International Telecommunication Union

ITU-T G.8052.1/Y.1346.1

(01/2021)

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Packet over Transport aspects – Ethernet over Transport aspects

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Operation, administration, maintenance (OAM) management information and data models for the Ethernet transport network element

Recommendation ITU-T G.8052.1/Y.1346.1

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
Ethernet over Transport aspects	**G.8000–G.8099**
MPLS over Transport aspects	G.8100–G.8199
Synchronization, quality and availability targets	G.8200–G.8299
Mobile network transport aspects	G.8300–G.8399
Service Management	G.8600–G.8699
ACCESS NETWORKS	G.9000–G.9999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T G.8052.1/Y.1346.1

Operation, administration, maintenance (OAM) management information and data models for the Ethernet transport network element

Summary

Recommendation ITU-T G.8052.1/Y.1346 specifies the management information model and data models for Ethernet transport network element (NE) to support specific interface protocols and specific management control (MC) functions. The information model is interface protocol neutral and specified using the unified modelling language (UML). The information model of this Recommendation is derived through pruning and refactoring from Recommendation ITU-T G.7711/Y.1702 core information model and Recommendation [ITU-T G.8052/Y.1346] foundation Ethernet transport NE information model. The data models are interface protocol specific and translated from the information model with the assistance of automated translation tooling. The specific data models considered in this Recommendation include, but are not limited to, YANG data models. The specific MC functions covered by this Recommendation are the ITU-T defined Ethernet operation, administration, and maintenance (OAM) functions, with the set of op codes assigned to the ITU-T and the corresponding OAM protocol data units (PDU) and behaviours specified in Recommendation ITU-T G.8013/Y.1731 and the equipment characteristics in ITU-T G.8021/Y.1341. These OAM functions complement the IEEE 802.1 defined connectivity fault management (CFM) functions; and the YANG module defined in this Recommendation augments the IEEE 802.1Q CFM YANG module.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.8052.1/Y.1346.1	2021-01-13	15	11.1002/1000/14558

Keywords

CFM, connectivity fault management, Ethernet, information model, OAM, protocol-neutral, transport Ethernet, transport resource, UML, YANG.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T G.8052.1/Y.1346.1

Operation, administration, maintenance (OAM) management information and data models for the Ethernet transport network element

1 Scope

This Recommendation specifies the management information model and data models for Ethernet transport network element (NE) to support specific interface protocols and specific management-control (MC) functions.

The information model is interface protocol neutral and specified using the unified modelling language (UML). The information model of this Recommendation is derived through pruning and refactoring from [ITU-T G.7711] core information model and [ITU-T G.8052] foundation Ethernet transport NE information model.

The data models are interface protocol specific and translated from the information model with the assistance of automated translation tooling. The specific data models considered in this Recommendation include, but are not limited to, YANG data models.

The specific MC functions covered by this Recommendation are the ITU-T defined Ethernet operation, administration, and maintenance (OAM) functions, with the set of op codes assigned to the ITU-T and the corresponding OAM protocol data units (PDU) and behaviours specified in [ITU-T G.8013] and the equipment characteristics in [ITU-T G.8021]. These OAM functions complement the connectivity fault management (CFM) functions currently specified in clause 12.14 of [IEEE 802.1Q]; and the YANG module defined in this Recommendation augments the IEEE 802.1Q CFM YANG module.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.7710] Recommendation ITU-T G.7710/Y.1701 (2020), *Common equipment management function requirements*.

[ITU-T G.7711] Recommendation ITU-T G.7711/Y.1702 (2018), *Generic protocol-neutral information model for transport resources*.

[ITU-T G.8013] Recommendation ITU-T G.8013/Y.1731 (2015), *Operations, administration and maintenance (OAM) functions and mechanisms for Ethernet-based networks*.

[ITU-T G.8021] Recommendation ITU-T G.8021/Y.1341 (2018), *Characteristics of Ethernet transport network equipment functional blocks*.

[ITU-T G.8051] Recommendation ITU-T G.8051/Y.1345 (2018), *Management aspects of the Ethernet transport (ET) capable network element*.

[ITU-T G.8052] Recommendation ITU-T G.8052/Y.1346 (2018), *Protocol-neutral management information model for the Ethernet transport capable network element*.

[ITU-T Q.822] Recommendation ITU-T Q.822 (1994), *Stage 1, stage 2 and stage 3 description for the Q3 interface – Performance management*, plus Amendment 1 (2003).

[ITU-T X.739] Recommendation ITU-T X.739 (1993), *Information technology – Open Systems Interconnection – Systems Management: Metric objects and attributes, plus Amendment 1 (1997) and Technical Corrigendum 1 (1998)*.

[IEEE 802.1Q] IEEE 802.1Q (2018), *IEEE Standard for Local and metropolitan area networks – Bridges and Bridged Networks.*

[IEEE 802.1Qcp] IEEE 802.1Qcp (2018), *IEEE Standard for Local and metropolitan area networks – Bridges and Bridged Networks – Amendment 30: YANG Data Model*.

[IEEE 802.1Qcx] IEEE 802.1Q cx (2020), *IEEE Standard for Local and metropolitan area networks – Bridges and Bridged Networks Amendment 33: YANG Data Model for Connectivity Fault Management*.

[IETF RFC 6991] IETF RFC 6991 (2013), *Common YANG Data Types*.

[IETF RFC 7950] IETF RFC 7950 (2016), *The YANG 1.1 Data Modeling Language*.

[IETF RFC 8340] IETF RFC 8340 (2018), *YANG Tree Diagrams*.

[IETF RFC 8342] IETF RFC 8342 (2018), *Network Management Datastore Architecture (NMDA)*.

[IETF RFC 8343] IETF RFC 8343 (2018), *A YANG Data Model for Interface Management*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 dual-ended [ITU-T G.8013]

3.1.2 maintenance entity (ME) [ITU-T G.8013]

3.1.3 maintenance entity group (MEG) [ITU-T G.8013]

3.1.4 MEG end point (MEP) [ITU-T G.8013]

3.1.5 MEG intermediate point (MIP) [ITU-T G.8013]

3.1.6 MEP compound function [ITU-T G.8052]

3.1.7 MIP compound function [ITU-T G.8052]

3.1.8 on-demand measurement [ITU-T G.8052]

3.1.9 on-demand monitoring [ITU-T G.8052]

3.1.10 one-way [ITU-T G.8013]

3.1.11 proactive measurement [ITU-T G.8052]

3.1.12 proactive monitoring [ITU-T G.8052]

3.1.13 single-ended [ITU-T G.8013]

3.1.14 traffic conditioning function [ITU-T G.8051]

3.1.15 traffic shaping function [ITU-T G.8021]

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AIS Alarm Indication Signal

CC Continuity Check

CFM Connectivity Fault Management

ET Ethernet Transport

FM Fault Management

ID Identifier

LM Loss Measurement

MA Maintenance Association

MC Management-Control

MD Maintenance Domain

MEG Maintenance Entity Group

MEP MEG End Point

MIP MEG Intermediate Point

NE Network Element

OAM Operation, Administration, Maintenance

PDU Protocol Data Unit

PM Performance Monitoring

RDI Remote Defect Indication

SDO Standards Developing Organization

UML Unified Modelling Language

VLAN Virtual Local Area Network

5 Conventions

5.1 Information modelling conventions

See clause 5.1 of [ITU-T G.7711].

5.1.1 UML modelling conventions

See clause 5.1 of [ITU-T G.7711].

5.2 Model artefact lifecycle stereotypes conventions

See clause 5.2 of [ITU-T G.7711].

In this Recommendation, the UML model object classes with lifecycle stereotype of *preliminary* or *experimental* are deemed as not mature yet and thus are not translated for the final YANG data model provided in clause 8.1.

5.3 Forwarding entity terminology conventions

See clause 5.3 of [ITU-T G.7711].

5.4 Conditional package conventions

See clause 5.4 of [ITU-T G.7711].

5.5 Pictorial diagram conventions

See clause 5.5 of [ITU-T G.7711].

6 Ethernet OAM functions

This clause identifies the Ethernet transport (ET) OAM functions that are modelled by the information model and data models of this Recommendation.

All the Ethernet OAM OpCodes are owned by IEEE 802.1, with some subsets of the OpCodes have been assigned by IEEE 802.1 to ITU-T SG15, MEF, and IETF. The assignee SDOs are responsible for the OAM PDU specification of their respective assigned OpCodes. The following list is a summary of the OAM categories, SDOs, and their responsible OAM PDU types.

– CFM: IEEE 802.1: CCM
– LB/LT IEEE 802.1: LBM/LBR, LTM/LTR
– Carrier: SG15: GNM/BNM, AIS, LCK, TST, APS, MCC/EDM, LMM/LMR, 1DM, DMM/DMR, EXM/EXR, VSM/VSR, CSF, 1SL, SLM/SLR
– Service: MEF: LLM/LLR, SAT
– Link: IETF: TRILL

Table 6-1 provides a summary of the OpCode, OAM PDU type and applications, and their relevance with MEP and MIP.

Table 6-1 – Ethernet OAM PDU types and applications

OpCode value	OAM PDU type	OAM application	OpCode relevance for MEPs/MIPs
IEEE 802.1 defined			
1	CCM*	CC (Continuity check), Remote defect indication (RDI), Dual-ended proactive loss measurement (LM) (fault 1s, pm 100ms, ps 3.33ms)	MEPs
3	LBM*	Loopback (Unicast and Multicast) Message Throughput	MEPs and MIPs (connectivity verification)
2	LBR*	Loopback (Unicast and Multicast) Reply Throughput	MEPs and MIPs (connectivity verification)
5	LTM	Link trace Message	MEPs and MIPs
4	LTR	Link trace Reply	MEPs and MIPs
6	RFM		
7	SFM		
ITU-T SG15 defined			
32	GNM	Generic notification Message	MEPs
32-1	BNM	Bandwidth notification Message	MEPs

Table 6-1 – Ethernet OAM PDU types and applications

OpCode value	OAM PDU type	OAM application	OpCode relevance for MEPs/MIPs
33	AIS	Alarm indication signal (AIS)	MEPs
35	LCK	Locked signal	MEPs
37	TST	Test, Throughput	MEPs
39	APS	Linear APS	Refer to [ITU-T G.8031]
40	APS	Ring APS	Refer to [ITU-T G.8032]
41	MCC	Maintenance communication channel	MEPs
41-1	EDM	Expected defect Message	MEPs
43	LMM	Single-ended proactive and on-demand LM	MEPs
42	LMR	Single-ended proactive and on-demand LM	MEPs
45	1DM	Dual-ended Delay and Delay variation	MEPs
47	DMM	Single-ended Delay and Delay variation	MEPs
46	DMR	Throughput	MEPs
49	EXM	Experimental Message	Outside the scope of [ITU-T G.8013]
48	EXR	Experimental Reply	Outside the scope of [ITU-T G.8013]
51	VSM	Vendor-specific Message	Outside the scope of [ITU-T G.8013]
50	VSR	Vendor-specific Reply	Outside the scope of [ITU-T G.8013]
52	CSF	Client signal fail	MEPs
53	1SL	Dual-ended Synthetic LM	MEPs
55	SLM	Single-ended Synthetic LM	MEPs
54	SLR	Single-ended Synthetic LM	MEPs
34, 36, 38, 44, 60-63	Reserved		
MEF defined			
56	LLR	Latching Loopback Reply	
57	LLM	Latching Loopback Message	
58	SAT	Service activation test Control Protocol	
59	SAT	Service activation test Control Message	
IETF defined			
64	TRILL	Path Trace Reply	
65	TRILL	Path Trace Message	
66	TRILL	Multi-destination Tree Verification Reply	
67	TRILL	Multi-destination Tree Verification Message	
68-59	Reserved		

NOTE 1 – The CCM PDU supports multiple applications, namely continuity check (CC), remote defect indication (RDI), and loss measurement (LM) and each application requires different message rate (default rate for fault is 1 second, pm 100 msec, APS 3.33 msec.)

NOTE 2 – There has been agreement among IEEE 802.1, MEF, and ITU-T SG15 that the assignee SDOs will also be responsible for the YANG model of their respective OAM. In ITU-T, the ET OAM (i.e., Carrier-Grade Ethernet OAM) is specified in [ITU-T G.8013] with the equipment functional model in [ITU-T G.8021], the management requirements in [ITU-T G.8051] and information model in [ITU-T G.8052].

NOTE 3 – For some OAM PDUs, such as CCM and LBM/LBR, while the basic PDUs are defined in [IEEE 802.1Q], some of their usages are further enhanced in [ITU-T G.8013] and [ITU-T G.8021] to provide specific OAM application needs. For example, the LBM/LBR PDUs are used to provide the following OAM functionalities:

– LB_Discover: to discover the MAC addresses of the other MEPs in the same MEG.
– LB_Series: to send a series of N LB messages to a particular MEP/MIP and report back the total number of received LBR frames, as well as counts of specific errors.
– LB_Test: to send a series of LB messages carrying a test pattern to a particular MEP; and report back the total number of LBM frames sent, as well as the total number of LBR frames received.

The UML model of these OAM applications are defined in [ITU-T G.8052] and the corresponding pruned/refactored UML and YANG are defined in this Recommendation. The YANG model of this Recommendation augments the [IEEE 802.1Q] base YANG model.

NOTE 4 – OAM messages (requests and responses) are configured and processed at the MEP/MIP. Thus, consistent model/view among the SDOs on MEP/MIP is critical, regardless of whether they have formal UML MEP/MIP model (such as ITU-T SG15 in [ITU-T G.8052]) or not (such as [IEEE 802.1Q]). The base YANG model of MEP/MIP for CFM is defined in [IEEE 802.1Q]. It is used as the base for augmentation for the YANG model of this Recommendation.

The ET OAM functions covered in this Recommendation complements the [IEEE 802.1Q] defined connectivity fault management (CFM) functions.

The UML information model for the ET OAM is defined in clause 7.

The YANG module for the ET OAM is contained in clause 8.1. This YANG module is translated from the ET OAM UML information model and augments the IEEE 802.1Q CFM YANG module ieee802-dot1q-cfm.yang.

To ensure the seamless augmentation of the ET OAM YANG to the [IEEE 802.1Q] CFM YANG, the CMF YANG has been reverse-engineered into UML form to assist the modelling (pruning and refactoring of the base [ITU-T G.8052] UML model). The reverse-engineered UML is contained in clause 7.1.

7 Ethernet transport OAM information model

7.1 IEEE CFM UML reverse-engineered from CFM YANG

To assist ET OAM UML pruning and refactoring and to ensure that the translated ET OAM YANG can augment seamlessly the IEEE 802.1Q CFM YANG, the CFM YANG modules have been manually reverse-engineered into UML form. Contained in Appendix I is the IEEE 802.1Q CFM YANG modules.

Figures 7-1 to 7-10 illustrate the UML diagrams extracted from the reverse-engineered CFM UML model. The essences of the diagrams are reflected in the captions of the respective figures.

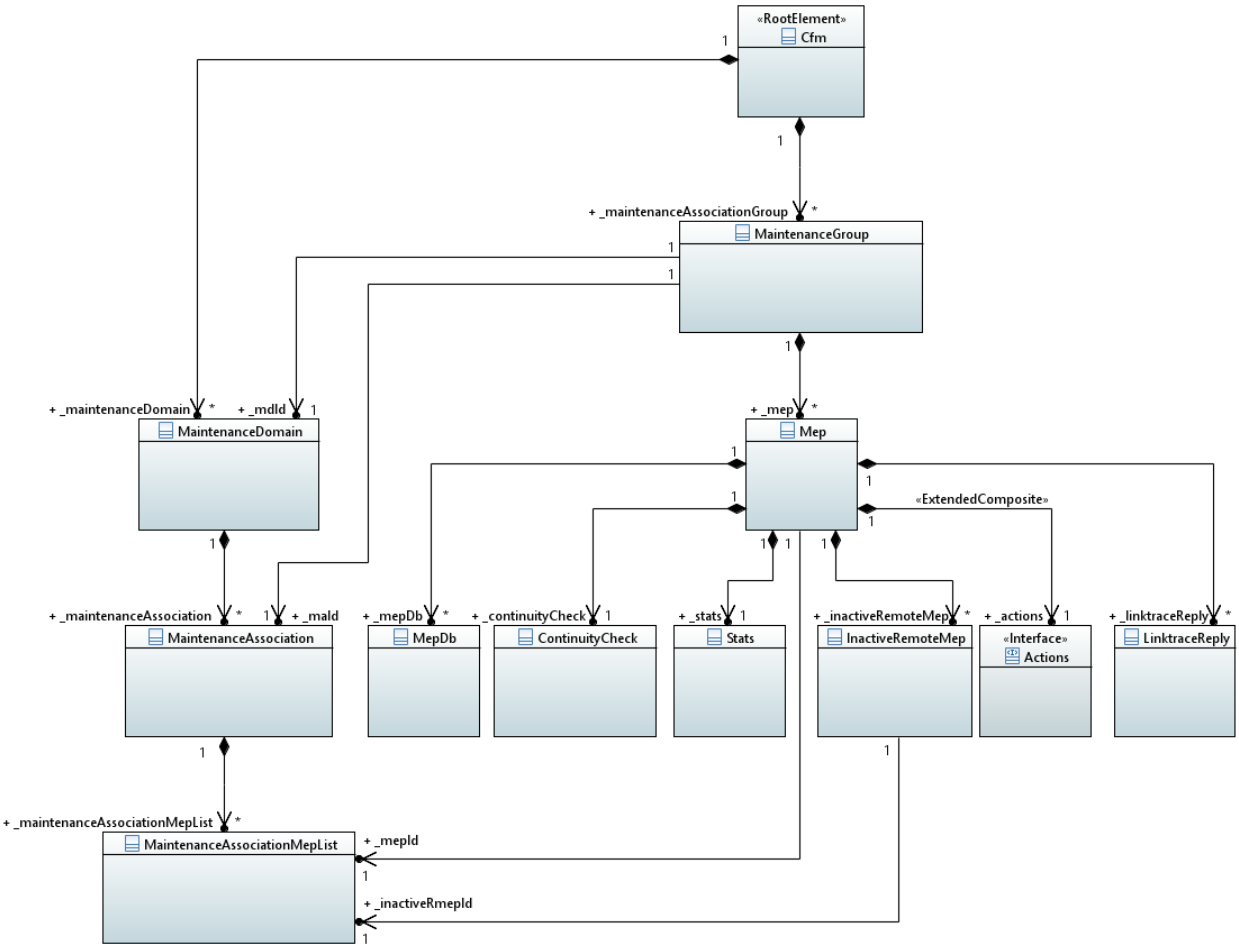

Figure 7-1 – IEEE 802.1Q CFM model – High level structure

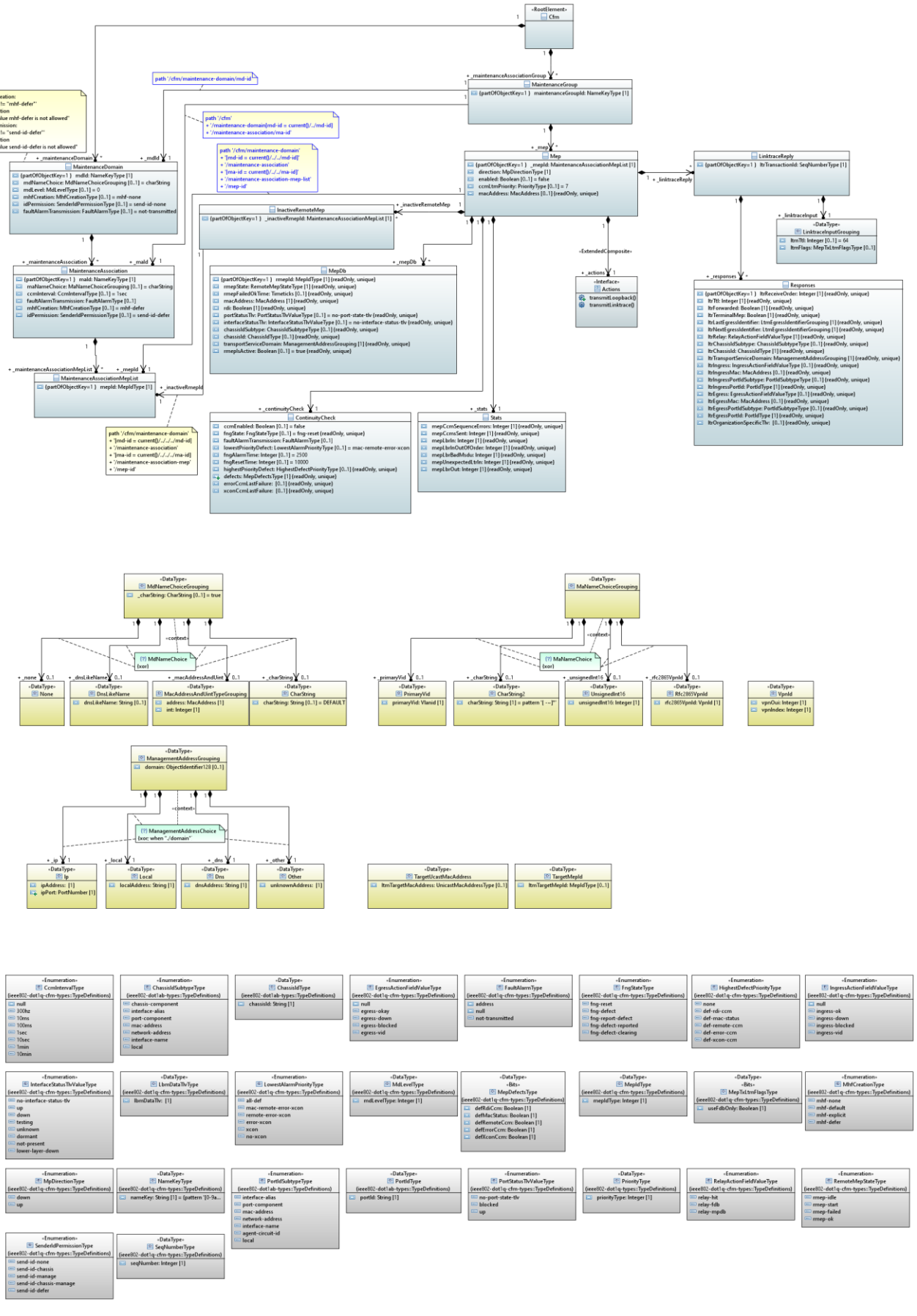

Figure 7-2 – IEEE 802.1Q CFM model – Detail structure

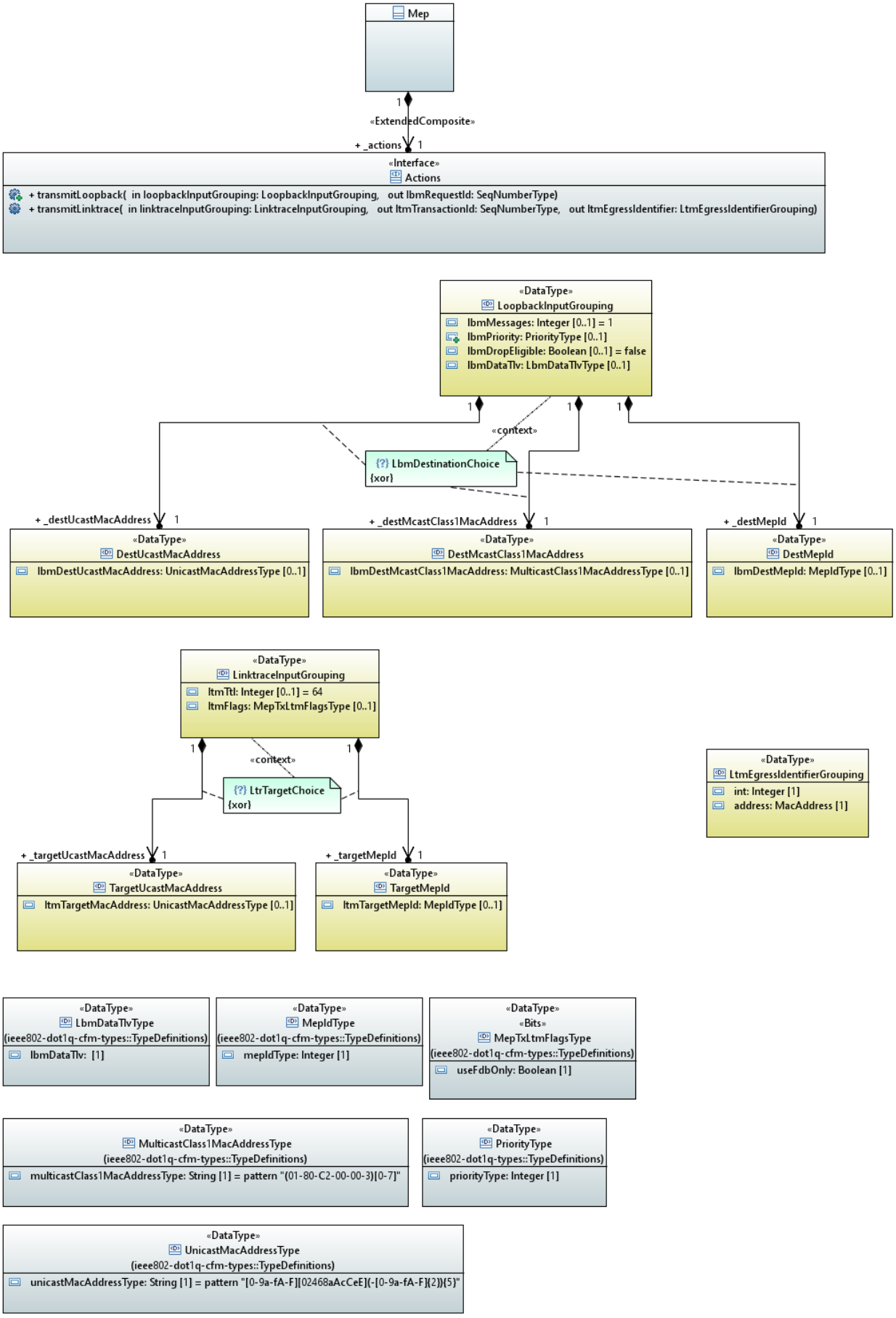

Figure 7-3 – IEEE 802.1Q CFM model – Operations

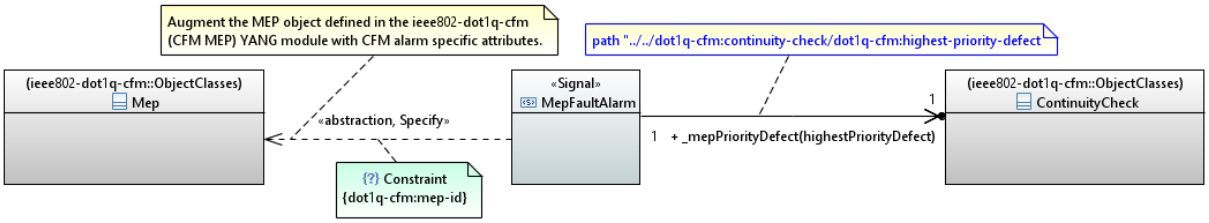

Figure 7-4 – IEEE 802.1Q CFM model – Alarm

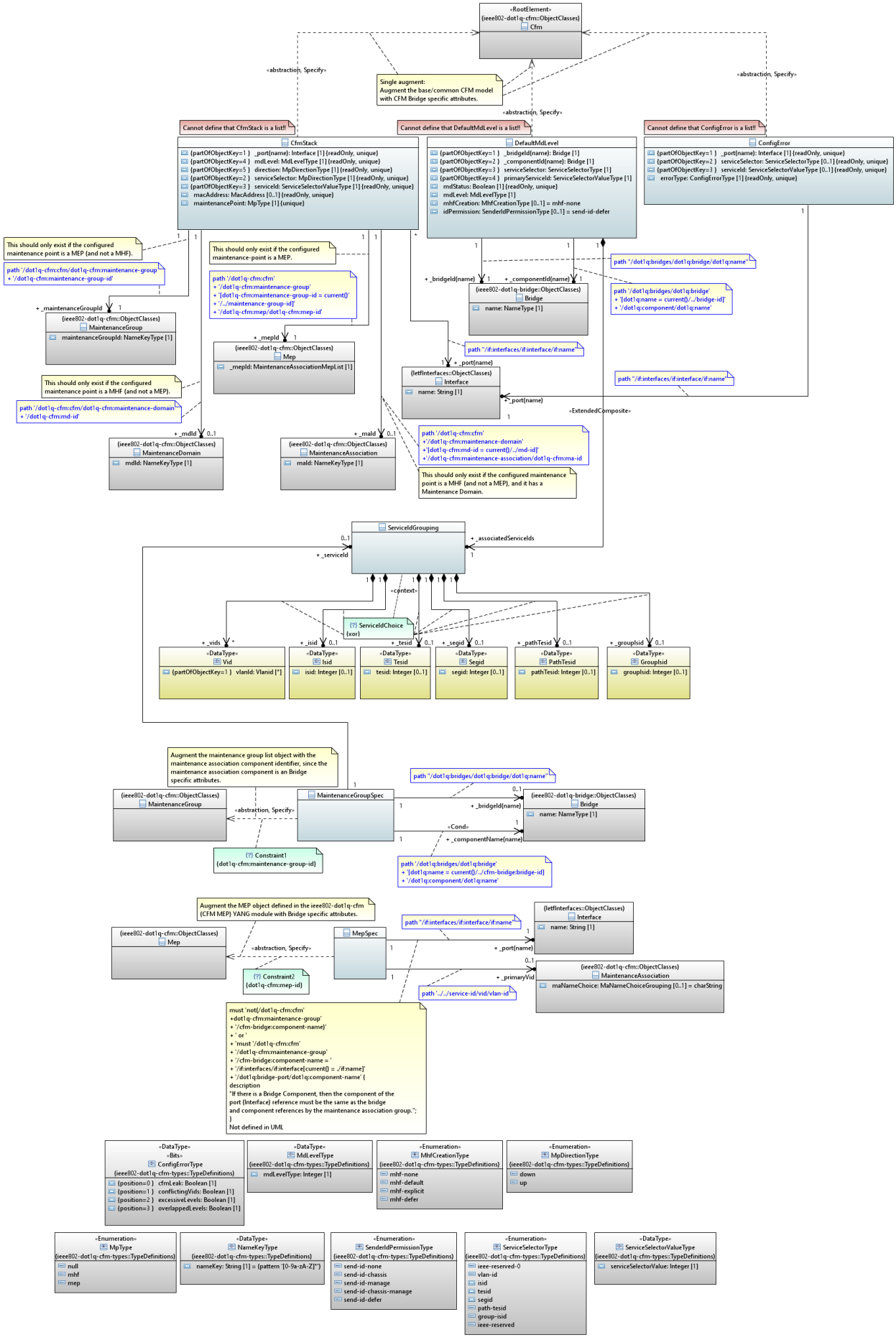

Figure 7-5 – IEEE 802.1Q CFM model – CFM bridge

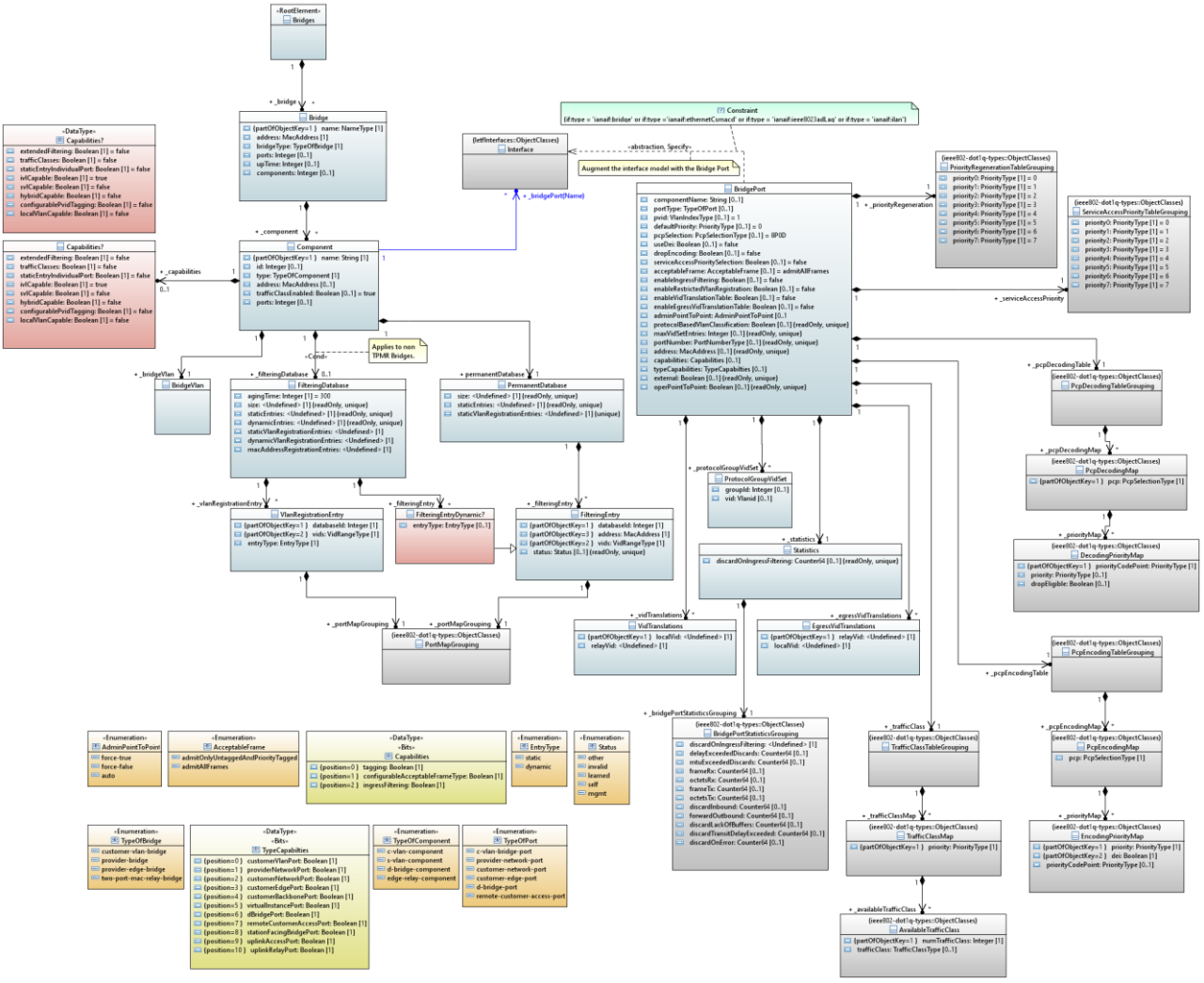

Figure 7-6 – IEEE 802.1Q bridge model

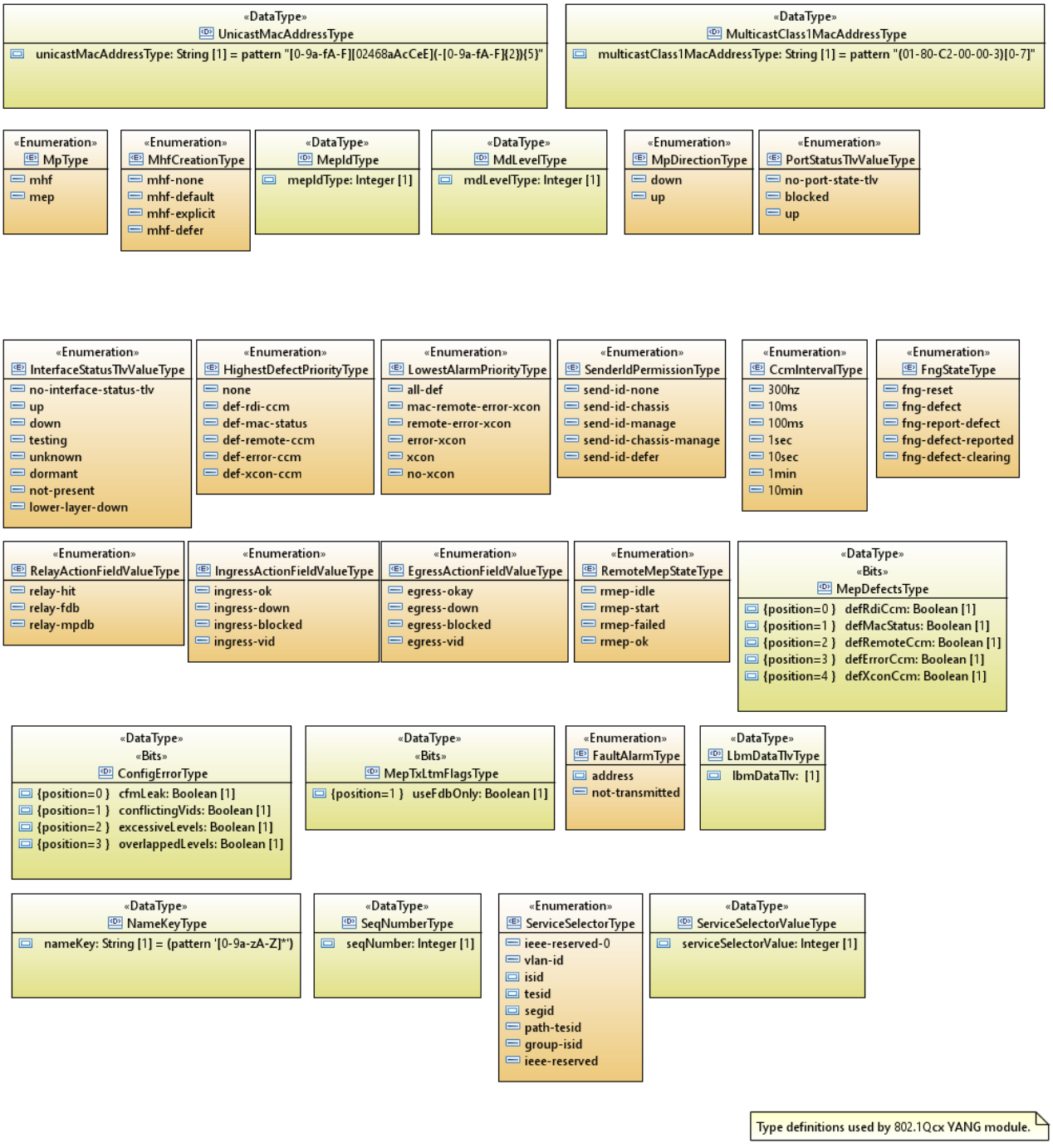

Figure 7-7 – IEEE 802.1Q CFM model – Data types

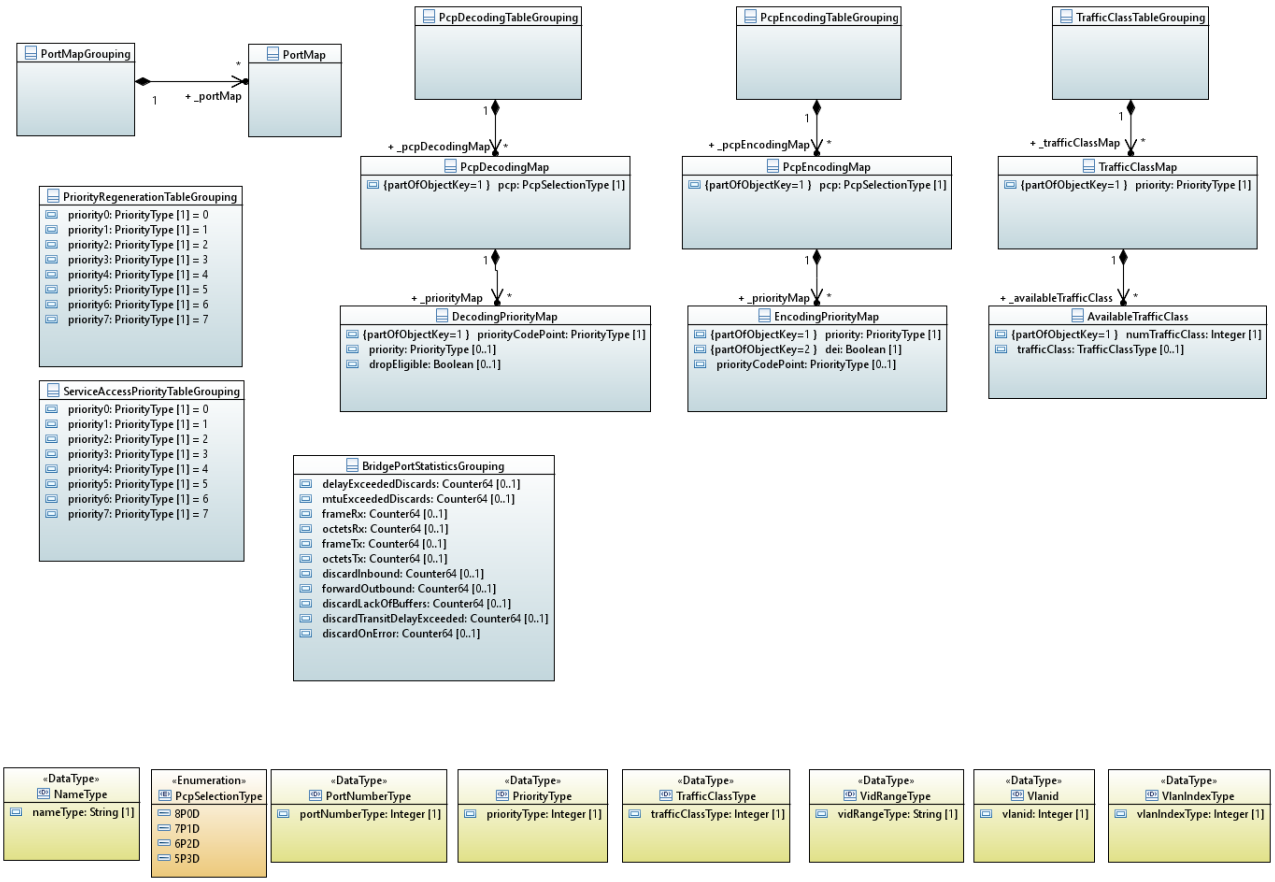

Figure 7-8 – IEEE 802.1Q model – Data types

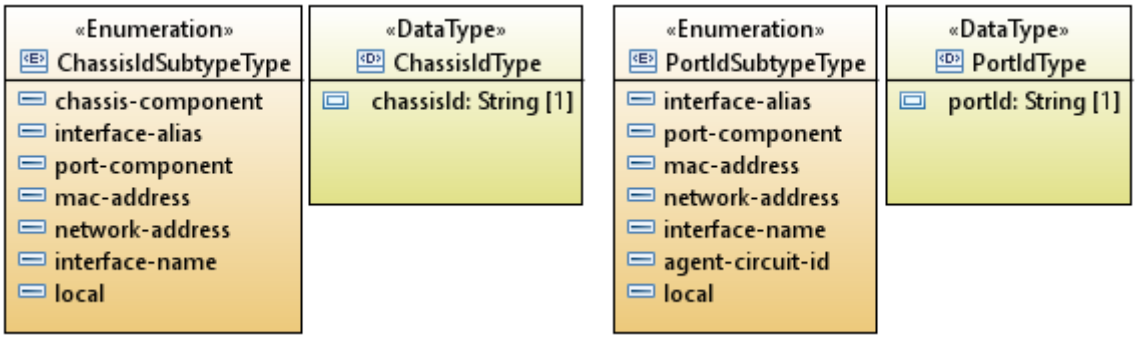

Figure 7-9 – IEEE 802.1AB data types

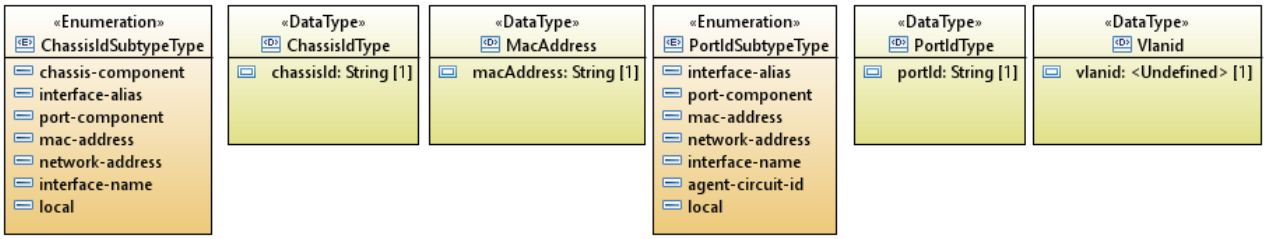

Figure 7-10 – IEEE 802 model – Data types

7.2 Ethernet transport OAM UML

This clause specifies the UML information model of the ET OAM functions identified in clause 6. This information model is derived through pruning and refactoring the [ITU-T G.7711] core information model and [ITU-T G.8052] foundation ET NE information model.

7.2.1 ITU-T G.8052 base object classes

To manage the ET OAM functions identified in clause 6, the following ITU-T G.8052 object classes are considered for pruning/refactoring to meet the needs of this Recommendation:

- ETH_TrailTerminationPoint/Bidirectional/Sink/Source *and the subordinate Pacs*
- ETH_ConnectionTerminationPoint/Bidirectional/Sink/Source *and the subordinate Pacs*
- Mep/ Bidirectional/Sink/Source
- MipBidirectional
- MepControl
- MipControl
- MeasurementJobControl
- OnDemandMeasurementJob
- OnDemandMeasurementJobControl
- OnDemandDualEndedMeasuremnetJobControlSink
- OnDemandDualEndedMeasuremnetJobControlSource
- OnDemandSingleEndedMeasurementJobControl
- ProActiveMeasurementJobControl
- ProActiveDualEndedMeasurementJobControlSink
- ProActiveDualEndedMeasurementJobControlSource
- ProActiveSingleEndedMeasurementJobControl
- CurrentData/HistoryData
- ProactiveDmCurrent/HistoryData
- ProactiveLmCurrentData/HistoryData
- Proactive1SlCurrentData/HistoryData
- Proactive1DmCurrentData/HistoryData
- ThresholdProfile

Besides the above identified ITU-T G.8052 object classes, additional object classes and interface class are defined in this Recommendation specifically for augmenting the IEEE 802.1Q CFM base model. Listed below are these defined artefacts of this Recommendation.

- Object classes and Pacs
    - MaBridgeSpec
    - MepBridgePortSpec
    - MipBridgePortSpec
    - EthMepOamSpec
        - EthMeaJobPac
            - ProActiveDualEndedMeaJob
                - ProActiveDualEndedMeaJobControlTarget
                - DualEndedCurrentData

            - DualEndedHistoryData
        - ProActiveDualEndedMeaJobControlInitiator
    - OnDemandDualEndedMeaJob*
        - OnDemandDualEndedMeasurementJobControlSink*
        - OnDemandDualEndedMeasurementJobControlSource*
    - ProActiveSingleEndedMeaJob
        - ProActiveSingleEndedMeaJobControl
            - SingleEndedCurrentData
                - SingleEndedHistoryData
    - OnDemandSingleEndedMeaJob*
        - OnDemandSingleEndedMeasurementJobControl*
    - ThresholdProfile*
- AlarmSeverityAssignmentProfile*
- EthMipSpec
    - Mip

– Interface class
- EthMepAction*

NOTE – *In the list above, classes that are noted with an asterisk (*) mean that the lifecycle of the class is either preliminary or experimental and they are not deemed as mature yet, therefore they are not translated into YANG and are not included in the YANG data model provided in clause 8.1*.

7.2.2 Augmentation to the IEEE CFM reverse-engineered UML

The YANG model described in this Recommendation aims to augment the IEEE 802.1Q CFM YANG for the ETH OAM functionality. In UML form, the ITU-T G.8052.1 UML model aims to augment the IEEE 802.1Q CFM UML.

Figure 7-11 provides an overview of the augmentation relationship between the IEEE 802.1Q classes and those described in this Recommendation. It illustrates, at high level, that:

– EthMepOamSpec augments IEEE Mep for the ETH OAM (see Figure 7-14 for details)

– EthMepAction* augments IEEE Actions for the ETH OAM operations (see Figure 7-19)

– EthMipSpec augments IEEE MaintenanceDomain for the ETH MIP (see Figure 7-18)

– MepBridgePortSpec augments IEEE Mep and also references IEEE BridgePort to associate the MEP (which supports the ITU-T ETH OAM functionality) with the bridge port (see Figure 7-13)

– MipBridgePortSpec augments ITU-T Mip and also references IEEE BridgePort to associate the MIP (which supports the ITU-T ETH OAM functionality) with the bridge port (see Figure 7-13)

– MgBridgeSpec augments IEEE MaintenanceGroup for ITU-T OAM fault management support (see Figure 7-13)

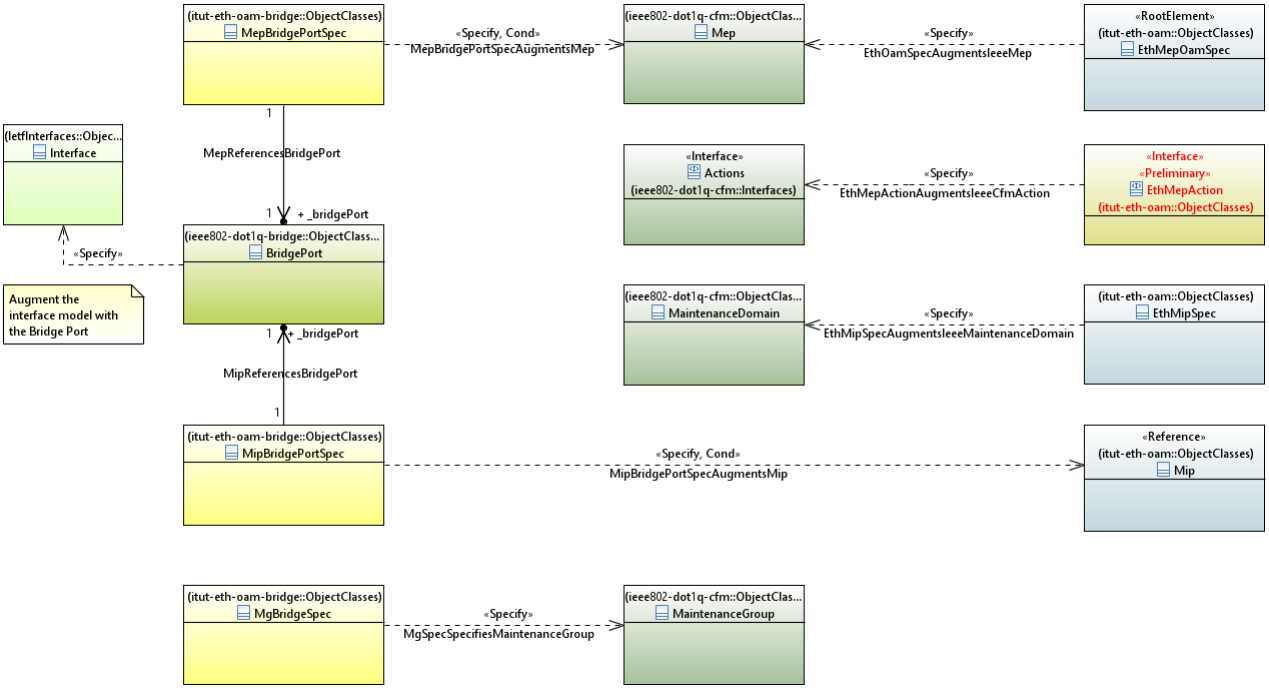

Figure 7-11 – IEEE and ITU-T OAM augmentation relationship

7.2.2.1 Maintenance association name choice

Figure 7-12 depicts the maintenance association name choice.

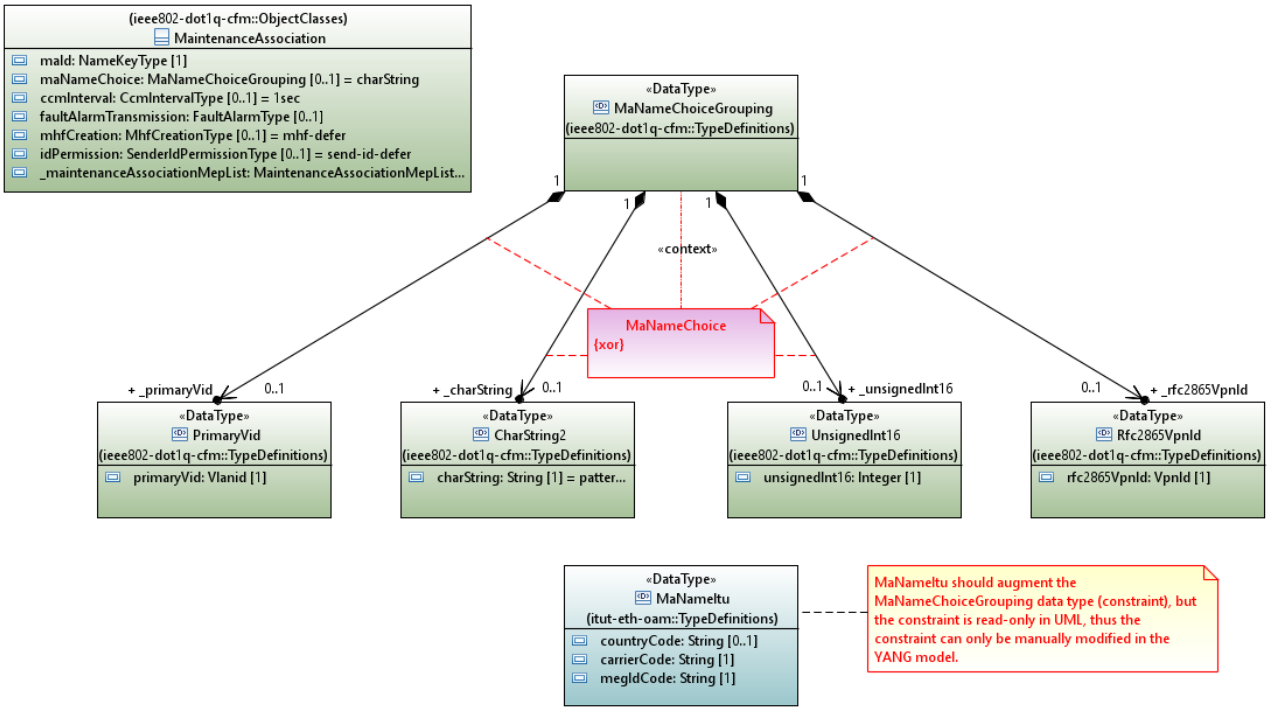

Figure 7-12 – Maintenance association name choice

7.2.2.2 Forwarding plane binding

For the ITU-T G.8013 ETH OAM functions to be supported in the Ethernet network, the MEP and MIP instances need to be associated with the forwarding plane of the Ethernet network. Thus, in the case IEEE 802.1Q bridges are deployed in the Ethernet network, the MEPs and MIPs need to be

associated with the IEEE 802.1Q bridge ports. The maintenance group (i.e., MEG) needs to be augmented with the VLAN ID information for those VLANs that the MEG is monitoring.

Figure 7-13 shows the MEP, MIP, and maintenance group augmentation structure. The MepBridgePortSpec object described in this Recommendation augments the IEEE 802.1Q Mep object and references the IEEE 802.1Q BridgePort. Similarly, the MipBridgePortSpec object of this Recommendation augments the Mip object and references the IEEE 802.1Q BridgePort. The MgBridgeSpec augments the IEEE 802.1Q MaintenanceGroup with the VLAN IDs.

NOTE – For other Ethernet network, the forwarding plane termination point will be augmented by an EthernetTpSpec, which prunes/refactors the ITU-T G.8052 ETH TTP and CTP object classes. However, this scenario is outside the scope of the current edition of this Recommendation .

In [IEEE 802.1Q] CFM, MIPs are implicitly created and thus no MIP object class is defined in [IEEE 802.1Q]. In Ethernet transport network, MIP could be explicitly created. In this Recommendation, the MIP object class is specified. It is defined through pruning/refactoring from the ITU-T G.8052 MIP base object class. It allows explicit instantiation of MIP instances in the ITU-T G.8013 ET OAM environment.

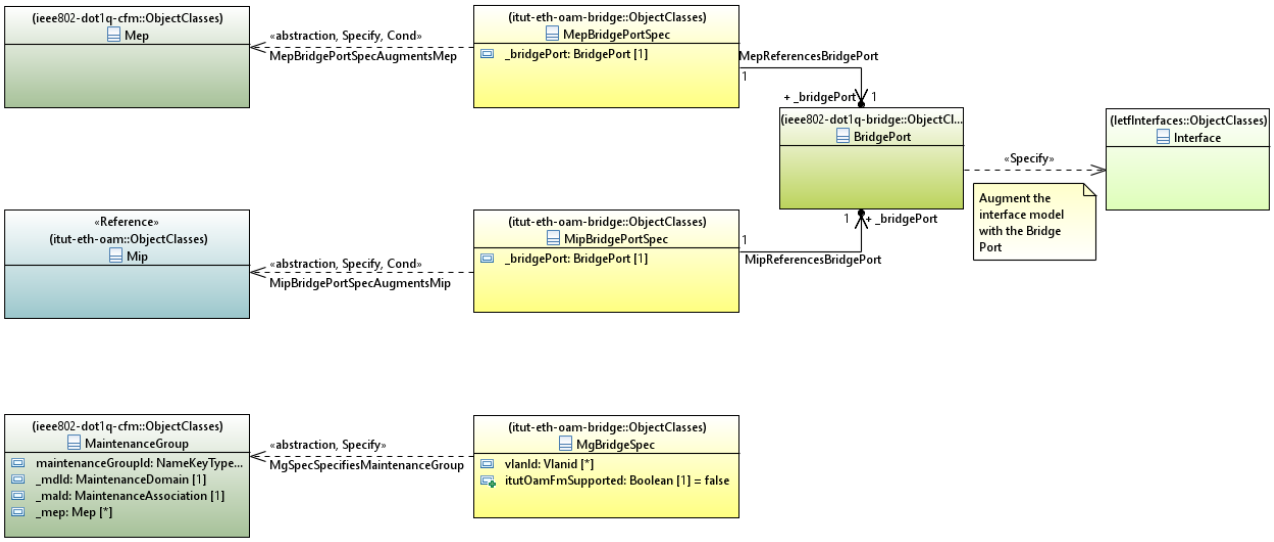

Figure 7-13 – Augmentation for bridge information

7.2.2.3 MEP and measurement jobs

The Mep object class of the reverse-engineered IEEE 802.1Q CFM UML is the touch point for ETH MEP OAM augmentation. It represents the IEEE 802.1Q CFM mep YANG node. The IEEE 802.1Q CFM Mep UML class is augmented with the EthMepOamSpec class of this Recommendation. Figure 7-14 shows the MEP OAM augmentation structure, which is organized according to the MEP OAM functions (OpCode per se). This organization is preferred over the alternative way, which organizes according to MEP Bi/Sink/Source.

The EthMepOamSpec object class of this Recommendation contains the EthMeaJobPac and the following OAM attributes:

– tcmMep
– clientMel
– ethAis
– ethLck
– ethCsf*
– ethBw*

– ethAps*

– ethAlarm*

– _asap*

The OAM attributes are defined through pruning/refactoring from the ITU-T G.8052 Mep, MepSink, MepSource, and MepBidirectional classes, as shown in Table II-2 of Appendix II.

The EthMepOamSpec contains zero or more instances of EthMeaJobPac. Each EthMeaJobPac contains zero or more instances of ThresholdProfile* and an instance of measurement job. The ETH measurement jobs could be categorized according to the measurement purpose (i.e., application) and the control mechanism as shown in Table 7-2.1.

Table 7-2.1 – ETH measurement job and control

Purpose (application)	**Control**	**Measurement job class**	**Needed control classes**
Performance monitoring	*Dual ended*	ProActiveDualEndedMeaJob	ProActiveDualEndedMeaJobControlInitiator *at the initiating MEP*
			ProActiveDualEndedMeaJobControlTarget *at the responding MEP*
	Single ended	ProActiveSingleEndedMeaJob	ProActiveSingleEndedMeaJobControl *at the initiating MEP*
Maintenance	*Dual ended*	OnDemanDualEndedMeaJob*	OnDemandDualEndedMeaJobControlSource* *at the initiating MEP*
			OnDemandDualEndedMeaJobControlSink* *at the responding MEP*
	Single ended	OnDemandSingleEndedMeaJob*	OnDemandSingleEndedMeaJobControl* *at the initiating MEP*

The measurement job control classes and measurement current/history data classes are pruned and refactored from the corresponding classes from [ITU-T G.8052].

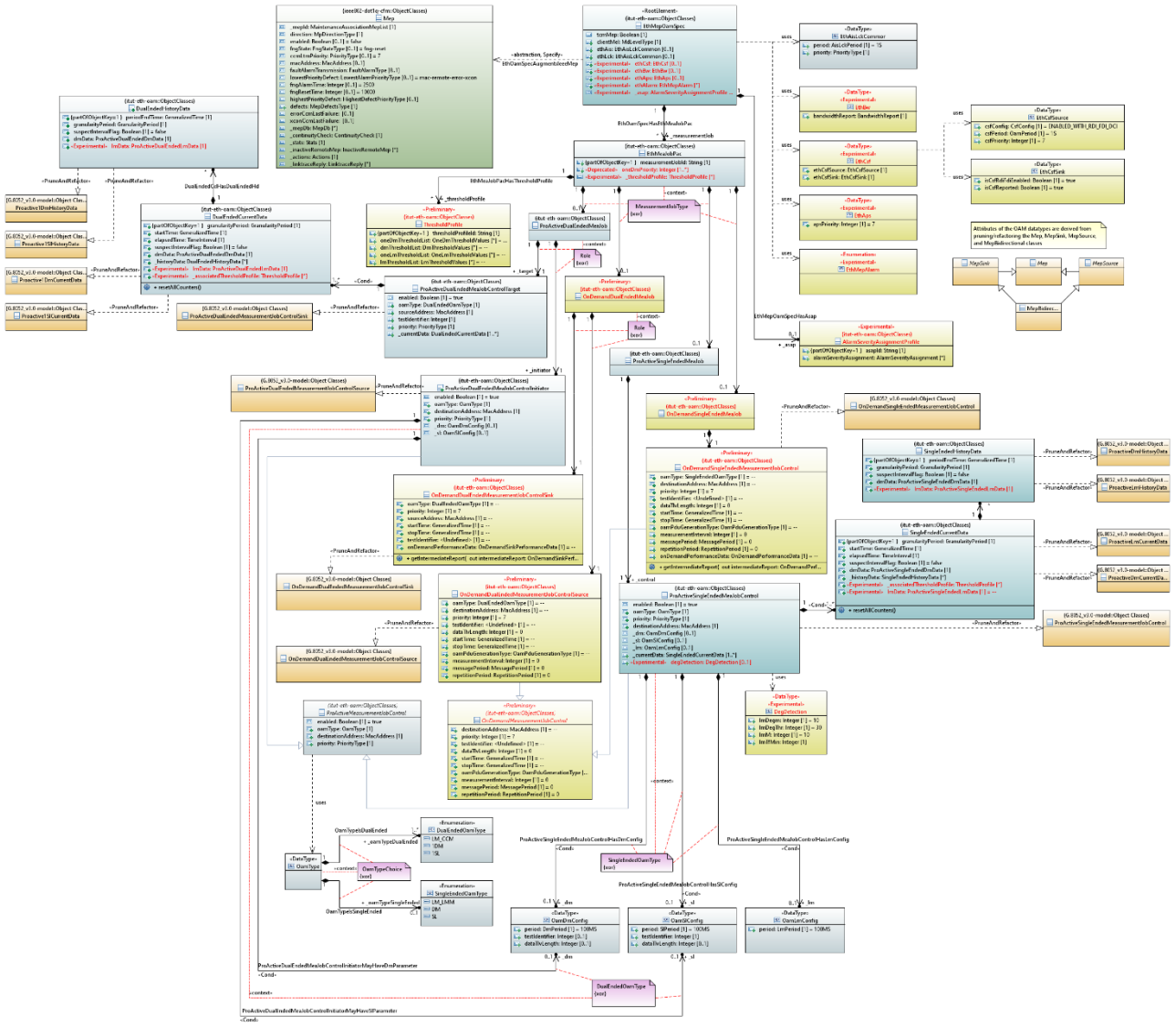

Figure 7-14 – CMF MEP augmentation with ETH MEP OAM

Table II.1 of Appendix II contains the analysis of pruning/refactoring the attributes of the [ITU-T G.8052] MEP object classes for this Recommendation.

Figure 7-15 shows the model of controlling the ETH proactive and on-demand measurement jobs.

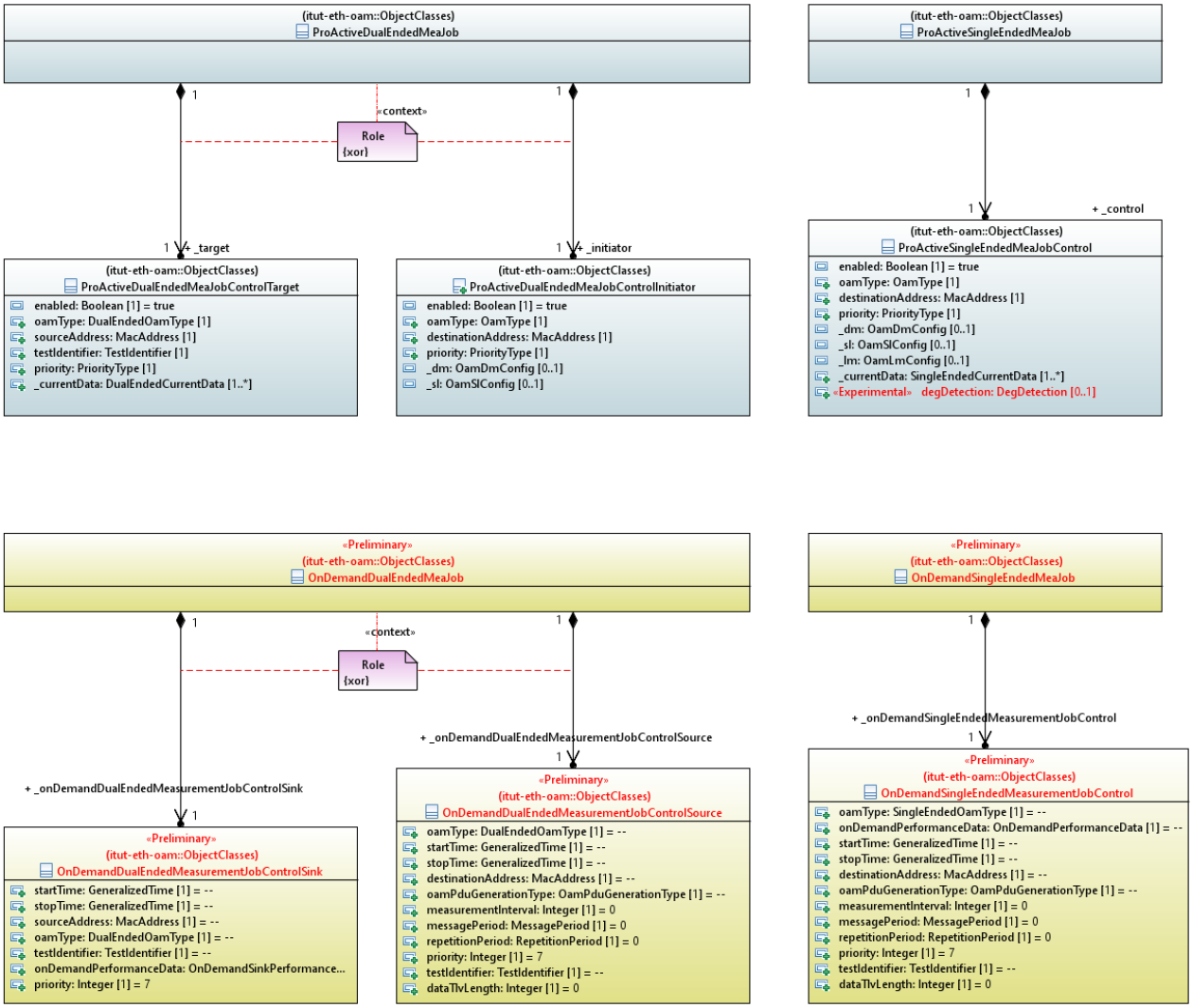

Figure 7-15 – Measurement job control

Figure 7-16 shows the ETH CurrentData and ThresholdProfile object classes for ETH performance monitoring measurement thresholding.

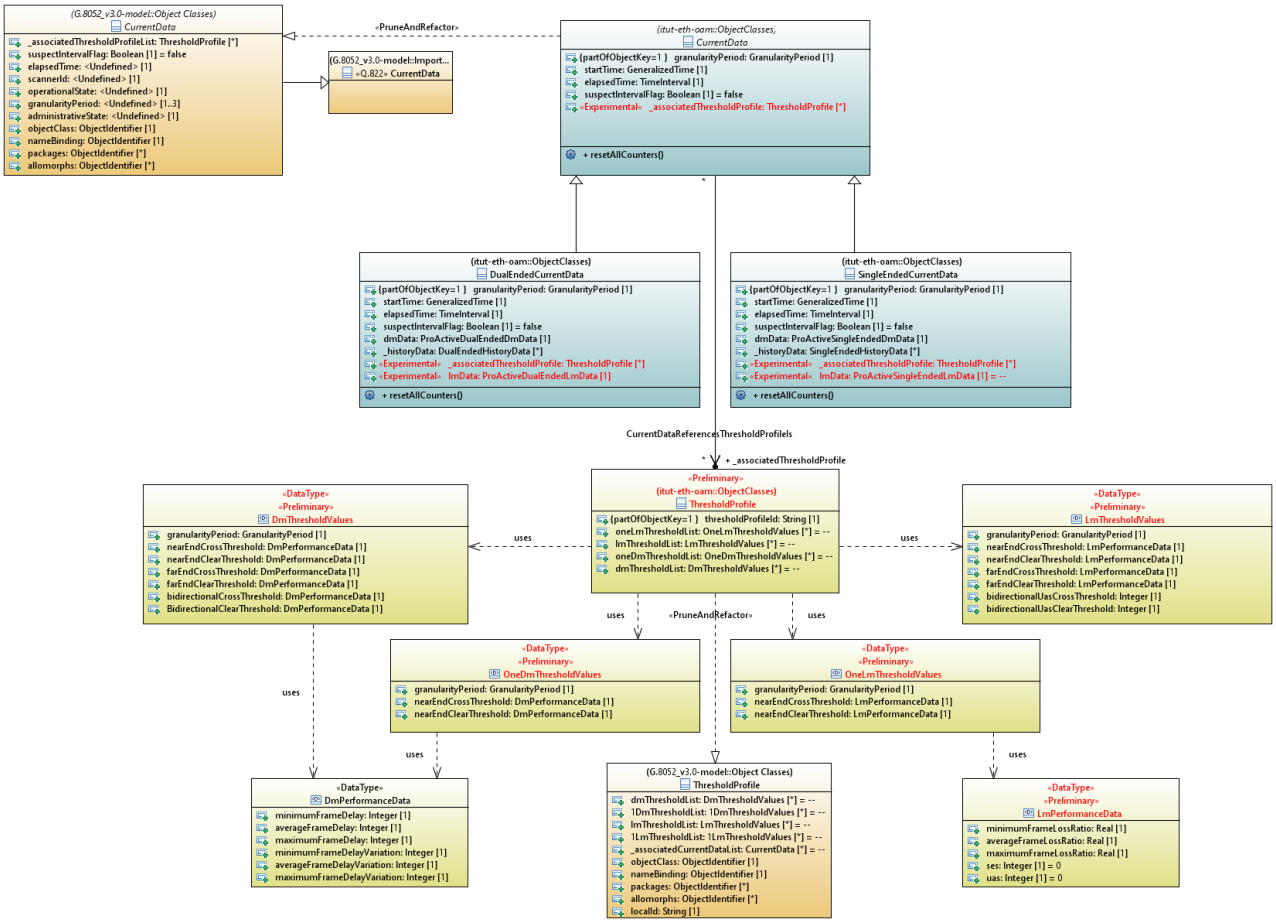

Figure 7-16 – ETH PM current data and thresholding

Figure 7-17 shows the pruning and refactoring of the ITU-T G.8052 HistoryData to derive the ETH CMF HistorytData and subclasses.

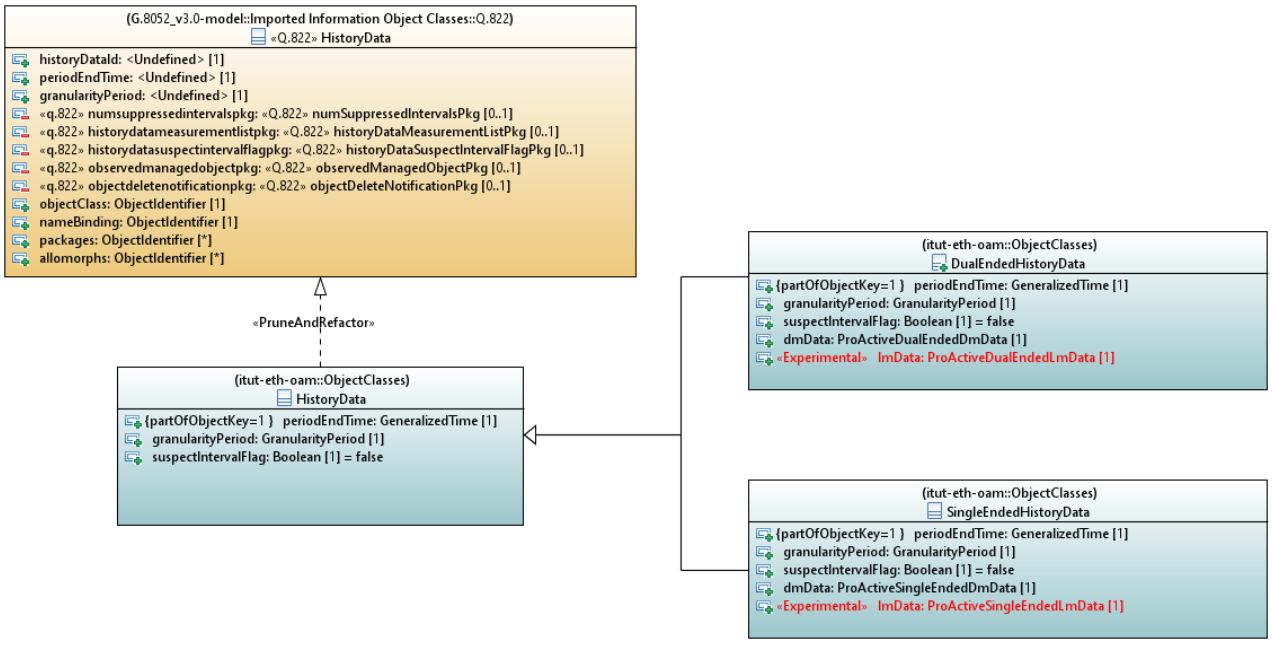

Figure 7-17 – ETH PM history data

7.2.2.4 MIP

The EthMipSpec object class specified in this Recommendation augments the IEEE 802.1Q CFM MaintenanceDomain. Figure 7-18 shows the augmentation.

The EthMipSpec instance contains zero or more instances of Mip, which is pruned from ITU-T G.8052 MipBirectional object class.

Table II-2 of Appendix II contains the analysis of pruning/refactoring the attributes of the ITU-T G.8052 MIP object classes for this Recommendation .

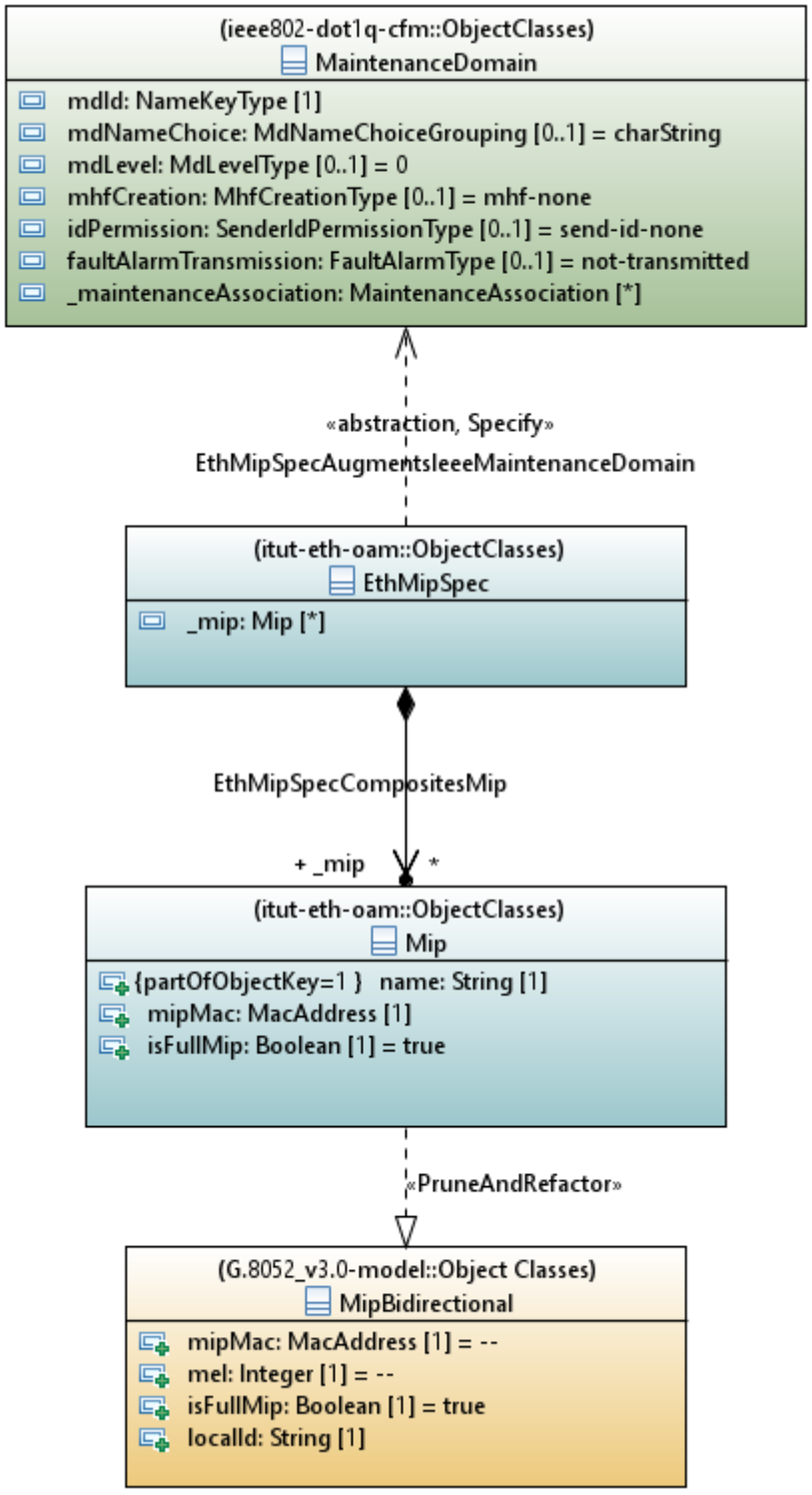

Figure 7-18 – ETH MIP augmentation and pruning/refactoring

7.2.2.5 Operations

The reverse-engineered IEEE 802.1Q CFM UML Actions interface class is the touch point for ETH MEP OAM operation augmentation. This Actions interface class contains the IEEE 802.1Q CFM Transmit Loopback and Transmit Link Trace operations. It is augmented with the EthMepAction interface class for the ETH OAM operations of this Recommendation.

Figure 7-19 shows the operation augmentation structure.

The EthMepAction interface class consists of operations that are pruned/refactored from the ITU-T G.8052 MepBidirectional, MepSink, MepSource, MepControl, MeasurementJobControl, OnDemandSingleEndedMeasurementJobControl, and OnDemandDualEndedMeasurementJobControlSink object classes.

Table II.3 of Appendix II contains the analysis of pruning/refactoring the attributes of the ITU-T G.8052 ETH operations for this Recommendation.

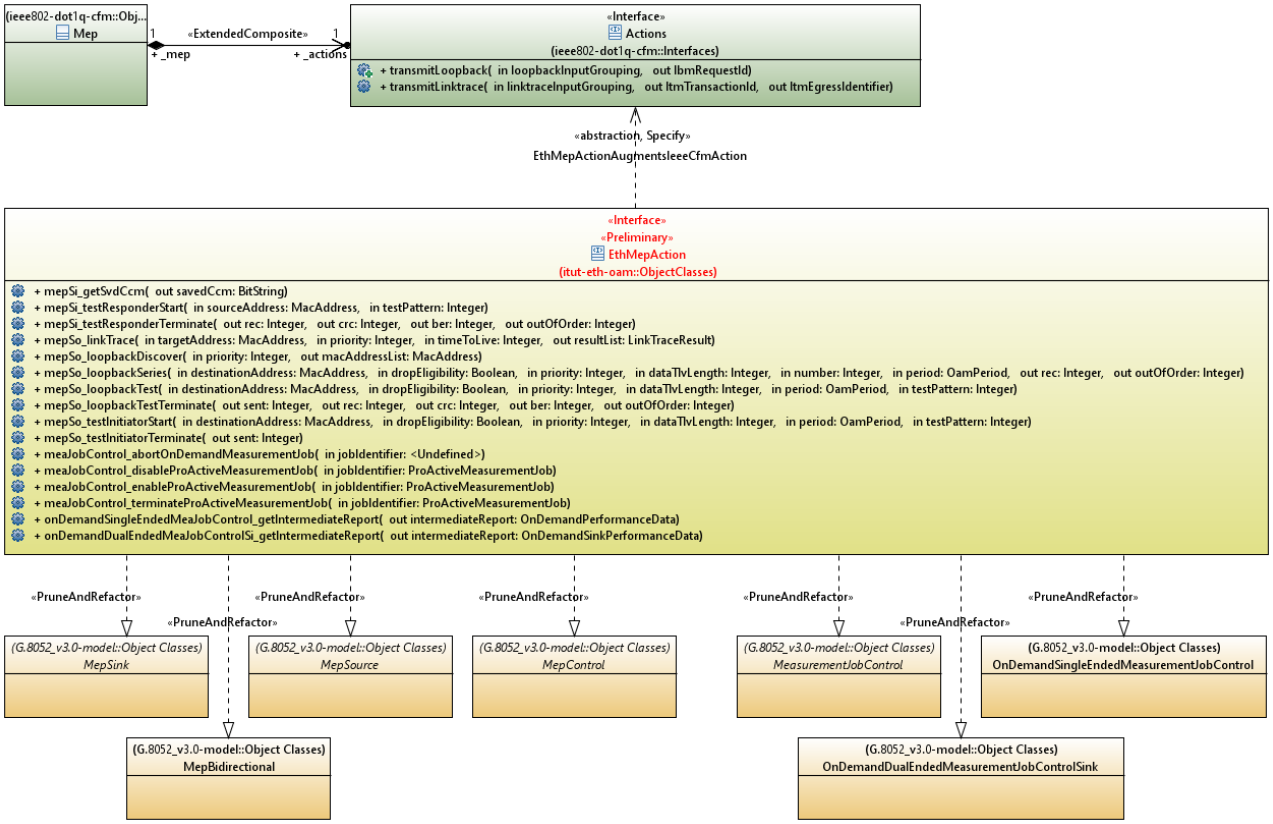

Figure 7-19 – Operation pruning/refactoring augmentation structure

7.3 UML model files

The UML model for this Recommendation developed using the Papyrus open-source modelling tool can be found at: https://www.itu.int/ITU-T/formal-language/itu-t/g/g8052.1/2021/g8052.1_v1.00_uml.zip

The model files include the following:

- The uml model for this Recommendation, which consists of the following files:
  - The papyrus project file;
    - project.
  - The .di, .notation, and .uml files of the itut-eth-oam module:
    - itut-eth-oam.di;
    - itut-eth-oam.notation;
    - itut-eth-oam.uml.
  - The .di, .notation, and .uml files of the itut-eth-oam-bridge module:
    - itut-eth-oam-bridge.di;
    - itut-eth-oam-bridge.notation;
    - itut-eth-oam-bridge.uml.
- The UML Profiles, which defines the properties of the UML artefacts:
  - The OpenModelProfile folder, which contains the .di, .notation, and uml of the open model profile;
  - The OpenInterfaceModelProfile folder, which contains the .di, .notation, and uml of the open model interface profile;
  - The ProfileLifecycleProfile folder, which contains the .di, .notation, and uml of the profile lifecycle profile.
  - The ClassDiagramStyleSheet.css style sheet.
- The UML models that are needed (i.e., imported) by the model of this Recommendation are as follows:
  - [ITU-T G.7711] core information model;
  - [ITU-T G.8052] base Ethernet information model;
  - IEEE models, i.e., the UML models that are reverse-engineered from the IEEE Yang data models;
  - IETF model, i.e., the UML models that is reverse-engineered from the IETF Yang data model.

8 Carrier Ethernet OAM data models

This clause contains the interface-protocol-specific data models of the carrier Ethernet OAM functions identified in clause 6. These data models are translated from the interface-protocol-neutral UML information specified in clause 7.

8.1 Carrier Ethernet OAM YANG data model

This clause contains the YANG data model of this Recommendation.

The YANG data models defined in this version of the Recommendation uses the YANG 1.1 language defined in [IETF RFC 7950]. The tree format defined in [IETF RFC 8340] is used for the YANG data model tree representation. The YANG data model(s) defined in this Recommendation conforms to the network management datastore architecture in [IETF RFC 8342].

The YANG module of this Recommendation is for augmenting/extending the IEEE 802.1Qcx CFM YANG module to support the [ITU-T G.8013/Y.1731] OAM functionalities. The IEEE 802.1Qcx YANG data model for CFM is available in clause 48 of [IEEE 802.1Qcx], which includes the YANG data modules in clause 48.6.

The YANG model of this Recommendation is translated from the interface-protocol-neutral UML information provided in clause 7.3. The translation is done with the assistance of the Open Source translation tooling xmi2yang, which is developed according to [b-ONF TR-531] mapping guidelines.

At the time of publication of this Recommendation, the xmi2yang mapping tool is still a work in progress. Therefore, manual modifications on the tool-generated yang are necessary. The yang with such manual modification can be found at https://www.itu.int/ITU-T/formal-language/itu-t/g/g8052.1/2021/g8052.1_v1.00_yang.zip

Appendix I

IEEE 802.1Q CFM and related YANG

(This appendix does not form an integral part of this Recommendation.)

The IEEE 802.1Q CFM YANG module is available at the following link:

– https://github.com/YangModels/yang/tree/master/standard/ieee/published/802.1

Appendix II

Analysis of ITU-T G.8052 attributes and operations for ITU-T G.8052.1

(This appendix does not form an integral part of this Recommendation.)

This appendix summarizes the analysis and disposition of the attributes and operations of the base [ITU-T G.8052] model on whether they should be retained, refactored or pruned for [ITU-T G.8052.1], and the rationale of doing so.

Table II.1 – Ethernet MEP classes pruning/refactoring

Source artefact	P&R	Rationale
G8052LocalClass::localId	pruned	Available in IEEE::Mep
MEP		
Mep::adminState	pruned	Available in IEEE::Mep::adminState
Mep::mepMac	pruned	Available in IEEE::Mep::macAddress
Mep::mel	pruned	Available in IEEE::MaintenanceDomain::mdLevel
Mep::clientMel	refactored	Moved to (refactored into) to the datatype EthAis, EthLck, EthBw
Mep::megIdentifier	pruned	Available in IEEE::MaintenanceGroup::maintenanceGroupId
Mep::isCcEnabled	pruned	Available in IEEE::ContinuityCheck::ccmEnabled
Mep::ccPeriod	pruned	Available in IEEE::MaintenanceAssociation::ccmInterval
Mep::ccPriority	pruned	Available in IEEE Note: there is no ccm priority, although there is IEEE::Mep::ccmLtmPriority
Mep::lckPeriod	refactored	Moved to (refactored into) to datatype EthLck
Mep::lckPriority	refactored	Moved to (refactored into) to datatype EthLck
MEP Sink		
MepSink::peerMepRefList	pruned	Note: Seems indirectly from Mep through the association to MaintenanceAssociationMepList to the peer Mep; but the cardinality is only 1
MepSink::aisPeriod	refactored	Moved to (refactored into) to datatype EthAis

Table II.1 – Ethernet MEP classes pruning/refactoring

Source artefact	P&R	Rationale
MepSink::aisPriority	refactored	Moved to (refactored into) to datatype EthAis
MepSink::isCsfReported	refactored	Moved to (refactored into) to datatype EthCsf
MepSink::isCsfRdiFdiEnabled	refactored	Moved to (refactored into) to datatype EthCsf
MepSink::currentProblemList	refactored	Moved to (refactored into) to datatype EthMepAlarm
MepSink::bandwidthReport	refactored	Moved to (refactored into) to datatype EthBw
MepSink::1DmPriority	EthMeaJobPac	Moved to (refactored into) to EthMeaJobPac Removed.
MepSink::_onDemandDualEndedMeasurementJobControlSink	pruned	ITU-T G.8052.1 augments the IEEE::Mep using the Spec model approach. The model structure is now difference from [ITU-T G.8052]. So, the navigable attributes from the Mep/MepSink/MepSource/MepBidirectional are no longer applicable.
MepSink::_proactiveDualEndedMeasurementJobControlSink	pruned	ITU-T G.8052.1 augments the IEEE::Mep using the Spec model approach. The model structure is now difference from [ITU-T G.8052]. So, the navigable attributes from the Mep/MepSink/MepSource/MepBidirectional are no longer applicable.
MEP Source		
MepSource::mepIdentifier	pruned	Available in IEEE::Mep::_mepId
MepSource::csfConfig	refactored	Moved to (refactored into) to datatype EthCsf
MepSource::csfPeriod	refactored	Moved to (refactored into) to datatype EthCsf
MepSource::csfPriority	refactored	Moved to (refactored into) to datatype EthCsf
MepSource::apsPriority	refactored	Moved to (refactored into) to datatype EthAps
MepSource::_proactiveDualEndedMeasurementJobControlSource	pruned	ITU-T G.8052.1 augments the IEEE::Mep using the Spec model approach. The model structure is now difference from [ITU-T G.8052]. So, the navigable attributes from the

Table II.1 – Ethernet MEP classes pruning/refactoring

Source artefact	P&R	Rationale
		Mep/MepSink/MepSource/MepBidirectional are no longer applicable.
MepSource::_onDemandMeasurementJobControlSource	pruned	ITU-T G.8052.1 augments the IEEE::Mep using the Spec model approach. The model structure is now difference from [ITU-T G.8052]. So, the navigable attributes from the Mep/MepSink/MepSource/MepBidirectional are no longer applicable.
MEP Bidirectional		
MepBidirectional::_associatedRapsGroupRef	pruned	ITU-T G.8052.1 augments the IEEE::Mep using the Spec model approach. The model structure is now difference from [ITU-T G.8052]. So, the navigable attributes from the Mep/MepSink/MepSource/MepBidirectional are no longer applicable.
MepBidirectional::_associatedSncpGroupRef	pruned	ITU-T G.8052.1 augments the IEEE::Mep using the Spec model approach. The model structure is now difference from [ITU-T G.8052]. So, the navigable attributes from the Mep/MepSink/MepSource/MepBidirectional are no longer applicable.
MepBidirectional::_onDemandSingleEndedMeasurementJobControl	pruned	ITU-T G.8052.1 augments the IEEE::Mep using the Spec model approach. The model structure is now difference from [ITU-T G.8052]. So, the navigable attributes from the Mep/MepSink/MepSource/MepBidirectional are no longer applicable.
MepBidirectional::_proactiveSingleEndedMeasurementJobControl	pruned	ITU-T G.8052.1 augments the IEEE::Mep using the Spec model approach. The model structure is now difference from [ITU-T G.8052]. So, the navigable attributes from the Mep/MepSink/MepSource/MepBidirectional are no longer applicable.

Table II.2 – Ethernet MIP classes pruning/refactoring

Source artefact	To be pruned or moved to	Rationale
MIP Bidirectional		
MipBidirectional::mipMac	retained	Not in IEEE::Mip. Moved (re-factored) to EthMipPac
MipBidirectional::mel	pruned	The IEEE MIP has attribute mdLevel. An ITU-T MEG is equivalent to an IEEE MD which contains only one IEEE MA.
MipBidirectional::isFullMip	retained	Not in IEEE::Mip. Moved (re-factored) to EthMipPac
G8052LocalClass::localId	retained	Not in IEEE::Mip. Moved (re-factored) to EthMipPac
Raps Capable Half MIP Bidirectional		
RapsCapableHalfMipBidirectional::mipMac	retained	Not in IEEE::Mip. Moved (re-factored) to EthMipRapsCapablePac
RapsCapableHalfMipBidirectional::mel	pruned	The IEEE MIP has attribute mdLevel. An ITU-T MEG is equivalent to an IEEE MD which contains only one IEEE MA
RapsCapableHalfMipBidirectional::rapsPriority	retained	Not in IEEE::Mip. Moved (re-factored) to EthMipRapsCapablePac
G8052LocalClass::localId	retained	Not in IEEE::Mip. Moved (re-factored) to EthMipPac

Table III.3 – Ethernet operations pruning/refactoring

Source artefact	P&R	Rationale
EthMepInterface		
mepBi_establishOnDemandSingleEndedMeasurementJob	pruned	Achieved via object creation of an instance of OnDemandSingleEndedMeaJob and a subtending OnDemandSingleEndedMeasurementJobControl instance
mepBi_establishProActiveSingleEndedMeasurementJob	pruned	Achieved via object creation of an instance of ProActiveSingleEndedMeasurementJob and a subtending ProActiveSingleEndedMeasurementJobControl instance

Table III.3 – Ethernet operations pruning/refactoring

Source artefact	P&R	Rationale
mepSi_establishOnDemandDualEndedMeasurementJobSink	pruned	Achieved via object creation of an instance of OnDemandDualEndedMeasurementJob and a subtending OnDemandDualEndedMeasurementJobControlSink instance
mepSi_establishProActiveDualEndedMeasurementJobSink	pruned	Achieved via object creation of an instance of ProActiveDualEndedMeasurementJob and a subtending ProActiveDualEndedMeasurementJobControlSink instance
mepSi_getSvdCcm	retained	No equivalence in IEEE CFM
mepSi_testResponderStart	retained	No equivalence in IEEE CFM. TST is ITU-T OAM
mepSi_testResponderTerminate	retained	No equivalence in IEEE CFM. TST is ITU-T OAM
mepSo_establishOnDemandDualEndedMeasurementJobSource	pruned	Achieved via object creation of an instance of OnDemandDualEndedMeasurementJob and a subtending OnDemandDualEndedMeasurementJobControlSource instance
mepSo_establishProActiveDualEndedMeasurementJobSource	pruned	Achieved via object creation of an instance of ProActiveDualEndedMeasurementJob and a subtending ProActiveDualEndedMeasurementJobControlSource instance
mepSo_linkTrace	Undecided	For further study. CFM and ITU-T G.8013 LT parameters are not the same.
mepSo_loopbackDiscover	retained	No equivalence in IEEE CFM. LB Discover is ITU-T OAM
mepSo_loopbackSeries	retained	No equivalence in IEEE CFM. LB Series is ITU-T OAM
mepSo_loopbackTest	retained	No equivalence in IEEE CFM. LB Test is ITU-T OAM
mepSo_loopbackTestTerminate	retained	No equivalence in IEEE CFM. LB Test is ITU-T OAM
mepSo_testInitiatorStart	retained	No equivalence in IEEE CFM. TST is ITU-T OAM
mepSo_testInitiatorTerminate	retained	No equivalence in IEEE CFM. TST is ITU-T OAM
mepControl_createMep	pruned	Achieved via object creation of an instance of Mep

Table III.3 – Ethernet operations pruning/refactoring

Source artefact	P&R	Rationale
mepControl_deleteMep	pruned	Achieved via object deletion of an instance of Mep
mepControl_getAllContainedMeps	pruned	Achieved via retrieval of all object instances of Mep
mepControl_modifyMep	pruned	Achieved via object modification of an instance of Mep
meaJobControl_abortOnDemandMeasurementJob	retained	No equivalence in IEEE CFM. Measurement is ITU-T OAM
meaJobControl_disableProActiveMeasurementJob	retained	No equivalence in IEEE CFM. Measurement is ITU-T OAM
meaJobControl_enableProActiveMeasurementJob	retained	No equivalence in IEEE CFM. Measurement is ITU-T OAM
meaJobControl_getAllContainedMeasurementJobs	pruned	Achieved via retrieval of all contained measurement job object instances
meaJobControl_getCurrentDataValues	pruned	Achieved via retrieval of CurrentData object instances.
meaJobControl_getHistoryDataValues	pruned	Achieved via retrieval of HistoryData object instances.
meaJobControl_terminateProActiveMeasurementJob	retained	No equivalence in IEEE CFM. Measurement is ITU-T OAM
onDemandSingleEndedMeaJobControl_getIntermediateReport	retained	No equivalence in IEEE CFM. Measurement is ITU-T OAM
onDemandDualEndedMeaJobControlSi_getIntermediateReport	retained	No equivalence in IEEE CFM. Measurement is ITU-T OAM
EthMipInterface		
mipControl_createMip	pruned	Achieved via object creation of an instance of Mip
mipControl_createRapsCapableMip	pruned	Achieved via object creation of an instance of RAPS Capable Mip
mipControl_deleteMip	pruned	Achieved via object deletion of an instance of Mip
mipControl_getAllContainedMips	pruned	Achieved via retrieval of all contained instances of Mip

Appendix III

Client and server implementation compatibility

(This appendix does not form an integral part of this Recommendation.)

Client and server implementation scenarios.

	IEEE client ieee yang	ITU client ieee yang + itu yang
IEEE server ieee yang	A **ieee yang**	C **ieee yang**
ITU server ieee yang + itu yang	B **ieee yang** *Note*: – The client will only configure the ieee yang – The itu yang will be ignored by the client	D **ieee yang + itu yang**

Appendix IV

Mapping of the IEEE 802.1Qcx CFM and ITU-T G.8013 parameters

(This appendix does not form an integral part of this Recommendation.)

This appendix analyses and summarizes the comparison and mapping between the IEEE 802.1Qcx CFM parameters (i.e., the leaf nodes) and [ITU-T G.8021] parameters (i.e., MI signal values).

ieee802-dot1q-cfm.yang	**ITU-T G.8021 parameter**
cfm/maintenance-group/mep/mep-db/**rmep-failed-ok-time**: ro mandatory	Not supported in ITU-T. Need to agree on what value the ITU-T server to put into this leaf when encoding the value (to indicate it is not supported).
cfm/maintenance-group/mep/mep-db/**mac-address**: ro mandatory	Not supported in ITU-T.
cfm/maintenance-group/mep/mep-db/**port-status-tlv**: ro optional	Not supported in ITU-T. It is optional.
cfm/maintenance-group/mep/mep-db/**interface-status-tlv**: ro optional	Not supported in ITU-T. It is optional. Not support is fine.
cfm/maintenance-group/mep/continuity-check/**defect**: *5 bits*: def-rdi-ccm, def-mac-status, def-remote-ccm, def-error-ccm, def-xcon-ccm	No cDEG, no cUNPr. xcon-ccm is composition of cUNL and cMMG. error-ccm is composition of cUNP and cUNM. Proposal solution: define an itu-defects leaf, with typedef ..., and describe the relationship of some of the bits with the 802.1 mep-defect-type.
cfm/maintenance-group/mep/action: transmit-loopback/**input: loopback-input-grouping: case dest-mep-id**	Case dest-mep-id is not supported.
cfm/maintenance-group/mep/action: transmit-loopback/**output: leaf lbm-request-id**	To check and verify whether this is Transaction ID/Sequence Number (see Figure 9.3-1 of [ITU-T G.8013])
cfm/maintenance-group/mep/action: transmit-linktrace/**input: linktrace-input-grouping: case target-mep-id**	Case target-mep-id is not supported? To check and verify whether this is TargetMAC Address (see Figure 9.5-1 of [ITU-T G.8013])
cfm/maintenance-group/mep/action: transmit-linktrace/**input: linktrace-input-grouping: leaf ltm-flags**	To check and verify whether this is Flags (see Figure 9.5-1 of [ITU-T G.8013])
cfm/maintenance-group/mep/action: transmit-linktrace/**output: ltm-transaction-id**	To check and verify whether this is Transaction ID (see Figure 9.5-1 of [ITU-T G.8013])
cfm/maintenance-group/mep/action: transmit-linktrace/**output: ltm-egress-identifier**	To check and verify whether this is Egress Identifier (see Figure 9.5-3 of [ITU-T G.8013])

ieee802-dot1q-cfm.yang	ITU-T G.8021 parameter
cfm/maintenance-group/mep/linktrace-reply/responses/**ltr-receive-order**	This SHOULD be a stamp assigned by the Linktrace initiator to the received LTR frame, not a field inside the LTR frame. This SHOULD belong to [ITU-T G.8021] (the process at the sink function of the initiator MEP), instead of [ITU-T G.8013]. Currently [ITU-T G.8021] bundles all of the LTR results into a single "Results" parameter, it does not say how the different responses are distinguished within this. This will require update to [ITU-T G.8021].
cfm/maintenance-group/mep/linktrace-reply/responses/**ltr-forwarded**	To check and verify whether this is the FwdYes flag (see Figure 9.6-2 of [ITU-T G.8013])
cfm/maintenance-group/mep/linktrace-reply/responses/**ltr-terminal-mep**	To check and verify whether this is the TerminalMEP flag (see Figure 9.6-2 of [ITU-T G.8013])
cfm/maintenance-group/mep/linktrace-reply/responses/**ltr-relay**	To check and verify whether this is the RelayAction field (see Figure 9.6-1 of [ITU-T G.8013])

Bibliography

[b-ONF TR-531] ONF TR-531 (2018) *UML-YANG Mapping Guidelines.* (https://www.opennetworking.org/software-defined-standards/models-apis/)

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	**Y.1300–Y.1399**
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	Y.3000–Y.3499
CLOUD COMPUTING	Y.3500–Y.3599
BIG DATA	Y.3600–Y.3799
QUANTUM KEY DISTRIBUTION NETWORKS	Y.3800–Y.3999
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	
General	Y.4000–Y.4049
Definitions and terminologies	Y.4050–Y.4099
Requirements and use cases	Y.4100–Y.4249
Infrastructure, connectivity and networks	Y.4250–Y.4399
Frameworks, architectures and protocols	Y.4400–Y.4549
Services, applications, computation and data processing	Y.4550–Y.4699
Management, control and performance	Y.4700–Y.4799
Identification and security	Y.4800–Y.4899
Evaluation and assessment	Y.4900–Y.4999

For further details, please refer to the list of ITU-T Recommendations.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	**Transmission systems and media, digital systems and networks**
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2021