST be present for other SubNetworks.";
      type leafref {
        path "../..../SubNetwork/id";
      }
    }

    leaf-list containedChildren{
      description "Reference to all directly contained SubNetwork instances.
        If subnetworks form a containment hierarchy this is
        modeled using references between the child SubNetwork and the parent
        SubNetwork.";
      type leafref {
        path "../..../SubNetwork/id";
      }
    }
  }
}

```

The following instance data example shows how the reference values specify the SubNetwork hierarchy:

```

Top level:  subnet=root
            | \ +-----+
            | +-----+ | |
Level 1:    subnet=A1  subnet=B1  subnet=C1
            | \ +-----+
            | +-----+ | |
Level 2:    subnet=A2  subnet=B2  subnet=C2
            | \ +-----+
            | +-----+ | |
Level 3:    subnet=A3  subnet=B3  subnet=C3

Top level:  id=root          parents=null          containedChildren= A1,B1,C1
Level 1:    id=A1,(B1,C1)  parents=root          containedChildren = A2,B2,C2
Level 2:    id=A2,(B2,C2)  parents=root,A1       containedChildren = A3,B3,C3
Level 3:    id=A3,(B3,C3)  parents=root,A1,A2    containedChildren = A4,B4

```

When reading/writing self-contained classes only the last such class instance needs to be specified in the Netconf request as that uniquely identifies the exact instance. The following Netconf request could be used to retrieve all attributes of SubNetwork=root, SubNetwork=A1, SubNetwork=B2, NRFFrequency=22

```

<rpc message-id="101" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-config>
    <source>
      <running/>
    </source>
    <!-- SubNetwork=root, SubNetwork=A1, SubNetwork=B2, NRFFrequency=22 -->
    <filter type="subtree"/>
    <SubNetwork>
      <id>B2</id>
      <NRFFrequency>
        <id>22</id>
      </NRFFrequency>
    </SubNetwork>
  </get-config>
</rpc>

```

There is no need to specify the ancestors `SubNetwork=root`, `SubNetwork=A1` as any `subNetwork` can be addressed directly.

6.2.8 Multi-root management tree

YANG supports multi-rooted managed models natively; the standardized IETF models have many root "list"/"container" nodes.

6.2.9 Alternative containment

Stage 2 models allows multiple different name-containment hierarchies. A particular name-containment hierarchy implemented by a specific vendor/product can be discovered in run-time, by reading the content of the `ietf-yang-library` and the `ietf-yang-schema mount` modules.

YANG provides multiple possible methods to model alternative containment hierarchies.

In cases where the number of YANG modules affected by the alternative containment is small, the use of a feature-controlled augmentation is proposed.

```
augment "/SubNetwork" {
  if-feature ExternalsUnderSubNetwork ;
  uses ExternalNRCellCUWrapper ;
}
```

In cases where the number of YANG modules affected by the alternative containment is large (cca. more than 8), the following mapping is proposed (using the optional containment of `SubNetwork` and `ManagedElement` as an example):

- If the `ManagedElement` is a root class, no further documentation or implementation steps are required.
- If the `ManagedElement` shall be contained under `Subnetwork` it shall be mounted under the `SubNetwork` "list" using the YANG schema mount mechanism as described in RFC8528.[13]

Mounted schemas will appear in Netconf, the CLI and management GUIs as if they were part of a common containment hierarchy.

Yang Schema Mount provides vendor the flexibility of arranging the containment tree in accordance of operator intention, and provides a way for a consumer to discover the actual mount and containment hierarchy in run-time.

6.2.10 Attribute – simple, single value

6.2.10.1 Introduction

Reference TS 32.156 [3] clause 5.2.1

The multiplicity of the attribute is either 0..1 or 1..1. Whether zero is allowed is defined by the `isNullable=true/false` property.

6.2.10.2 YANG Mapping

Non-structured single value attributes are mapped to a "leaf".

```
// attribute single value, nonstructured
leaf myAttribute { type xxx; }
```

6.2.11 Attribute – simple, multivalued

6.2.11.1 Introduction

Reference [3] clause 5.2.1

The multiplicity of the attribute may be greater than 1.

6.2.11.2 YANG mapping

If the attribute is `isUnique=true` or `isWritable=false` it is mapped to a leaf-list.

If the attribute is `isUnique=false` and `isWritable=true` map it to a list with an additional dummy index. The name of the list shall be `<attributeName>Wrap`. The name of the dummyIndex shall be `idx` and shall have a type `uint32` or `uint64`.

```
// Attribute multivalue, non-structured

// attribute is unique or read-only
leaf-list mySimpleMultivalueAttribute1 { type xxx; }

// attribute is non-unique and read-write
list mySimpleMultivalueAttribute2Wrap {
  key idx;
  leaf idx { type uint32 ; }
  leaf mySimpleMultivalueAttribute2 {type xxx;}
}
```

6.2.12 Attribute, structured

6.2.12.0 Introduction

Reference TS 32.156 [3] clause 5.2.1

6.2.12.1 YANG Mapping

Structured attributes are mapped to a grouping containing member parts; and a list using the grouping. (Structured attributes that are not used in multiple places may define the member parts directly in the list.)

```
// attribute, structured, isUnique=true OR isWritable=false
grouping pLMNIdGrp {
  description "PLMN-Id= Mobile Country Codes (MCC) &
  Mobile Network Codes(MNC)";
  leaf MCC {
    type t_mcc;
  }
  leaf MNC {
    type t_mnc;
  }
}

list pLMNIdList {
  key "MCC MNC";
  config true;
  description "a list of PLMN-Ids";
  ordered-by user;
  uses pLMNIdGrp;
}

// attribute, structured, isUnique=false, isWritable=true
list pLMNIdList {
  key "idx";
  leaf idx { type uint32 ; };
  leaf member1 { type xxx ; }
  leaf member2 { type yyy ; }
}
```

If the attribute is `isUnique=true` in YANG all member parts should be specified as keys. If it is known that one or a subset of members are unique without considering the rest of the members, it is allowed to specify only the unique subset as keys.

If the attribute is `isUnique=false` and `isWritable=false`, the YANG "key" statement is not used. YANG allows defining `ReadOnly` lists without a key.

If the attribute is `isUnique=false` and `isWritable=true` an additional dummy index shall be defined in YANG. The name of the `dummyIndex` shall be `idx` and shall have a type `uint32` or `uint64`.

6.2.13 defaultValue

6.2.13.1 Introduction

Reference TS 32.156 [3] clause 5.2.1.1.

The 3GPP/UML `defaultValue` has a different meaning than the YANG "default" statement.

The 3GPP `defaultValue` could be considered an `initialValue` as it has effect only at object creation. If the attribute is later deleted the 3GPP `defaultValue` has no effect. In YANG the "default" is always used whenever a leaf/leaf-list does not have a value: both at creation of the parent object and if the leaf/leaf-list is deleted (set to null in 3GPP operation).

NOTE: The 3GPP `defaultValue` is not used for structured attributes. In YANG there is no default value for containers or list entries.

6.2.13.2 YANG mapping

For a simple `isNullable=false` attribute use the YANG "default" statement.

For a simple `isNullable=true` attribute map the 3GPP `defaultValue` to the 3GPP YANG "yext3gpp:initial-value", extension. (Defined in the `_3gpp-yang-extensions` module). The `initial-value` property should also be included in the data node's "description" statement.

NOTE 1: For simple attributes that are `isUnique=false` and `isWritable=true` that are mapped to YANG lists neither the YANG default nor the "yext3gpp:initial-value", statement can be used. The 3GPP default shall be documented only in the description text.

NOTE 2: extensions are not understood or enforced by standard YANG tools, they need extra SW implementation.

6.2.14 multiplicity and cardinality

6.2.14.0 Introduction

Reference TS 32.156 [3] clause 5.2.1.1

Reference TS 32.156 [3] clause 5.2.8

6.2.14.1 YANG mapping

Multiplicity of attributes mapped to a list or leaf-list shall be mapped to the "min-elements" and "max-elements" YANG statements.

Cardinality for containment of classes shall be mapped to "min-elements" and "max-elements" on the list representing the child objects.

Cardinality for reference relationships shall be mapped to "min-elements" and "max-elements" on the reference attributes representing the reference.

6.2.15 isNullable

6.2.15.0 Introduction

Reference TS 32.156 [3] clause 5.2.1.1

6.2.15.1 YANG mapping

isNullable=true for attributes that are mapped to a leaf shall be mapped to a "mandatory false;" YANG statement.

isNullable=false for attributes that are mapped to a leaf shall be mapped to a "mandatory true;" YANG statement.

isNullable=true for an attribute that is mapped to a list or leaf-lists shall be mapped to "min-elements X; (where X is greater than zero.)"

isNullable=true for an attribute that is mapped to a list or leaf-lists shall be mapped to "min-elements 0;". However if the minimum multiplicity of the attribute is greater than zero then an additional "must" statement shall be added forbidding any multiplicity values between 1 and the minimum multiplicity (but allowing zero and the minimum).

NOTE: YANG/Netconf does not differentiate between a non-existent (NULL) sequence and a sequence with zero elements. However this distinction would be very confusing for the operator, so better not use it.

6.2.16 dataType

6.2.16.0 Introduction

Reference TS 32.156 [3] clause 5.3.4

Reference TS 32.156 [3] clause 5.4.3

6.2.16.1 YANG mapping

Mapping for predefined datatypes shall be the following:

- integer -> One of the 8 YANG integer types
- string -> string
- Boolean -> Boolean

3GPP user-defined datatypes shall be mapped to the YANG "typedef" statement.

6.2.17 enumeration

6.2.17.0 Introduction

Reference TS 32.156 [3] clause 5.3.5

6.2.17.1 YANG mapping

The 3GPP enumeration datatype shall be mapped to the YANG "enumeration" YANG type.

6.2.18 choice

6.2.18.0 Introduction

Reference TS 32.156 [3] clause 5.3.6

6.2.18.1 YANG mapping

The 3GPP choice stereotype shall be mapped to a Yang "choice" statement.

6.2.19 isInvariant on attribute

Reference [TS 32.156 [3] Model repertoire] clause 5.2.1.1

6.2.19.1 YANG mapping

Attributes with the property isWritable=false shall be mapped to YANG "config false;" leafs/leaf-lists/lists. Config=false nodes are controlled by the system. The user cannot change them at all; isInvariant=true is implied.

Attributes with the properties isWritable=true AND isInvariant=false shall be mapped to YANG "config true;" leafs/leaf-lists/lists.

Attributes with the properties isWritable=true AND isInvariant=true shall be mapped to YANG "config true;" leafs/leaf-lists/lists marked with the "yext3gpp:isInvariant" extension defined in the YANG module _3gpp-common-yang-extensions.yang in 3GPP TS 28.632.

NOTE: The combination of isInvariant=true AND isWritable=true can not be represented in YANG. YANG does not differentiate between the initial setting and a subsequent changing of an attribute. 3GPP defined the invariant extension statement to mark this 3GPP property. Generally, extensions are not understood or enforced by standard YANG tools, they need extra SW implementation.

6.2.20 isReadable/isWritable

Reference [TS 32.156 [3] Model repertoire] clause 5.2.1.1

6.2.20.1 YANG mapping

isReadable=false attributes can not be represented in YANG. Assumed not to be a problem. A YANG extension could be defined to handle it if needed.

Attributes with the properties isReadable=true AND isWritable=false shall be mapped to YANG config=false leafs/leaf-lists/lists. As config=false is inherited down the containment tree, it should not be placed on each leaf, leaf-list, etc. once the containing list/container is marked config false;

Attributes with the properties isReadable=true AND isWritable=true shall be mapped to YANG config=true leafs/leaf-lists/lists. "config true;" should not be explicitly declared as that is the default case.

6.2.21 isOrdered

Reference [TS 32.156 [3] Model repertoire] clause 5.2.1.1

6.2.21.1 YANG mapping

The property isOrdered=true shall be mapped to the "ordered-by user ;" YANG statement.

6.2.22 isUnique

Reference [TS 32.156 [3] Model repertoire] clause 5.2.1.1

6.2.22.1 YANG mapping

The property isUnique=True shall be mapped to the YANG "unique" statement. Leaf-list are always unique in YANG, no marking needed.

6.2.23 allowedValues

Reference [TS 32.156 [3] Model repertoire] clause 5.2.1.1

6.2.23.1 YANG mapping

For attributes with a type=integer or a user-defined type based on integers allowedValues shall be mapped to a YANG "range" statement with specific values.

For attributes with a type=string or a user-defined type based on string allowedValues shall be mapped either to an enumerated YANG type or to a sting with alternatives defined using the YANG "pattern" statement.

For attributes with a type=enumeration or a user-defined type based on enumeration allowedValues shall be mapped to a YANG enumeration type restricted with YANG "enum" substatements. (<https://tools.ietf.org/html/rfc7950#section-9.6.3>)

6.2.24 Xor constraint

Reference [TS 32.156 [3] Model repertoire] clause 5.2.10

6.2.24.1 YANG mapping

Model elements with a Xor constraint shall be mapped to the YANG "choice" statement.

6.2.25 ProxyClass

Reference [TS 32.156 [3] Model repertoire] clause 5.3.1

6.2.25.1 YANG mapping

A proxyclass is not directly mapped to YANG. A proxyclass represents a number of specific classes. Attributes, links, methods (or operations), and interactions that are present in the proxyclass shall be modelled in the represented specific classes.

6.2.26 SupportQualifier

6.2.26.1 Introduction

Reference [3] clause 6 - Qualifiers

6.2.26.2 YANG mapping

SupportQualifier=M is the default case in YANG so it needs no mapping.

SupportQualifier=O shall be mapped the same way as SupportQualifier=M. Just like in the other solution sets the supportQualifier shall not be directly visible in the 3GPP Stage 3 YANG model. The support is indicated the following way:

- If the vendor supports an optional item, there is no further modeling needed
- If the vendor does not support the optional item, it needs to create a separate vendor specific YANG module and include a "deviation" statement in it formally declaring the non-supported parts. A single YANG module may contain any number of deviations. E.g.:

```
deviation /ManagedElement/attributes/optionalAttribute {deviate not-supported;}
```

SupportQualifier=CO {if the item is not supported} is mapped the same way as a not supported SupportQualifier=O item.

SupportQualifier=CM & CO (if item is supported) shall be mapped as a SupportQualifier=M item, also considering the following:

- if the condition can be expressed with XPATH, an additional "when" statement shall be used.
- otherwise make the data node non-mandatory and define the condition in the description statement.

6.2.27 isNotifiable

6.2.27.1 Introduction

Reference TS 32.156 [3] clause 5.2.1.1

6.2.27.2 YANG mapping

Attributes that are isNotifiable=False shall be marked with the "yext3gpp:notNotifiable" YANG extension statement defined in the YANG module _3gpp-common-yang-extensions.yang.

Attributes that are isNotifiable=True shall not be marked in any way, as it is a default case.

Annex A (informative): Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2019-09	SA#85					Change control version	16.0.0
2019-12	SA#86	SP-190172	0001	-	F	Implement Edithelp comments	16.1.0
2019-12	SA#86	SP-190172	0002	-	F	Solutions for Editor's notes →Not implemented due to CR clash (MCC)	16.1.0
2019-12	SA#86	SP-190172	0003	1	F	Resolution of Editors Note in clause W4.3 Class definitions→ not implemented due to CR clash (MCC)	16.1.0
2019-12	SA#86	SP-191166	0004	2	B	Additions to YANG style Guide	16.1.0
2020-03	SA#87E	SP-200169	0005	-	B	YANG Guidelines Update	16.2.0
2020-03	SA#87E	SP-200172	0006	-	F	Remove incorrect example from constraints table	16.2.0
2020-03	SA#87E	SP-200172	0007	-	F	Resolution of Editors Note in clause W4.3 Class definitions	16.2.0
2020-07	SA#88E	SP-200489	0008	1	B	Update YANG Guidelines	16.3.0
2020-07	SA#88E	SP-200490	0009	-	B	Update YANG Guidelines	16.3.0
2020-12	SA#90e	SP-201089	0011	-	F	Fix incorrect reference in notification template	16.4.0
2020-12	SA#90e	SP-201089	0012	-	F	Update thresholdCrossingNotification to be a common notification.	16.4.0
2021-06	SA#92e	SP-210416	0017	-	F	Align different (abbreviated) names for support qualifier to "S"	16.5.0
2021-06	SA#92e	SP-210418	0020	1	F	Change format for NRM stage 3 definition rules from JSON to YAML	16.5.0
2022-12	SA#98e	SP-221171	0029	-	F	Add missing mapping of isNotifiable	16.6.0

History

Document history		
V16.3.0	August 2020	Publication
V16.4.0	January 2021	Publication
V16.5.0	August 2021	Publication
V16.6.0	January 2023	Publication