Microwave Information Model

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Document History

Version	Date	Description of Change
0.1	August 7th, 2016	Initial version of the Microwave Information Model as technology specific extension to the TR-512 ONF Core Information Model 1.1 [ONF CM]
0.2	November 18th, 2016	Consolidating review comments and findings of the 3rd MW PoC. Version for ONF-wide review.
1.0	December 15th, 2016	Consolidating comments of the ONF-wide review and finalizing for approval by ONF Tech Council. Version for official publishing.

1.1.0-1	February 15th, 2019	Consolidating all improvements discussed in the wireless transport project since publishing version 1.0, incorporating the information and data models of the 5th ONF PoC, provided for review on project level.
1.1.0-2	March 4th, 2019	Consolidating all feedback from review on project level, provided for review on working group level.
1.1.0	April 10th, 2019	Finalized and published as ONF TR-532 v1.1
2.0.0-1	January 4th, 2024	Updating the document and changing from explicit listing to references
2.0.0	January 23rd, 2024	Finalized and published as ONF TR-532 v2.0

1 Introduction

This ONF Technical Recommendation (TR) is a collection of technology specific extensions to the TR-512 ONF Core Information Model 1.4.1 [ONF CM]. This management-control is expected to be achieved by wireless devices and SDN applications within or on top of an SDN Controller.

The biggest difference between version 2.0 and its predecessors is that the previously monolithic Microwave Information Model has been broken down into its technology-specific components. These can now be combined on a device-specific basis.

Apart from that, the provided version 2.0 comprises several new models and it consolidates solutions to all the findings made during appliance of version 1.1 e.g., in the live network of Telefonica Germany.

2 Definitions

2.1 Terms

The primary purpose of this document is to define terms and hence terms are defined throughout the document. Key terms are highlighted in section 2.2 Abbreviations and Acronyms of this document and of the TR-512 ONF Core Information Model 1.4.1 [ONF CM] by referring to the section in this document where the term is defined.

2.2 Abbreviations and Acronyms

Term	**Explanation**
ALIC	Adjacent Link Interference Cancelation
ATPC	Automatic Transmit Power Control
CEPT	European Conference of Postal and Telecommunications Administrations
CPRI	Common Public Radio Interface
CTP	Connection Termination Point
Cur	Current
DCN	Data Communication Network

Term	Explanation
E1	TDM frame containing 30 digital voice channels
ERC	European Research Council
FC	Forwarding Construct
FD	Forwarding Domain
FDD	Frequency Division Duplexer
Hsb	Hot stand-by
ID	Identifier
Int	Integer
IP	Internet Protocol
L3VPN	Layer 3 Virtual Private Network
LLDP	Link Layer Discovery Protocol
LTP	Logical Termination Point
MAC	Media Access Control
MIMO	Multiple Input Multiple Output Transmission
MW	Point-to-point microwave, including millimeter wave
NGFI	Next Generation Fronthaul Interface
ODU	Outdoor Unit
*_Pac	Technology Specific Conditional Package
PDH	Plesiochronous Digital Hierarchy
PmP	Point-to-multipoint
REC	Recommendation
Ref	Reference
Rx	Receive
QoS	Quality of Service
SDH	Synchronous Digital Hierarchy
SDN	Software Defined Network
SFP	Small Form-factor Pluggable
SNCP	Sub-Network Connection Protection
TDD	Time-Division Duplexer
TDM	Time-Division Multiplexing
TTP	Trail Termination Point
TR	ONF Technical Recommendation
tx	Transmit

Term	Explanation
UUID	Universally Unique Identifier
VLAN	Virtual Local Area Network
WRED	Weighted Random Early Detection
XPIC	Cross Polarization Interference Cancelation

Table 1: Abbreviations and Acronyms

3 Compliance Statement

Completeness

A device's interface must not be denoted as compliant to this Microwave Information Model, if it doesn't implement all components, which are required to manage the functionalities that are available at the device.

Support

The hardware does not necessarily need to make available all functionalities covered by this modeling. In case some functionality is not available at the hardware, the device's interface shall answer the default values defined in this model. All functionalities, which are available at the hardware and covered by the Microwave Information Model, must be manageable with this model (to the extent of the comprised attributes).

Options

This Microwave Information Model offers two alternative modeling of the logical structuring of the physical resource provided by the radio link. The device's interface must at least implement the alternative, which is specific to its device type (e.g., pure Ethernet, Ethernet+TDM Hybrid).

Proprietary Extensions

Interfaces implementing components of this Microwave Information Model that contain additional vendor-specific attributes must not be denoted as compliant. Such interfaces might be called "based on" or "expanding" it.

4 Overview of the Microwave Information Model

4.1 Coverage

The Microwave Information Model covers the following aspects:

- The radio link with its analogue characteristics like center frequency, channel bandwidth, modulation etc.
- Grouping of radio links into diversity, protection and frequency re-use configurations
- Segmentation of the transport resources provided by a radio link
- Allocation of higher layer traffic flows (e.g., Ethernet, E1, CPRI) on these segments
- Bundling of several radio links' resources for Ethernet transport
- Header compression on the transmission path
- Ethernet PHY according to IEEE 802.3 from 10Mbit/s to 100Gbit/s
- Ethernet Layer 1 connections inside the device

- Frame handling in regards of policing, scheduling, and managed discarding
- Ethernet MAC according to IEEE 802.1 including Quality of Service (QoS) and MAC table reading
- Virtual Local Area Network (VLAN) according to IEEE 802.1Q
- VLAN connections inside the device incl. CustomerBridge, ProviderBridge and ProviderEdgeBridge
- Link Layer Discovery Protocol (LLDP) according to IEEE-802.1AB
- Basic IPv4 interfaces according to IETF RFC 791 and Layer 3 Virtual Private Networks
- Synchronization according to ITU-T G.7721
- Firmware Management and Back-up-and-Restore
- Equipment in general and particularly transmitters like ODUs and SFPs

It does not cover e.g. user management, DCN, IP routing, or TDM multiplexing.

The Microwave Information Model provides the necessary attributes for

- the device informing the SDN Controller about its technology specific capabilities
- the Controller configuring the device
- the device providing status, problem and performance information

The structures and attributes for notifying alarms, object creations, object deletions and attribute value changes are harmonized across all technology specific components of the Microwave Information Model.

4.2 Overview

The following picture visualizes some relationships between the technology specific components provided within this specification.

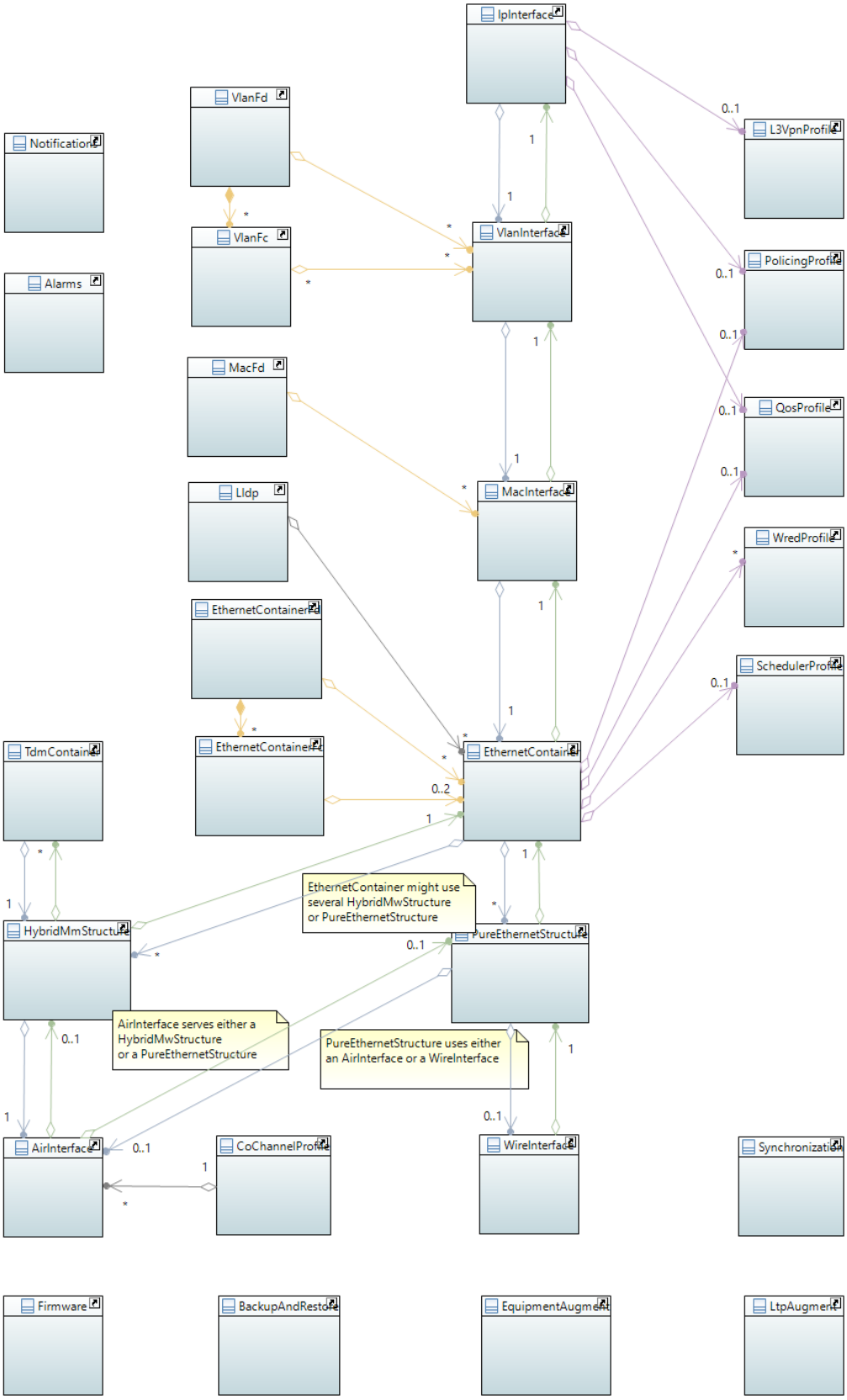

Figure 1: Model Overview

The representing of the hardware inventory of the device is covered by the Equipment section of the ONF CM. This modeling is very generic. Practical experience has shown that additional harmonization is required to ensure that the attributes provided in the ONF CM are consistently populated across implementations from different vendors.

The TransmitterEquipment specification defines such a harmonization particularly for ODUs and SFPs. It is also an essential part of this document (TransmitterEquipment_2.0.0-tsi.240104.1625+spec.1).

5 Conventions

5.1 UML Modeling Conventions

This TR follows the conventions as described in the TR-512 ONF Core Information Model 1.4.1 [ONF CM] and the TR-514 ONF UML Modeling Guidelines [ONF UMLG].

5.2 Default Values

An attribute representing the default value during operation shall indicate the underlying feature not being supported by the hardware.

The default values in the Microwave Information Model have been defined in accordance with the following basic principles:

- Every attribute (except keys, which have to be unique, references and RPC parameters) shall have a default value.
- The default value shall be inside the value range of the data type of the attribute.

- Capability attributes:
  - The default value shall either indicate unavailability of the functionality (if applicable)
  - or be outside the range of reasonable values of the attribute.

- Configuration, status, and performance attributes:
  - The default value shall either represent the configuration, status or performance measurement value right after starting the device (in case such a “neutral” value is applicable to the attribute)
  - or be outside the range of reasonable values of the attribute.

Lists of data types shall contain the minimum multiplicity number of elements. This also means that lists of data types with a minimum multiplicity of zero shall just be empty as a default.

5.3 ONF Stereotypes

5.3.1 attributeValueChangeNotification

This stereotype defines whether a notification has to be raised, when the attribute changes its value.

It has been set on “true” for all attributes, which are comprised in Configuration classes or in data types used by attributes of the Configuration classes.

It has also been set on “true” for status attributes, which might be subject to automated changes, but do not represent gradually changing measurement values.

The attributeValueChangeNotification stereotype has been set on “false” for status attributes, which are exclusively following configuration activities. This is for avoiding double messaging.

5.3.2 objectCreationNotification and objectDeletionNotification

These stereotypes define whether a notification has to be raised when an instance of a class has been created, respectively deleted.

It has been set on “true” for all *_Pac classes, which are potentially attached to the LayerProtocol class of the Core Information Model.

5.3.3 isInvariant

This stereotype defines whether the value of the attribute can be changed, or not, after it has been created.

It has been set on “true” (means: cannot be changed) for the following attributes:

- *Ids, which are representing target addressed for referencing data types or classes, (except ContainerIDs, which are required for connecting logical traffic from outside the reach of the modeling with a Container)
- All attributes, which are comprised in Capability classes or in data types used by attributes of the Capability classes
- All attributes, which are comprised in data types that are attached to the *Performance classes.
- All attributes, which are comprised in Notifications

It has been set on “false” (means: can be changed) for the following attributes:

- All attributes, which are comprised in Configuration classes
- All attributes, which are comprised in Status classes or in data types used by attributes of the Status classes

5.3.4 valueRange

This stereotype identifies the allowed values for the attribute.

It has not been used within the Microwave Information Model, because of a conflict with the policy defined for default values in chapter 5.2

5.3.5 partOfObjectKey

This stereotype indicates whether the attribute is part of the object key or not. Value “0” (default) means the attribute is not part of the object key. Values > “0” indicate that the attribute is part of the object key and the value defines the order of the attribute in case the key is composed of more than one attribute.

5.3.6 unit

This optional stereotype contains a textual definition of the unit associated with the attribute’s value.

The following units have been used in the Microwave Information Model

Unit	**Meaning**
%	Percentage
Bytes	Total number of Bytes
Bytes/min	Bytes per minute
Bytes/s	Bytes per second

Unit	Meaning
Celsius	Degree Celsius
dB	Decibel
dBm	Decibel milliwatt
error/s	Errors per second
frame/s	Frames per second
kbit/s	1000 bit per second
kHz	1000 Hertz
packet/s	Packets per second
s	Second
symbols	Number of symbols

Table 2: Units

5.3.7 Support Qualifier

This stereotype qualifies the support of the object class at the management interface.

Aside the following exceptions, the SupportQualifier has always been left on its default value “mandatory”:

- The PureEthernetStructure_Pac class is “conditional_mandatory” for device types transporting pure Ethernet.
- The HybridMwStructure_Pac class is “conditional_mandatory” for device types transporting Ethernet + TDM.

5.3.8 bitLength

The bitlength stereotype has been used to define Integer primitives smaller than 64bit.

5.3.9 Unsigned

The unsigned stereotype has been applied whenever it was required to expand the positive value range of some attribute to its maximum.

5.3.10 Encoding and Counter

The encoding and counter stereotypes have not been applied.

6 Special elements

6.1 Multiple Structure Classes

The Microwave Information Model supports allocating traffic flows on the physical resources of the radio interface. The allocation is modeled by associating *Container classes with sub-segments provided by the *Structure classes.

The methods of sub-segmenting and allocating depend on the implementation of the wireless transport device (e.g. time division duplex vs. frequency division duplex, point-to-point vs. shared medium).

Due to the very basic differences of these methods and the ways of modeling them, the Microwave Information Model offers several Structure_Pacs that must be alternatively applied depending on the devices type (see also chapter 3).

The current version of the modeling offers Structure_Pacs for point-to-point links, which are implementing frequency division duplex and are distinguishing Pure Ethernet and Hybrid microwave links.

- The PureEthernetStructure_Pac offers a single segment, which might vary in size, if adaptive modulation is activated. One or several (only in case the value of the EthernetContainerCapability: bundlingIsAvail attribute is set on “1”) of those segments can be linked to an EthernetContainer_Pac.
- The HybridMwStructure_Pac provides multiple TDM segments, which are of fixed size, and an additional segment for Ethernet that is of variable size. There is a one-to-one relation between TdmContainer_Pac and TDM segment. The Ethernet segment behaves equally to the one provided by the PureEthernetStructure_Pac.

Besides allowing definition of much simpler *Structure classes, this way of modeling is also seen to be more flexible regarding future expansions.

6.2 TDM Containers

The Microwave Information Model basically allows transporting any kinds of TDM signals. This is possible, because neither TDM containers nor TDM segments are fixedly predefined in the modeling.

Instead, the Capability class of the TdmContainer_Pac is associated with a list of TdmContainerType data types. Name and bandwidth consumption of container types can be defined within the TdmContainerType data type. Prescriptions for names and sizes are made within the comments at the corresponding attributes.

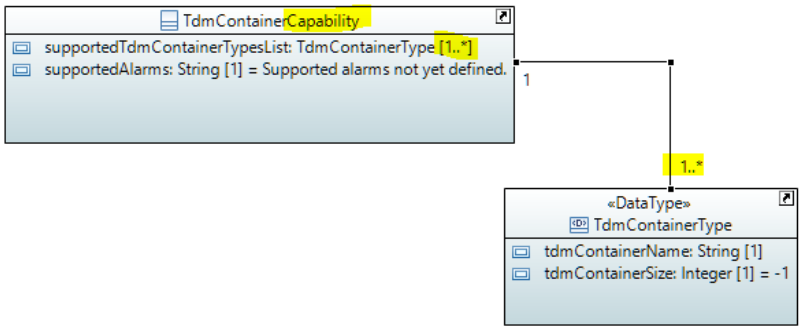

Figure 2: TDM Container Capabilities

The actual type of an instance of a TDM container can then be chosen from the defined types.

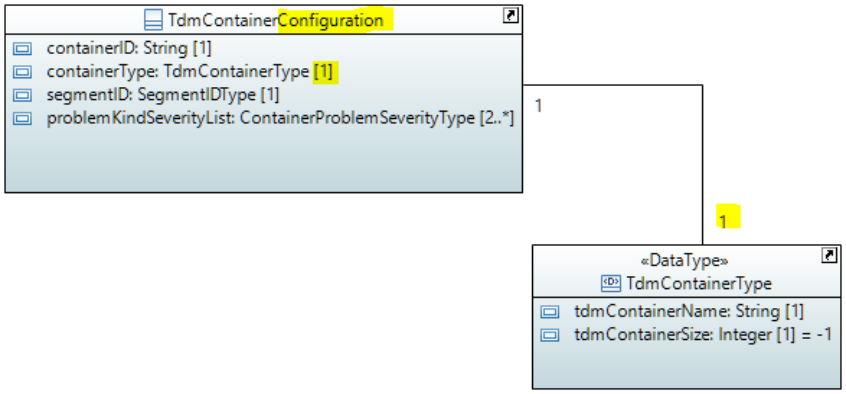

Figure 3: TDM Container Configuration

The modeling of the HybridMwStructure class is very similar. Obviously, bandwidth consumption of the container (tdmContainerSize attribute in TdmContainerType data type) and size of the transport resource (tdmSegmentSize attribute in TdmStructureType data type) have to have the same value for successful allocation.

6.3 TxPower Interpretation

AirInterface::AirInterfaceConfiguration::txPower shall be interpreted as a maximum value. Independently from any adaptive modulation or automated transmit power control (ATPC) configuration, the actually operated transmit power shall never exceed this value.

6.4 Adaptive Modulation Performance Data Interpretation

The TimeXStatesType data type is combining the definition of a transmission mode from the capabilities segment of the model with an Integer describing the length of the time period, in which this transmission mode had been operated. And the performance data holds a list of this data type.

This modeling does not outdate when vendors offer new combinations of modulation and coding scheme at their devices, but it has also some ambiguity to be ruled.

The number of the transmission modes, which is determined by all available combinations of channelBandwidth, modulationScheme, codeRate and symbolRateReductionFactor is assumed to usually exceed the number of TimeXStates, which is determined by the number of combinations of available performance values.

Example: In case a device does not collect performance data about the operated channelBandwidth it cannot differentiate corresponding TimeXStates. It is not clear, to which transmission mode some operation time period has to be associated, because the operated channelBandwidth has not been documented.

The following prescription is made to overcome this ambiguity:

The transmission mode, which is to be referenced in an instance of the TimeXStatesType data type, shall be chosen at first from the available performance data and after that still undefined channelBandwidth, modulationScheme, codeRate or symbolRateReductionFactor shall be chosen according to their status value at the end of the measurement period.

(txPowerMin, txPowerMax, rxThreshold, amUpshiftLevel, amDownshiftLevel and xpicIsAvail are determined by the combination of channelBandwidth, modulationScheme, codeRate and symbolRateReductionFactor, but do not contribute to the total number of different transmission modes.)

6.5 Capacity Calculation

The Microwave Information Model intentionally does not contain any attribute expressing a capacity. This is because interpretation of such value is differing a lot and misinterpretation is easily leading to errors of up to 20%.

Instead, it is recommended that the operator defines its own way of calculating capacities and applies this method on all kinds of media, including microwave. The Microwave Information Model comprises all necessary data for such calculation, even about packet compression, if wished to be regarded.

In case some operator or application provider would require some starting point for own considerations, the following proposal might be helpful.

Air interface capacity =

(channel bandwidth of the currently operated transmission mode)

/ (symbol rate reduction factor of the currently operated transmission mode)

* log2(number of states in the modulation scheme of the currently operated transmission mode)

* (code rate of the currently operated transmission mode)

/ 1.15

The symbol rate reduction factor is expressing a reduced symbol rate like 4 for ¼ BPSK or 2 for ½ BPSK. The code rate is to be calculated as the ratio of number of symbols carrying payload information to number of transmitted symbols, while the number of symbols carrying payload information equals the number of transmitted symbols – (number of symbols carrying overhead information + number of redundant symbols for forward error correction).

7 Backward Compatibility of this Version

Fundamental changes have been made to the structure of the Microwave Information Model since version 1.1. The originally monolithic model has been split into multiple technology-specific components (e.g., AirInterface and EthernetContainer modules) that can be flexibly combined. The method of attaching the individual component to the generic ONF CM has been changed, too. Modeling of both Alarms and Notifications have been separated from the technology-specific components and centralized.

Due to these fundamental changes to the structure, backward compatibility was ruled out from the start. Consequently, the present version has been labeled 2.0.

8 Changes in this Version

In addition to the modifications to the structure, technical contents have also been changed. Findings, discussions, and decisions are documented in GitHub Issues in the respective repository of each technology-specific component.

References to the repositories of all components that are part of this specification are listed in Annex A.

9 Backward Compatibility of the next Version

With this release, the Microwave Information Model is split into many individual components of varying maturity and separate version management.

It would not make sense to apply the concept of backward compatibility to the combined set of components in the future.

However, future versions of this specification will indicate whether newly added components can be used together with the ones being part of this version.

10 Future Work

Thanks to the constructive and persistent work of the ONF 5G-xhaul working group, the Microwave Information Model has reached completeness and maturity for use in operators' live networks. The first applications (REST server-based microservices) based on it have been convincing and are attracting further interest. The number of applications based on the interface is growing dynamically.

As a result, we expect a similarly dynamic increase of user requests for changes and extensions to existing models and beyond. In this sense, the Microwave Information Model is expected to advance from a provider-driven increase in attractiveness to a user-driven maximization of value.

We are looking forward to exciting discussions with our users about their needs.

11 Model and Specification Files

The components of the Microwave Information Model are defined by their UML models. These UML models are exports of Papyrus projects from Eclipse. The export files essentially contain the class diagram and a detailed description of all comprised classes, data types, associations, RPCs, attributes, and so on.

Other data formats are derived from the UML models. These include the graphical representation of the class diagram (overview), an MS Word document (GenDoc) verbally describing the classes and data types including their attributes, and the YANG modules generated by a translation tool.

Each UML model and its derived formats were compressed into a common zip file and added to the specification document before this set of files was also compressed into a common zip file, which is finally representing the entire ONF TR-532 version 2.0.

Further resources are provided to support the appliance of the Microwave Information Model. These include technology specific InterfaceValidators that can be used to automate the testing of the individual implementations of a component for conformity with its definition.

The definitions being part of this document can also be found alongside the associated resources in the GitHub repositories referenced in Annex A.

Please note that YANG module, data dictionary (GenDoc export), overview (png file) and associated resources (e.g., InterfaceValidator) are just implementations of the UML modeling files.

In case of any divergence, the UML modeling files are always the relevant data base.

12 References

Reference	Comment
[ONF CM]	TR-512 ONF Core Information Model Version 1.4.1, July 2023 (https://github.com/openBackhaul/core/tree/TR532v2_0)
[ONF UMLG]	TR-514 UML Modeling Guidelines; Version 1.3, September 2018 (https://opennetworking.org/wp-content/uploads/2018/08/TR-514_UML_Modeling_Guidelines_v1.3-1-1.pdf)

Table 3: References

13 Contributors

The ONF 5G-xhaul project gratefully acknowledges the following contributions to the Microwave Information Model and its associated resources.

Moderating the 5G-xhaul Project

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Reviewing and Commenting

Entire team

Annex A - Repositories

Repositories holding components of the Microwave Information Model and associated resources:

- AirInterface_2.0.0-tsi.240102.1740
  https://github.com/openBackhaul/AirInterface/tree/TR532v2_0
- Alarms_1.0.0-tsi.240122.1310
  https://github.com/openBackhaul/Alarms/tree/TR532v2_0
- BackupAndRestore_1.0.0-tsi.231005.1145
  https://github.com/openBackhaul/BackupAndRestore/tree/TR532v2_0
- CoChannelProfile_1.0.0-tsi.240103.1055
  https://github.com/openBackhaul/CoChannelProfile/tree/TR532v2_0
- CoreModel_1.4.1-tsi.230726.1645
  https://github.com/openBackhaul/Core/tree/TR532v2_0
- EquipmentAugment_1.0.0-tsi.240104.1330
  https://github.com/openBackhaul/Equipment/tree/TR532v2_0
- EthernetContainer_2.0.0-tsi.240104.1040
  https://github.com/openBackhaul/EthernetContainer/tree/TR532v2_0
- EthernetContainerFc_1.0.0-tsi.240103.1140
  https://github.com/openBackhaul/EthernetContainerFc/tree/TR532v2_0

- EthernetContainerFd_1.0.0-tsi.240103.0905
  https://github.com/openBackhaul/EthernetContainerFd/tree/TR532v2_0
- Firmware_1.0.0-tsi.240103.0940
  https://github.com/openBackhaul/Firmware/tree/TR532v2_0
- HybridMwStructure_2.0.0-tsi.240103.1130
  https://github.com/openBackhaul/HybridMwStructure/tree/TR532v2_0
- IpInterface_1.0.0-tsi.240105.1005
  https://github.com/openBackhaul/IpInterface/tree/TR532v2_0
- L3vpnProfile_1.0.0-tsi.240103.1150
  https://github.com/openBackhaul/L3vpnProfile/tree/TR532v2_0
- LLDP_1.0.0-tsi.240103.1220
  https://github.com/openBackhaul/LLDP/tree/TR532v2_0
- LtpAugment_1.0.0-tsi.240103.1010
  https://github.com/openBackhaul/LtpAugment/tree/TR532v2_0
- MacFd_1.0.0-tsi.240103.1245
  https://github.com/openBackhaul/MacFd/tree/TR532v2_0
- MacInterface_1.0.0-tsi.240105.1030
  https://github.com/openBackhaul/MacInterface/tree/TR532v2_0
- Notifications_1.0.0-tsi.230920.1200
  https://github.com/openBackhaul/Notifications/tree/TR532v2_0
- PolicingProfile_1.0.0-tsi.240104.1750
  https://github.com/openBackhaul/PolicingProfile/tree/TR532v2_0
- PureEthernetStructure_2.0.0-tsi.240103.1015
  https://github.com/openBackhaul/PureEthernetStructure/tree/TR532v2_0
- QosProfile_1.0.0-tsi.240104.1820
  https://github.com/openBackhaul/QosProfile/tree/TR532v2_0
- SchedulerProfile_1.0.0-tsi.240104.1835
  https://github.com/openBackhaul/SchedulerProfile/tree/TR532v2_0
- Synchronization_1.0.0-tsi.240103.1035
  https://github.com/openBackhaul/Synchronization/tree/TR532v2_0
- TdmContainer_2.0.0-tsi.240104.1855
  https://github.com/openBackhaul/TdmContainer/tree/TR532v2_0
- TransmitterEquipment_2.0.0-tsi.240104.1625+spec.1
  https://github.com/openBackhaul/Equipment/tree/TR532v2_0
- VlanFc_1.0.0-tsi.240104.1935
  https://github.com/openBackhaul/VlanFc/tree/TR532v2_0
- VlanFd_1.0.0-tsi.240104.1920
  https://github.com/openBackhaul/VlanFd/tree/TR532v2_0
- VlanInterface_1.0.0-tsi.240104.1910
  https://github.com/openBackhaul/VlanInterface/tree/TR532v2_0
- WireInterface_2.0.0-tsi.240104.1045
  https://github.com/openBackhaul/WireInterface/tree/TR532v2_0
- WredProfile_1.0.0-tsi.240104.1945
  https://github.com/openBackhaul/WredProfile/tree/TR532v2_0