Core Information Model (CoreModel)

TR-512.1

Overview

Version 1.3.1
January 2018

ONF Document Type: Technical Recommendation
ONF Document Name: Core Information Model version 1.3.1

Disclaimer

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Important note

This Technical Recommendations has been approved by the Project TST, but has not been approved by the ONF board. This Technical Recommendation is an update to a previously released TR specification, but it has been approved under the ONF publishing guidelines for 'Informational' publications that allow Project technical steering teams (TSTs) to authorize publication of Informational documents. The designation of '-info' at the end of the document ID also reflects that the project team (not the ONF board) approved this TR.

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Document History

Version	Date	Description of Change
1.0	March 30, 2015	Initial version of the base document of the "Core Information Model" fragment of the ONF Common Information Model (ONF-CIM).
1.1	November 24, 2015	Version 1.1
1.2	September 20, 2016	Version 1.2 [Note Version 1.1 was a single document whereas 1.2 is broken into a number of separate parts]
1.3	September 2017	Version 1.3 [Published via wiki only]
1.3.1	January 2018	Addition of text related to approval status.

1 Introduction

1.1 General introduction to the model

This ONF Technical Recommendation (TR) focuses on the Core Information Model (CoreModel) of the ONF Common Information Model (ONF-CIM). An information model describes the things in a domain in terms of objects, their properties (represented as attributes), and their relationships.

The ONF-CIM is expressed in a formal language called Unified Modeling Language (UML). UML defines a number of basic model elements, called UML artifacts. In order to assure consistent modeling, only a subset of these artifacts was used in the development of the ONF-CIM according to guidelines for creating an information model expressed in UML (documented in [ONF TR-514]).

The ONF-CIM is formed from a number of pieces and is focused on the CoreModel. At its heart, the CoreModel provides a representation of network forwarding resources[1] from a management-control perspective. The CoreModel is independent of:

- Specific forwarding technology, i.e. the CoreModel is forwarding technology neutral.
- Specific management-control interface protocol, i.e. the CoreModel is management-control interface protocol neutral (as described in [ONF TR-513]).

The ONF-CIM supports forwarding technology specific properties via application of the specification model (see 2.1.6 Specification Model (TR-512.7) on page 17) enabling reuse of existing technology specific standards definitions (e.g., from [ITU-T G.874.1]), pruned and refactored as appropriate (see [ONF TR-513]). The technology specific content, acquired in a runtime solution via "filled in" cases of specification, augment the CoreModel to provide a forwarding technology specific representation.

From an interfacing perspective, considering the SDN architecture [ONF TR-521] as an example, a controller may expose a view of the network in terms of ONF-CIM entities to client SDN controllers or applications to meet the needs of that client. The interface may expose the information in a client specific form where that form can be deterministically mapped to the ONF-CIM[2]. Tooling is used to generate an interface specific form from the UML[3] model[4].

[1] It is focused on representation of the functions/resources that have the primary purpose of supporting information forwarding (transfer and transform functions), that form a network that realizes virtual adjacency, for the purpose of control of those functions/resources. Those resources are referred to as network forwarding resources. The information model is not intended to cover functional resources that have a primary purpose of supporting storage or compute solutions.
[2] The Transport API (TAPI) provides an interface oriented representation (in UML) derived from the CoreModel using the “Pruning & Refactoring” process [ONF TR-513] supported by tooling.
[3] UML is not an interface protocol language.
[4] For example, TAPI [OSSDN-SNOWMASS] uses Eagle [OSSDN-EAGLE] tooling to generate interface specific form (Yang, JSON etc).

1.2 Introduction to this document

This document acts as a guide to the set of documents that describe the CoreModel of the ONF-CIM, providing:

- An introduction to the CoreModel of the ONF-CIM in the form of a brief overview of the model with links to the other documents in the set (see section 2.1 Model Document Structure on page 11 and section 2.2 Supporting documents on page 23 including a reference to the data dictionary (see section 2.2.2 Data Dictionary (TR-512.DD) on page 23)).
- A brief explanation of how to introduce attributes and structure related to a specific network technology (see section 2.1.6 Specification Model (TR-512.7) on page 17).
- A terminology translation table (see section 2.2.3 Terminology mapping (TR-512.TM) on page 23)
- An explanation of supporting guidelines with references to the guideline documents (see section 2.3 Supporting Guidelines on page 24).
- A summary of the main changes from the previous versions (see section 3 Summary of changes on page 2525).

A list of references used in the document set (see section 0

- References on page 28).
- A list of definitions used in the document set (see section 5 Definitions on page 30)
- A list of abbreviations used in the document set (see section 5.3 Abbreviations and acronyms on page 31).

Some conventions used in the document set including key stereotypes and keys to the diagram symbol sets (see section 0

- Conventions on page 36).
- A summary of future work (see section 7 Future CoreModel work areas on page 38)

In addition, a number of appendix documents, that provide examples and further explanatory details, are included with the deliverables. These are summarized in TR-512.A.1.

Separate work activities are taking the CoreModel and deriving interface models (see [OSSDN-SNOWMASS]).

In addition to the documentation referenced above and throughout this document, the TR-512 delivery package includes the CoreModel in Papyrus UML (see OnfModel folder). The ongoing intention is to publish using the environment versions as stated in the guidelines [ONF TR-515]. The precise versions are stated below. The OpenModelProfile is the latest available from GitHub at the time of publication:

Table 1: Tooling and Profile Versions

	[ONF TR-515] Version	GitHub Version	Version used for [ONF TR-512]	Comments
Eclipse	4.5.x "Mars"		4.5.0.20150621120 0 "Mars"	
Papyrus	1.1.x		1.1.1.20150807120 4	
Gendoc	0.5.x (0.5.1)		0.5.0.20150420050 2	Minor misalignment
OpenModelProfile		0.2.4	0.2.0	Version to be aligned during a future release

In addition, an Experimental profile has been used for some of the Experimental model. This profile will be integrated into the formal profile structure in a later release.

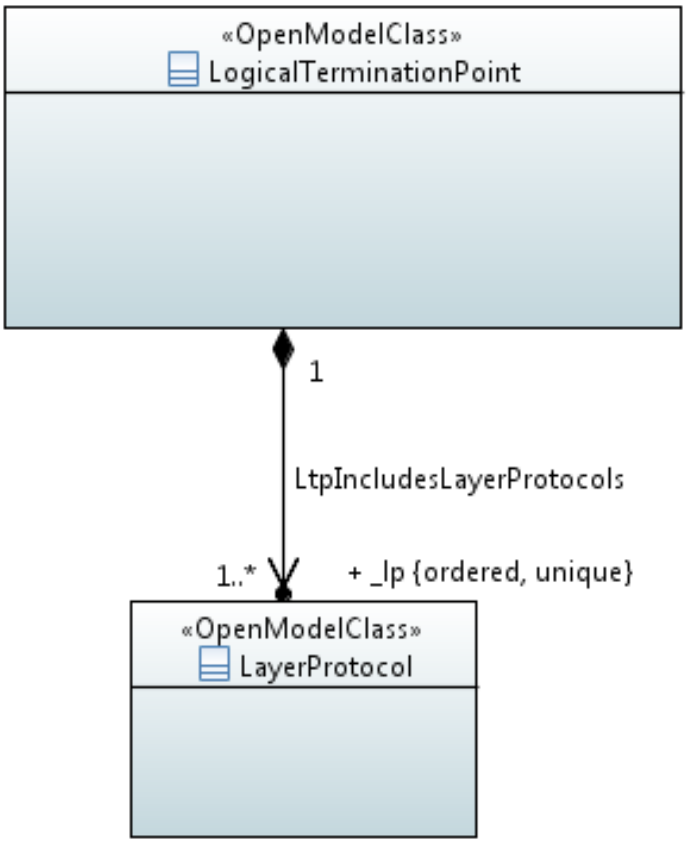
1.3 Viewing UML diagrams

Some of the UML diagrams in figures are very dense. To view them either zoom (sometimes to 400%) or open the associated image file (and zoom appropriately) or open the corresponding UML diagram via Papyrus (for each figure with a UML diagram the UML model diagram name is provided under the figure or within the figure).

The UML diagram convention is provided in [ONF TR-514]. There are some key aspects of the diagrams that need to be emphasized.

- Association end attribute (the name of which always starts with "_") highlighted in the diagrams by the navigable end of the association (arrow head) is an attribute of the class at the non-navigable end of the association. It is the convention not to show the attribute in the class in the diagrams. The attributes for non-navigable ends (owned by the association) are not shown in the diagram (so in the figure there is no attribute name by the black diamond).

- On some occasions, other properties of the association end attribute are also shown.



CoreModel diagram: Overview-LtpAndLp

Figure 1-1 Illustrating navigable association end attributes

In the diagram above, the text at the arrow head end _lp… is an attribute of the Logical Termination Point.

This attribute is shown in the fragment of abbreviated data dictionary below for LogicalTerminationPoint.

Table 2: Attributes for LogicalTerminationPoint

Attribute Name	Lifecycle Stereotype (empty = Mature)	Description

This sort of table is used in each of the documents on a section of the model and only provides summary information. For full information the reader should refer to the data dictionary (see section 2.2.2 Data Dictionary (TR-512.DD) on page 23) or the model itself (see OnfModel folder).

2 Model Overview

This section provides an overview of the ONF Core Information Model (CoreModel) and of the structure of the model description documentation. Each document described has a hyperlink that will take you to the document in your system[5]. The documents are all in the "ModelDescriptions" folder and are covered by two subsections:

- The documents referred to in Section 2.1 describe the core model artifacts progressing through the model from the basics of forwarding and termination through to a description of the augmentation mechanism of the specification model.
- The documents referred to in Section 2.2 provide additional supporting material including the Data Dictionary.

The remaining subsections provide:

- Related guidelines for model generation and usage (section 2.3)
- Key references (section 2.4)
- A brief overview of the Papyrus files (section 2.5)

2.1 Model Document Structure

The CoreModel of the ONF-CIM consists of model artifacts that are intended for use by multiple applications and/or forwarding technologies. For navigability, the CoreModel is further sub-structured into Core Network Model (CNM), Core Foundation Model, Core Physical Model, and the Core Specification Model.

The Core Network Model (CNM) consists of artifacts that model the essential network aspects that are neutral to the forwarding technology of the network. The CNM currently encompasses Forwarding, Termination, Timing, Topology, and Resilience aspects (subsets of the CNM).

This section provides a list of all associated documents that describe the model. Each of the following sub-sections provides some brief highlights from the associated document and a link to that associated document.

The model documentation is broken down into a number of key parts which relate to but do not exactly match the model breakdown:

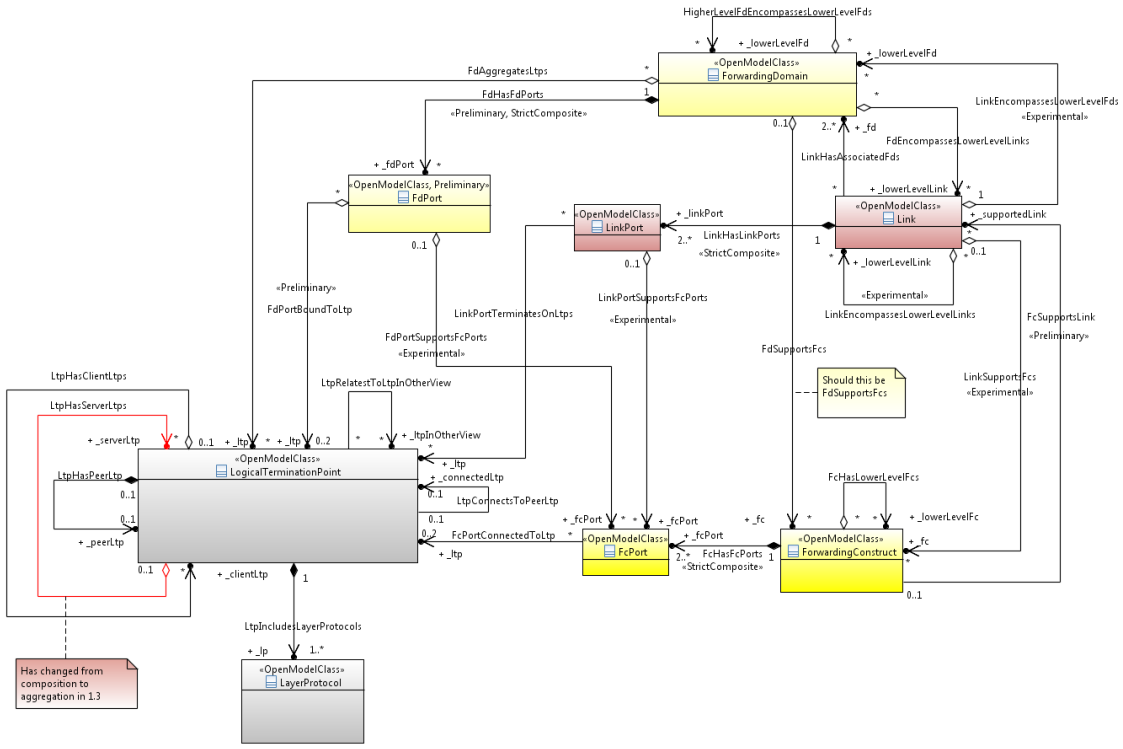
- CoreNetworkModel:
    - Forwarding and Termination (see section 2.1.1)
    - Topology (see section 2.1.3)
    - Resilience (see section 2.1.4)
    - Timing (see section 2.1.1)
- CoreFoundationModel (see section 2.1.2)
- CorePhysicalModel (see section 2.1.5)
- CoreSpecificationModel (see section 2.1.6)
- GeneralControllerModel (see section 2.1.7)
- OamModel (see section 2.1.8)

[5] The link will only work if you have unzipped the whole package as one.

- CoreOperationsModel (see section 2.1.9)
- ProcessingConstructModel (see section 2.1.10)

2.1.1 Core Network Model – Forwarding and Termination Model (TR-512.2)

The Forwarding and Termination document provides a high-level overview of the Termination and Forwarding aspects of the CoreNetworkModel. This model is essentially a canonical model of networking from a management-control perspective. The figure below is a skeleton class diagram illustrating the interrelationships between key object classes defined in the CoreNetworkModel of the CoreModel. The classes are colored to help recognize key groupings in the model. The colors are chosen to match the key entity colors in Figure 6-1 Network diagram symbol set (with the Link in the alternative color for clarity). This color scheme for class diagrams is used in some of the figures in the associated documents.



CoreModel diagram: Forwarding-LtpInterLayerSkeletonOverview

Figure 2-1 Skeleton Class Diagram of key object classes

2.1.2 Core Foundation Model (TR-512.3)

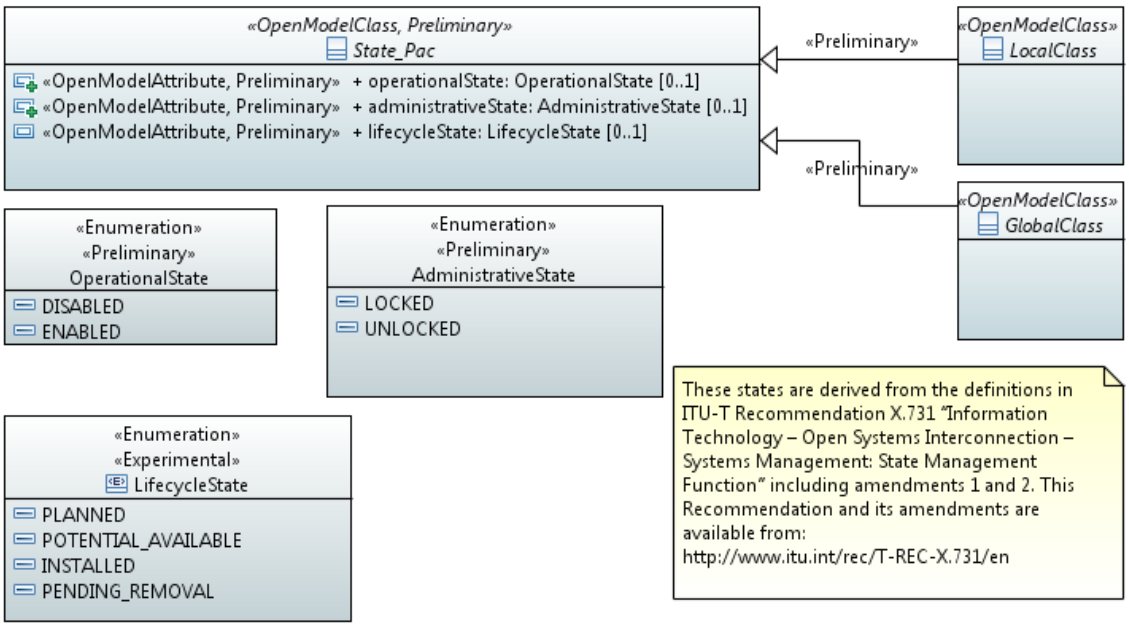
The Foundation document provides a detailed view of all aspects of the CoreModel that are relevant to all other parts of the ONF-CIM. Currently this model includes coverage of naming and identifiers as well as states.

2.1.2.1 Naming and Identifiers

Rationalizing the approach to naming, identification and addressing of entities described in the ONF-CIM

2.1.2.2 States

Basic states applicable to a majority of entities in the ONF-CIM

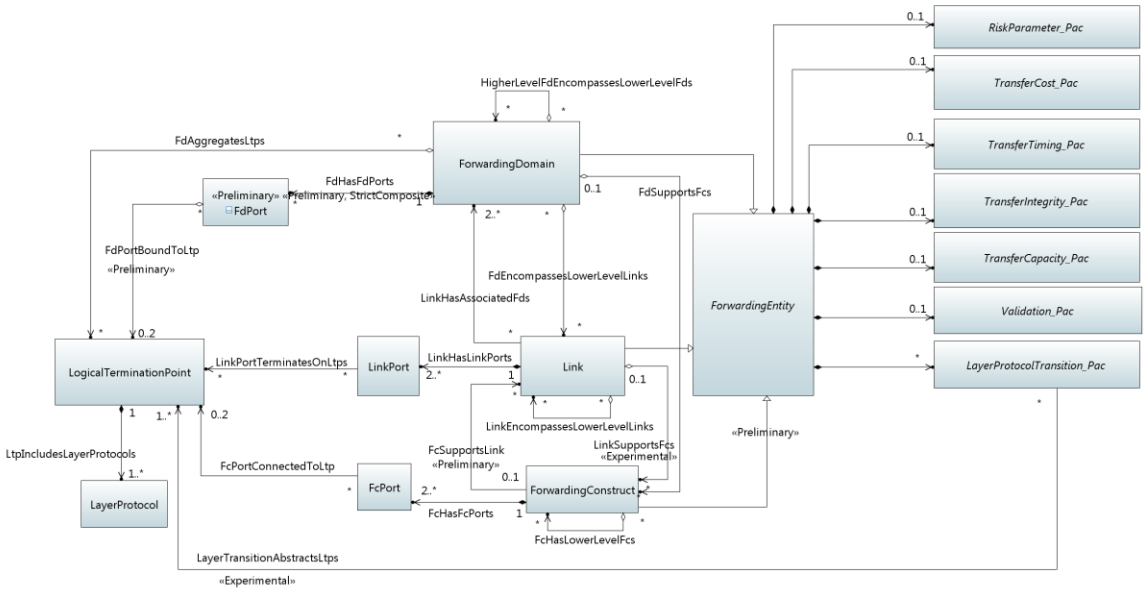


CoreModel diagram: GeneralizedStates

Figure 2-2 States for all Objects

2.1.3 Core Network Model – Topology Model (TR-512.4)

The topology document provides a detailed view of the topology model covering both the basic topology pattern with detailed attributes as well as multi-layered topology and topology views.



CoreModel diagram: Topology-HighLevelOverviewOfStructureAndPacs-LargeText

Figure 2-3 Key classes that form the network topology

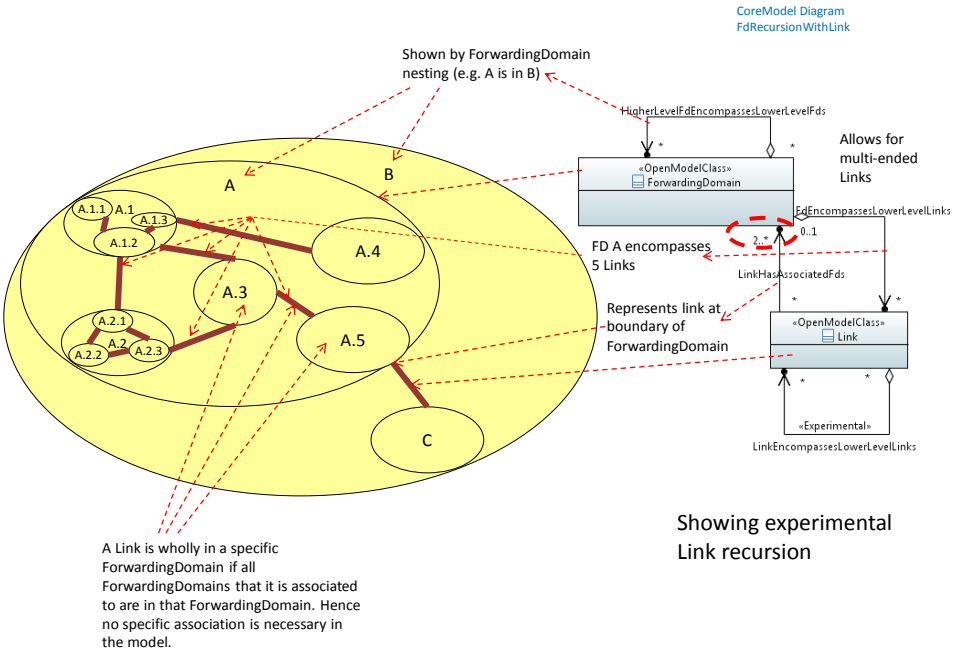


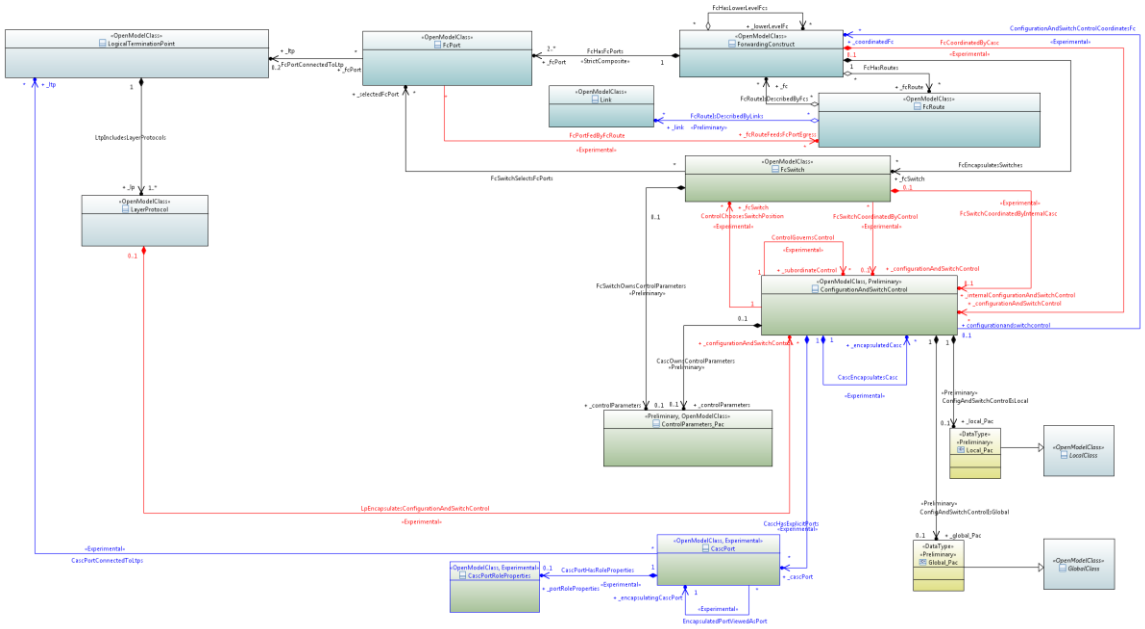
Figure 2-4 ForwardingDomain recursion with Link[6]

2.1.4 Core Network Model – Resilience Model (TR-512.5)

The Resilience document provides a view of the model for resilience (including protection and restoration) and encompasses:

- The basic resilience model structure
- The key attributes relevant to resilience
- The application of the resilience model to various cases

[6] The numbering of the FDs on the figure implies strict and fixed hierarchy. It should be noted that the association is aggregation and hence the hierarchy can change and an FD may move from being encompassed by one FD to being encompassed by another. Consider the numbering as simply a view of the current structure.



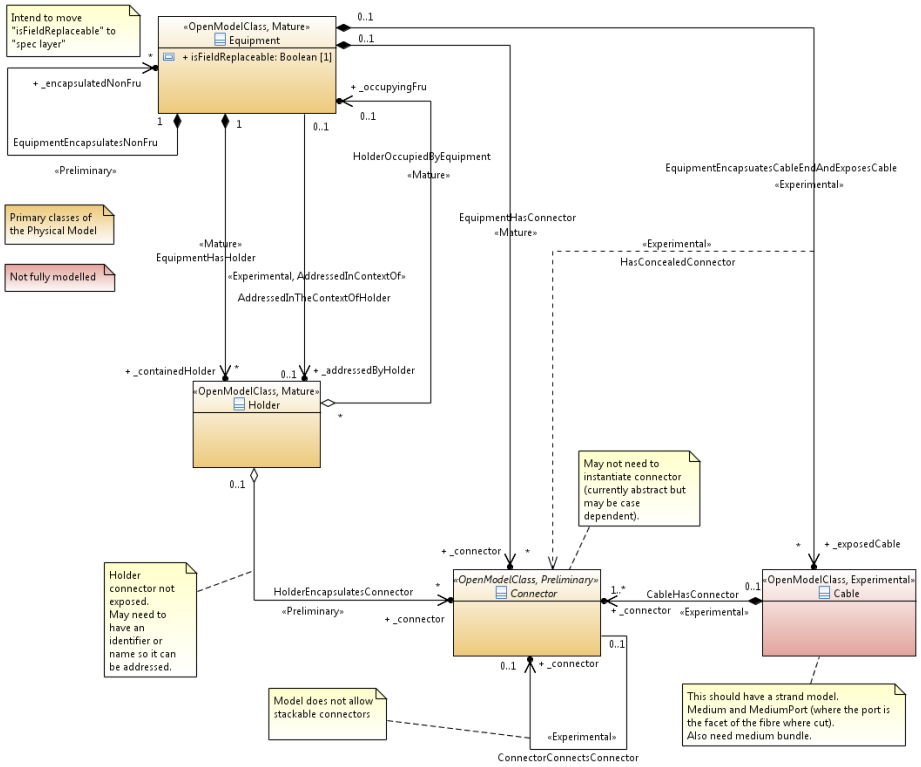
CoreModel diagram: Resilience-Pattern

Figure 2-5 Basic resilience pattern

2.1.5 Core Physical Model (TR-512.6)

The Physical model document provides a view of the model for physical entities (including equipment, holders and connectors). The document:

- Introduces the Physical model structure
- Describes the key classes of the Physical model
- Explains the attributes of the Physical model
- Describes the relationship between the connector and the LTP
- Shows how the model deals with the relationship between physical and functional views including resilience
- Explains how the Specification model describes equipment schemes (e.g. rules, etc.)
- Highlights work in progress to further advance the Equipment model



CoreModel diagram: Equipment-Pattern

Figure 2-6 Basic equipment pattern

2.1.6 Specification Model (TR-512.7)

There are several related needs that have given rise to the Specification model:

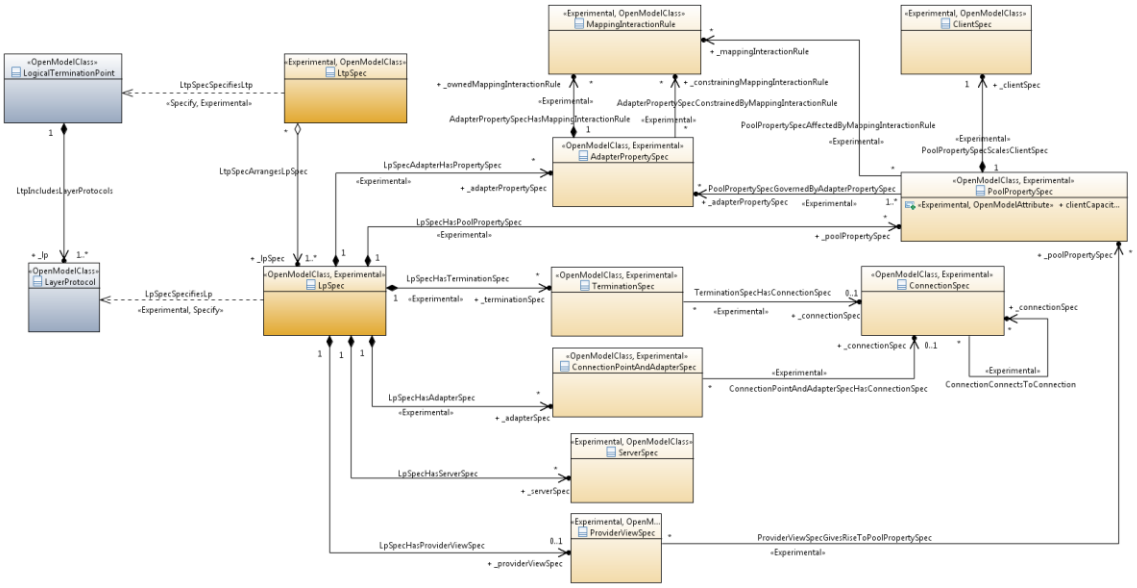
- Provide machine readable form of specific localized behavior:
  - Representing rules related to restrictions of specific cases of use of the model
  - Representing capabilities of specific cases of use
- Enable the introduction of run time schema where the essential structure of the model is known up front (at compile time) but the details are not
- Reduce the clutter in a representation where a set of details take the same values for all instances that related to a specific case
- Allow leverage of existing standards definitions (e.g., technology/application specific) in a machine readable language

The combination of the above resulted in a separation in the model of definitions of structure and content such that an instance of a class from one model fragment could have an association instance to another model fragment to enable the provision of a fragment of definition of the class and of subordinates.

The aim of all specification definitions is that they be rigorous definitions of specific cases of usage and enable machine interpretation where traditional interface designs would only allow human interpretation.

The following dedicated spec structures have been considered:

- FC spec: Main focus is to provide a representation of the effective internal structure of a ForwardingConstruct (FC)
- LTP and LP spec: Main focus is to provide a representation of Layer Protocol (LP) specific parameters for the Logical Termination Point (LTP)
- FD and Link spec: Main focus is on capacity and forwarding enablement restrictions
- Equipment spec: Main focus is to provide a representation of equipping constraints
- Scheme spec: Main focus is to provide a mechanism to describe any pattern (arrangement) of entities from the model for some specific purpose (e.g. to describe the structure of a [ITU-T G.8032] protection scheme



CoreModel diagram: Spec-LtpCapabilitySpecWithLtp

Figure 2-7 Class Diagram of the Spec Model of LTP and LP

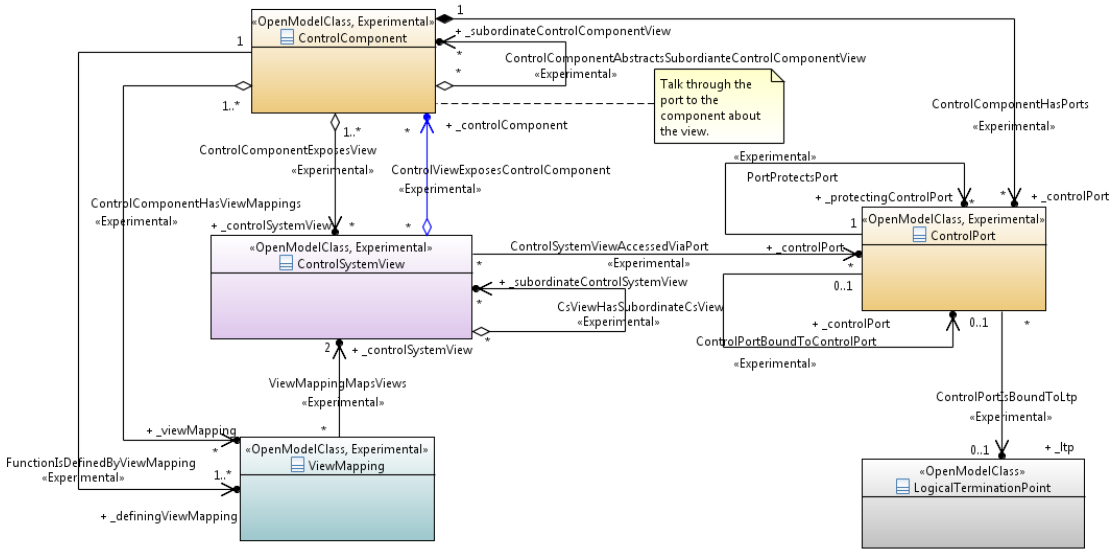
In addition there is work on a generalized spec pattern with the main focus to provide a common representation of the mechanism for relating a class to its spec, accounting for implementation needs.

2.1.7 Control Model (TR-512.8)

The ONF Architecture [ONF TR-521] talks of a recursion of control aligning well with the more general concept of the Management-Control Continuum from [TMF IG1118]. The control model in [ONF TR-512 V1.2] showed a traditional hierarchy rather than a generalized recursion.

Over many years it has become apparent that the traditional representation of the Network Element and of the Managed Element was not correct. It is clear that from one perspective the Network Element is simply a lower level member of the Management-Control Continuum. It is also apparent that all other aspects of the NE are covered by other parts of the model.

It was concluded that the NE should be remodeled as simply a control capability and that that capability should be generalized so that it could handle all aspects of the Management Control Continuum.



CoreModel diagram: Control-ControlComponentAndControlViewCore

Figure 2-8 Core Control Model

As explained in [TR-512 V1.2] the classes SdnController, NetworkControlDomain and NetworkElement[7] have been reassessed and deprecated and new classes have been developed in this release to replace them. It has been recognized that a uniform recursive model of control can be developed that provides a consistent treatment of what were previously seen as completely different things.

2.1.8 OAM Model (TR-512.9)

This document is not part of this release, it will be provided in a later release. The document will provide a view of the multi-technology OAM model.

2.1.9 Operations Pattern Model (TR-512.10)

The work has been carried out with the assumption that the future is cloud oriented such that the controllers are an interconnected system of cloud-based components. It is assumed that in a cloud environment the operations will be "outcome-oriented" interaction[8] where the focus is on stating the constraints that form a boundary that defines the desired target. In outcome-oriented interaction the operations/methods/activities/tasks used to achieve the desired outcome are firmly

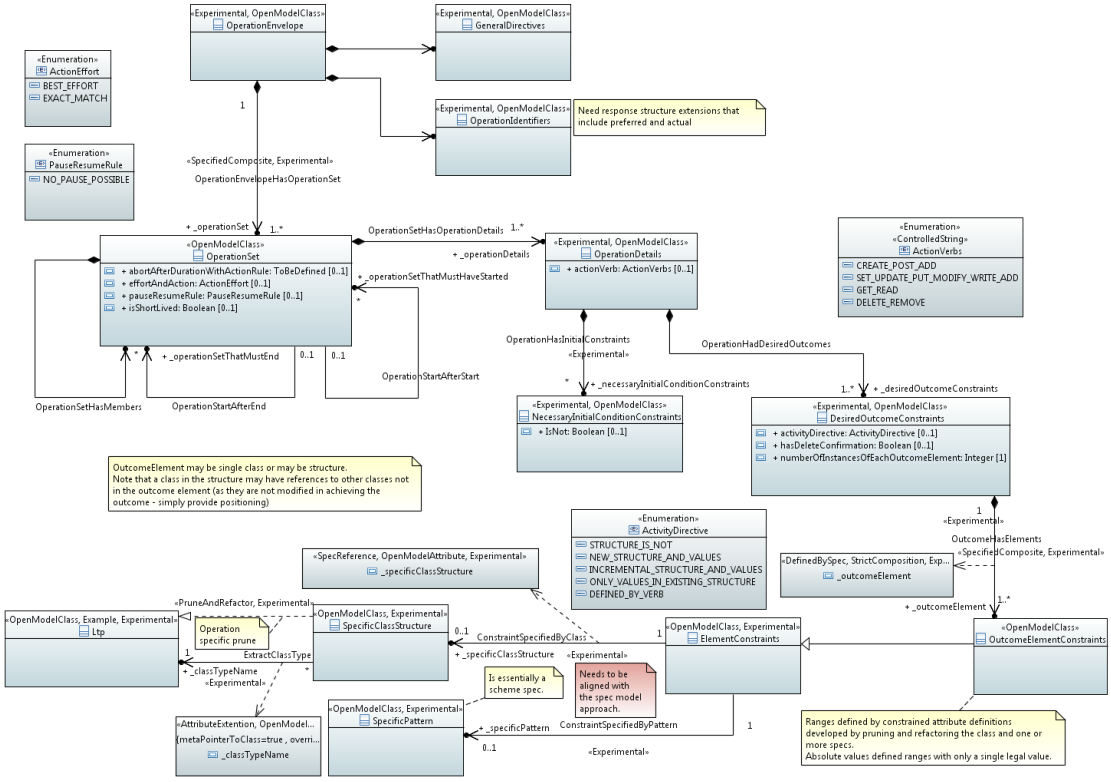
[7] The Network Element scope of the direct interface from a SDN controller to a Network Element in the infrastructure layer is similar to the EMS-to-NE management interface defined in the information models [ITU-T G.874.1] (OTN), [ITU-T G.8052] (Ethernet), and[ITU-T G.8152] (MPLS-TP).
[8] Intent is an outcome-oriented form of interaction.

in the domain of the provider. The client simply provides information about the desired outcome in the context of what has been agreed as possible. Hence the essential need of any interaction is the provision of information about the desired outcome in terms of constraints and potentially in the context of some expected initial system state. Whilst the content of any message may differ per interaction the structure will be consistent[9].

- The Operations Pattern Model is intended to provide a dynamic sophisticated structure that has "foldaway" parts
- The aim is to provide one structure:
    - For all outcome-oriented constraint-based forms including intent
    - Supports traditional Verb driven forms
        - with constrained valued
        - with absolute values
    - Enables operations that:
        - Act on multiple separate independent things
        - Have sequence and interdependency between parts and with other separate interactions
        - Are long lived or short lived (where the life may depend upon the case and may not be knowable before the request
- The aim is that the model will be used to generate schema where there is a continuum of compatible schema from the most basic simple CRUD (Create/Read/Update/Delete) forms to the most sophisticated forms such that the CRUD form can be seen as a tiny subset of the sophisticated form

The following figure shows the model of the request.

[9] Again, human language is a good analogy. The grammar remains constant, simple and repeating but the vocabulary is broad and changes/grows often rapidly.



CoreModel diagram: Operation-Structure

Figure 2-9 The structure of an operation (request)

2.1.10 Processing Construct Model (TR-512.11)

The ProcessingConstruct (PC) represents generalized functionality. The PC is used in conjunction with the ConstraintDomain (CD) that groups PCs and constrains their usage. In addition to being general applicable to represent functionality that is not being modeled in detail the PC and CD form the fundamental pattern that allows an important transition in the representation of a 'device'[10].

In the ONF CIM there are already separate classes for special types of functions:

- ForwardingConstruct to represent forwarding functionality
- LogicalTerminationPoint to represent termination, and
- ForwardingDomain to represent forwarding scope constraints.

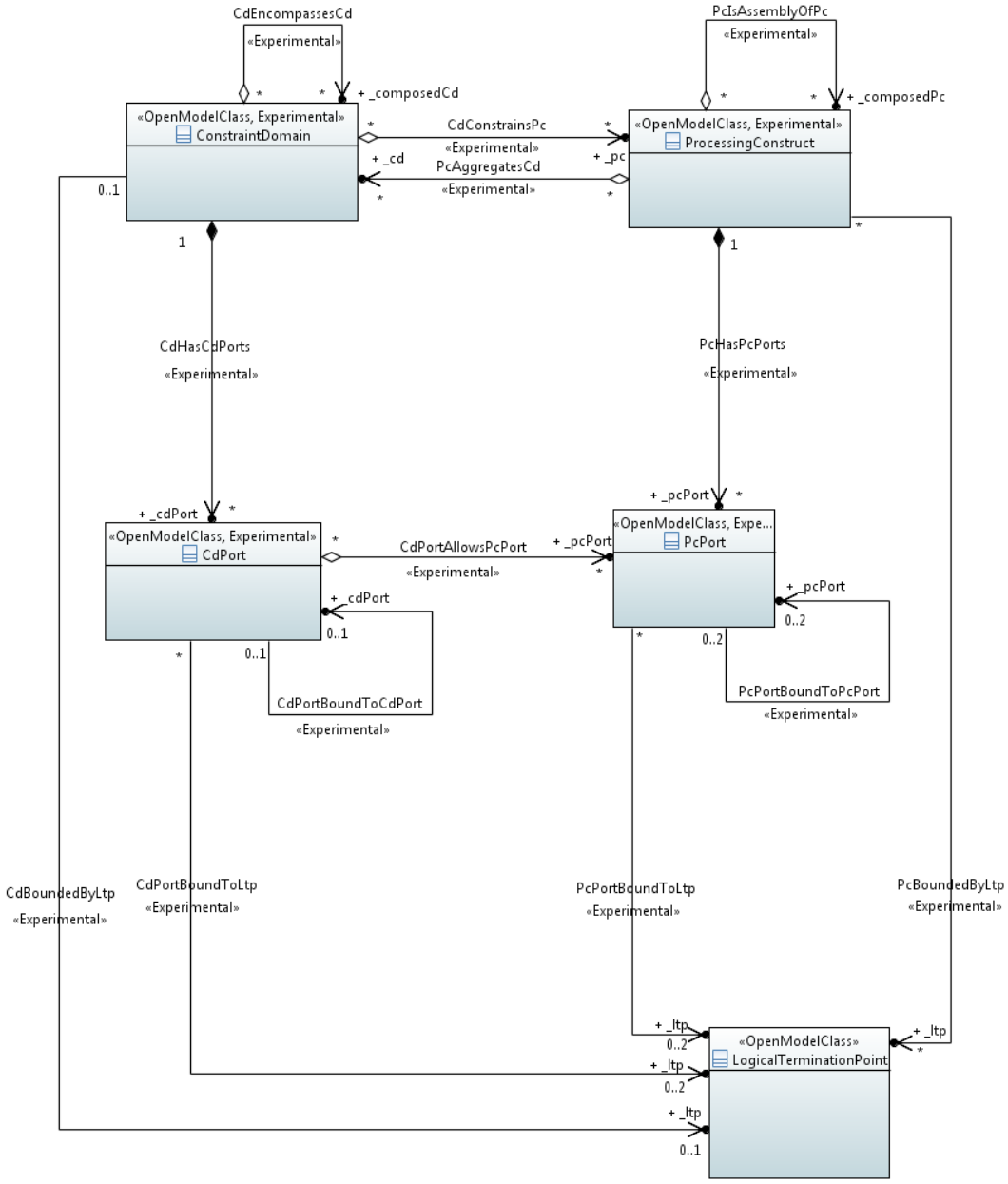
ProcessingConstruct is in addition to these concepts and is to be used where the major function of interest is related to processing rather than forwarding of information.

While there are a number of grey areas between processing and forwarding, there are a few 'pure' ProcessingConstructs:

[10] Here we will use the term ‘device’ in a loose and undefined manner to aid in the discussion. The term is not defined because it is not important for our discussion, the generally understood concept is sufficient.

- Memory
- CPU
- Storage

Another use for ProcessingConstruct is for representing control plane processes such as packet routing processes. Packet routers commonly run many routing protocols and may also run many instances of each routing protocol. Each routing process instance peers independently and using ProcessingConstruct we can show the actual control plane topologies.



CoreModel diagram: ProcessingConstruct-Core

Figure 2-10 Processing Construct and Constraint Domain core model

2.2 Supporting documents

There are further supporting documents described below:

- The "A" series of explanatory documents (see TR-512.A.1)
- The "double letter" series of supporting documents (described below)
    - The documents of this series were issued in V1.2 as part of the numeric series (e.g. TR-512.DD was TR-512.8 in V1.2)

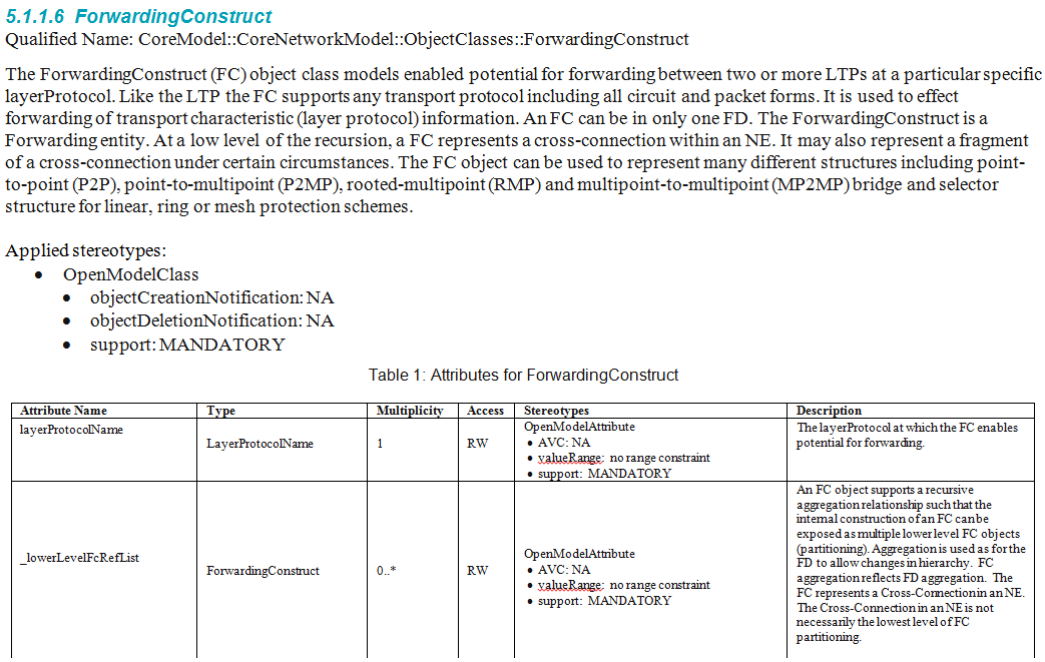
2.2.1 Appendix Overview (TR-512.A.1)

There is a set of supporting appendix documents (the "A" series) that provide further examples and explanation of the model. These documents are briefly summarized in TR-512.A.1.

2.2.2 Data Dictionary (TR-512.DD)

The data dictionary provides details of the classes, attributes and data types (i.e. syntax) that are used in the model. The individual "model focuses" documents provide details on key classes and attributes but do not provide all details to avoid clutter and replication.

An extract from the data dictionary is shown below.



5.1.1.6 ForwardingConstruct

Qualified Name: CoreModel::CoreNetworkModel::ObjectClasses::ForwardingConstruct

The ForwardingConstruct (FC) object class models enabled potential for forwarding between two or more LTPs at a particular specific layerProtocol. Like the LTP the FC supports any transport protocol including all circuit and packet forms. It is used to effect forwarding of transport characteristic (layer protocol) information. An FC can be in only one FD. The ForwardingConstruct is a Forwarding entity. At a low level of the recursion, a FC represents a cross-connection within an NE. It may also represent a fragment of a cross-connection under certain circumstances. The FC object can be used to represent many different structures including point-to-point (P2P), point-to-multipoint (P2MP), rooted-multipoint (RMP) and multipoint-to-multipoint (MP2MP) bridge and selector structure for linear, ring or mesh protection schemes.

Applied stereotypes:

- OpenModelClass
    - objectCreationNotification: NA
    - objectDeletionNotification: NA
    - support: MANDATORY

Table 1: Attributes for ForwardingConstruct

Attribute Name	Type	Multiplicity	Access	Stereotypes	Description
layerProtocolName	LayerProtocolName	1	RW	OpenModelAttribute • AVC: NA • valueRange: no range constraint • support: MANDATORY	The layerProtocol at which the FC enables potential for forwarding.
_lowerLevelFcRefList	ForwardingConstruct	0..*	RW	OpenModelAttribute • AVC: NA • valueRange: no range constraint • support: MANDATORY	An FC object supports a recursive aggregation relationship such that the internal construction of an FC can be exposed as multiple lower level FC objects (partitioning). Aggregation is used as for the FD to allow changes in hierarchy. FC aggregation reflects FD aggregation. The FC represents a Cross-Connection in an NE. The Cross-Connection in an NE is not necessarily the lowest level of FC partitioning.

Figure 2-11 Extract from data dictionary (V1.2)

2.2.3 Terminology mapping (TR-512.TM)

The terminology mapping document contains a table that provides overview translations from classes in the ONF-CIM to classes (and concepts) in other models. It will be helpful for someone who is familiar with one of the other industry standard terminology sets when working through the ONF-CIM.

2.2.4 Core Model Future Enhancements (TR-512.FE)

This document provides fragments of ongoing work and lists all work areas known to require further development. The data dictionary document does NOT include entities from this document. All the work mentioned in this document is experimental.

2.2.5 Gendoc fragment definitions (TR-512.GT)

This document provides a base document from which all other documents are derived. The document provides some examples of usage.

Note that Gendoc is the tool used to extract model element details and diagrams from the .uml and .notation files and to insert those into the TR-512 documentation.

Note all Gendoc templates are provided in the Gendoc folder.

2.3 Supporting Guidelines

Several guideline documents have been constructed to maintain consistency in the models generated by ONF. These guidelines have also been shared with organizations outside ONF and are now developed in a collaborative mode across multiple bodies in an open source project [OSSDN-EAGLE].

- **[ONF TR-513]:** This document specifies the principles and guidelines for the development and use of the ONF-CIM, including guidelines for deriving purpose-specific information model views (through pruning and refactoring selected subsets of artifacts from the ONF-CIM), and mapping to data schemas for protocol-specific control interfaces.
- **[ONF TR-514]:** The ONF-CIM is expressed in a formal language called UML (Unified Modeling Language). UML has a number of basic model elements, called UML artifacts. In order to assure consistent modeling, only a subset of the UML artifacts is used in the development of the ONF-CIM. The selected subset of UML artifacts is documented.
- **[ONF TR-515]**: This document specifies the guidelines for using the Papyrus tool used in the development of the ONF-CIM. It also describes how the ONF CIM modeling teams can cooperate in the GitHub environment for separate and coordinated development of the ONF-CIM fragments.

2.4 Key reference material

In the development of the CoreModel, information model work from other SDOs has been used as input, including [TMF TR215], [TMF TR225], [TMF SID 5LR], [ITU-T G.7711], [ITU-T G.874.1], [ITU-T G.8052], and [ITU-T G.8152]. The CoreModel is being shared with other bodies via various mechanisms including publication of a view of the model as an IETF draft [draft-lam].

2.5 Papyrus File

This section provides the link to the information model file and the companion Open Model Profile file specified using the "Papyrus" modeling tool.

Link to the Core Model files: OnfModel folder.

The file structure is as follows:

- .project,
- CoreModel.di,
- CoreModel.notation
- CoreModel.uml
- OpenModel_Profile.profile.di
- OpenModel_Profile.profile.notation
- OpenModel_Profile.profile.uml
- Experimental.profile.di[11]
- Experimental.profile.notation
- Experimental.profile.uml

In order to view and further extend or modify the information model, install the open source Eclipse software and the Papyrus tool. The installation guide for Eclipse and Papyrus can be found in [ONF TR-515].

2.6 Boundary of the work

As noted, the ONF Core IM does not cover interface definition. As a consequence, certain stereotype values are not relevant and hence are left at default including objectCreationNotification, objectDeletionNotification and passByReference. A majority of the attributes are read/write as in most cases a view can be conceived that will allow the attribute to be written.

3 Summary of changes

3.1 Summary of main changes between version 1.1 and 1.2

Changes to the model and/or related documentation:

- General
  - Change to doc structure
  - Change to gendoc
- Forwarding and Termination
  - Minor corrections made to multiplicities
  - Improvements made to documentation
- Foundation
  - An address structure has been added as «Experimental»
- Topology
  - Change of name of TopologicalEntity to ForwardingEntity

[11] The Experimental profile provides some stereotypes related to experimental rules (e.g. in the Physical model). The relevant stereotypes in this profile will be moved to a formal profile in the next release.

    - Incorporation of FC under ForwardingEntity and consideration of FC as closely related to topology
    - Capacity
- Resilience
    - Protection, restoration and recovery attributes added
    - Structure enhanced
    - Association to LTP from protection added in preparation for G.8032 modeling
    - Various examples of usage developed to both prove and document the resilience model
    - Corrections made to some multiplicities
    - Lifecycle stereotypes adjusted to reflect the advancing maturity of the model
- Equipment
    - New model added as «Experimental»
    - Focus of the model is on the pattern but all experimental work has been published as equal
- Specification
    - Addition of FD/Link spec details in terms of FD/Link capability statements
    - Refinement of FC spec to accommodate the Link (removal of Fc from class names in the spec and generalization to Forwarding recognizing the Link as a Forwarding entity).
    - Addition of sketches of the generalized spec model
    - Enhancements to details on LTP/LP spec and discussion on migration

3.2 Summary of main changes between version 1.2 and 1.3

- General
    - Change to doc structure:
        - To focus numeric series on describing the model
        - Adding an appendix ("A") series that provides further explanation
        - Adding a "double letter" series to capture ongoing model support material
    - Clean up of model structure
- Forwarding and Termination
    - Photonic/Media model including examples in an Appendix
    - Deprecating of NE, SdnController and NetworkControlDomain (replaced by the Control model and ProcessingConstruct/ConstraintDomain (see below)
    - LtpHasServerLtp is changed from composition to aggregation
    - Addition of Clock
- Foundation
    - Enhancements to the state model
- Topology
    - FdPort added to model as an optional
    - Aggregation of FD by FD via HigherLeeFdEncompassesLowerLevelFDs allows for many FDs to aggregate the same subordinate FD and this is reflected in the FcHasLowerLevelFc association multiplicity
    - Added explanation of use of model to support:
        - Serial-Compound Link

        - Inverse Multiplexing
        - Transitional Link
        - Multi-Port Links
        - State depedency
    - Added a clarification of the definition of Link
    - Explained the relationship between topology and the new control model
    - Enhanced the explanation of the approach of using the FC to represent the Call
    - Added explanation of the Resource-Service Continuum
- Resilience
    - G.8032 model with examples of use in an Appendix
    - Use of scheme spec concept
    - Timing protection
- Equipment
    - Upgrade of some classes and attributes from experimental to preliminary or mature
    - Integration with PC model providing an enhanced support for "Equipment protection" (via a model of function resilience)
- Specification
    - Improved introductory material
    - Refinements to the model to improve the decoupling of specification from the specified class
    - Addition of scheme spec concept
- Addition of the Control model
    - In conjunction with Processing Construct and Constraint Domain (see below) this provides:
        - A full consistent model of control
        - A replacement for the NE
- Addition of Operations Pattern model
    - This provides a generalized model of operations for an outcome-oriented interaction
- Addition of Processing Construct (PC) and Constraint Domain (CD)
    - This provides a generalized representation of functionality beyond Forwarding and Termination
- Addition of supporting information on patterns underpinning the model

3.3 Summary of main changes between version 1.3 and 1.3.1

- General
    - An important note related to the approval status of TR-512 was added to each of the documents.
- Addition of the Circuit switched examples

Note that there were no changes in the UML model in 1.3.1.

4 References

[draft-lam]	IETF draft-lam-teas-usage-info-model-net-topology-04, Usage of IM for network topology to support TE Topology YANG Module Development
[IEEE 1588]	1588 -2008 IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
[IETF RFC4122]	IETF RFC 4122 (July 2005) A Universally Unique Identifier (UUID) URN Namespace
[ISO/IEC 19505]	ISO/IEC 19505:2012 Information technology -- Object Management Group Unified Modeling Language (OMG UML)
[ITU-T G.780]	Recommendation ITU-T G.780/Y.1351 (07/10), Terms and definitions for synchronous digital hierarchy (SDH) networks
[ITU-T G.800]	Recommendation ITU-T G.800 (04/2016), *Unified functional architecture of transport networks*
[ITU-T G.805]	Recommendation ITU-T G.805 (03/2000), *Generic functional architecture of transport networks*
[ITU-T G.808.1]	Recommendation ITU-T G.808.1 (05/2014), *Generic protection switching – Linear trail and subnetwork protection*
[ITU-T G.812]	Recommendation ITU-T G.812 (06/04), Timing requirements of slave clocks suitable for use as node clocks in synchronization networks
[ITU-T G.813]	Recommendation ITU-T G.813 (03/03), Timing characteristics of SDH equipment slave clocks (SEC)
[ITU-T G.852.1]	Recommendation ITU-T G.852.1 (11/1996), *Enterprise viewpoint for simple subnetwork connection management*
[ITU-T G.852.2]	Recommendation ITU-T G.852.1 (11/1996), *Enterprise viewpoint description of transport network resource model*
[ITU-T G.872]	Recommendation ITU-T G.872 (01/17), Architecture of optical transport networks
[ITU-T G.874]	Recommendation ITU-T G.874 (08/2013), *Management aspects of optical transport network elements*
[ITU-T G.874.1]	Recommendation ITU-T G.874.1 (11/2016), *Optical transport network: Protocol-neutral management information model for the network element view,* plus Amendment 1 (08/2013)
[ITU-T G.7711]	Recommendation ITU-T G.7711/Y.1702 (ex. G.gim) (12/2016), *Generic Protocol-Neutral Information Model for Transport Resources*
[ITU-T G.8001]	Recommendation ITU-T G.8001/Y.1354 (04/16), *Terms and definitions for Ethernet frames over transport*
[ITU-T G.8032]	Recommendation ITU-T G.8032/Y.1344 (08/15), *Ethernet Ring Protection Switching*

[ITU-T G.8052]	Recommendation ITU-T G.8052/Y.1346 (11/2016), *Protocol-neutral management information model for the Ethernet Transport capable network element*
[ITU-T G.8081]	Recommendation ITU-T G.8081 (02/2012), *Terms and definitions for automatically switched optical networks*
[ITU-T G.8152]	Recommendation ITU-T G.8152/Y.1375 (12/2016), *Protocol-neutral management information model for the MPLS-TP network element*
[ITU-T M.3100]	Recommendation ITU-T M.3100 (04/2015), *Generic network information model*
[ITU-T M.3400]	Recommendation ITU-T M.3400 (02/2000), *TMN management functions*
[ITU-T Q.1741.9]	Recommendation ITU-T Q.1741.9 (06/15), IMT-2000 references to Release 11 of GSM evolved UMTS core network
[ITU-T X.731]	Recommendation ITU-T X.731 (01/1992), *Information technology - Open Systems Interconnection - Systems management: State management function*
[OASIS TOSCA]	https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=tosca
[ONF]	https://www.opennetworking.org/
[ONF TAPI]	ONF Transport API (see [OSSDN-SNOWMASS])
[ONF-TMF-MEF]	MEF ONF TMF Collaboration Agreement (see https://login.opennetworking.org/bin/c5i?mid=38&rid=61&cid=3&k1=1567&tid=1483824677)
[ONF TR-512]	This document series (V1.3.1, V1.2) (https://www.opennetworking.org/software-defined-standards/models-apis/ for the project deliverables (including the documents), https://www.opennetworking.org/wp-content/uploads/2014/10/TR-512_CIM_(CoreModel)_1.2.zip for V1.2 and navigate the project deliverables for V1.3.1 (as the link was not available during the final editing))
[ONF TR-521]	TR-521 (V1.1):: ONF SDN Architecture 1.1, February 2016 (https://3vf60mmveq1g8vzn48q2o71a-wpengine.netdna-ssl.com/wp-content/uploads/2014/10/TR-521_SDN_Architecture_issue_1.1.pdf)
[ONF TR-513]	TR-513 (V1.2): ONF Common Information Model Overview (https://www.opennetworking.org/software-defined-standards/models-apis/ for the project deliverables (including the document) and https://3vf60mmveq1g8vzn48q2o71a-wpengine.netdna-ssl.com/wp-content/uploads/2014/10/TR-513_CIM_Overview_1.2.pdf for the document)
[ONF TR-514]	TR-514 (V1.2): ONF UML Model Guidelines (https://www.opennetworking.org/software-defined-standards/models-apis/ for the project deliverables (including the document) and

	https://3vf60mmveq1g8vzn48q2o71a-wpengine.netdna-ssl.com/wp-content/uploads/2014/10/TR-514_UML_Modeling_Guidelines_v1.2.pdf for the document)
[ONF TR-515]	TR-515 (V1.2): ONF Papyrus Guidelines (https://www.opennetworking.org/software-defined-standards/models-apis/ for the project deliverables (including the document) and https://3vf60mmveq1g8vzn48q2o71a-wpengine.netdna-ssl.com/wp-content/uploads/2014/10/TR-515_Papyrus_Guidelines_v1.2.pdf for the document)
[OSSDN-EAGLE]	Project EAGLE: ONF Open Model, Profiles and Tools (https://github.com/OpenNetworkingFoundation/EAGLE-Open-Model-Profile-and-Tools and https://community.opensourcesdn.org/wg/EAGLE/workgroup)
[OSSDN-SNOWMASS]	Project SNOWMASS: ONF Transport API (https://github.com/OpenNetworkingFoundation/Snowmass-ONFOpenTransport and https://groups.opensourcesdn.org/wg/SNOWMASS/dashboard)
[TMF 612]	TM Forum MTOSI (4.0), Multi-Technology OS Interface
[TMF IG1118]	TM Forum IG1118 OSS/BSS Futures – Architecture R15.5.1 (liaised to ONF)
[TMF TR215]	TMF TR215 (V0.5.3) Logical Resource Network Model Advancements and Insights (liaised to ONF)
[TMF TR225]	TM Forum TR225 (R15.0.0), Logical Resource: Network Function Model (liaised to ONF)
[TMF SID 5LR]	TM Forum GB922 (R15.0.0) Information Framework (SID) Addendum 5LR (liaised to ONF)
[UML-YANG GUIDE]	UML- YANG Mapping Guidelines https://community.opensourcesdn.org/wg/EAGLE/document/172
[UML-YANG TOOL]	UML- YANG Mapping Tooling Navigate via https://github.com/OpenNetworkingFoundation/EAGLE-Open-Model-Profile-and-Tools

5 Definitions

5.1 Terms defined elsewhere

This document uses terms defined elsewhere. These terms are highlighted in section 5.3 Abbreviations and acronyms below by referring to the definition source document.

5.2 Terms defined in this TR

The primary purpose of this document is to define terms and hence terms are defined throughout the document. Key terms are highlighted in section 5.3 Abbreviations and acronyms below by referring to the section in this document where the term is defined.

5.3 Abbreviations and acronyms

This TR uses the following abbreviations and acronyms (Note that some cross references are included here rather than in the

References section where the cross reference is only relevant for abbreviation/acronym interpretation purposes):

AP	Access Point [ITU-T G.805]
API	Application Programmer's Interface
BBF	BroadBand Forum (see https://www.broadband-forum.org/)
BC	Boundary Clock
BMCA	Best Master Clock Algorithm
C&SC	Configuration and Switch Controller (model entity)
CASC	C&SC
CNM	Customer Network Management
CP	Connection Point [ITU-T G.805]
CRUD	Create Read Update Delete
CTP	Connection Termination Point. Note that definitions differ between TM Forum [TMF 612] and [ITU-T M.3100]. Both usages apply here when referring to legacy cases and the abbreviation is qualified in all cases of use.
DSRA	Digital Services Reference Architecture (see TMF)
ECC	Embedded Communications Channel [ITU-T G.874]
EMS	Element Management System [definition reference ITU-T M.3400 - TMN][12]
ERP	Ethernet Ring Protection
ERPS	Ethernet Ring Protection Switching
ETH	Ethernet MAC Layer [definition reference ITU-T G.8001]
eTOM	enhanced Telecommunications Operations Map (see TMF)
ETY	Ethernet Physical Layer [definition ITU-T G.8001]
FC	ForwardingConstruct (defined in the ONF-CIM - see TR-512.2). • Note that at this point the definition is subtly different to that in [TMF TR225]. The aim is to align the terms usage
FD	ForwardingDomain (defined in the ONF-CIM - see TR-512.2)
FDFr	FlowDomainFragment [TMF 612]
FRE	ForwardingRelationshipEncapsulation [TMF TR215]
FRU	Field Replaceable Unit
FTP	FloatingTerminationPoint [TMF 612]
GitHub	See www.github.com
GUID	Globally Unique IDentifier (see www.wikipedia .org/Globally_unique_identifier)
H2M	Human to Machine

[12] This term is not intended for use other than in reference to legacy systems.

IM	Information Model (see section 1 Introduction above)
IMP	Inverse MultiPlexing [ITU-T G.805]
IISOMI	Informal Inter-SDO Open Model Initiative (see [OSSDN-EAGLE])
ISO	International Organization for Standardization (see www.iso.org)
ITU	International Telecommunications Union (see www.itu.int)
ITU-T	Telecommunications Standardization Sector of ITU-T (see http://www.itu.int/en/ITU-T/Pages/default.aspx)
JSON	JavaScript Object Notation (www.json.org/)
LP	LayerProtocol (defined in the ONF-CIM – see TR-512.2). Note that there are two related terms: • layer-protocol: used to refer to the information transfer protocol (or Characteristic Information of the signal) • layerProtcolName: used to refer to the attribute in the LP class that carries the value that identifies the characteristic layer-protocol of the LP • LayerProtocolName: used to refer to the data type that holds the formal name of the layer-protocol
LTP	LogicalTerminationPoint (defined in the ONF-CIM - see TR-512.2)
M2M	Machine to Machine
MA	Management Agent
MAC	Media Access Control
MCC	Management Control Continuum (see [TMF IG1118]
ME	Managed Element OR Media Element (clarified per usage)
MEF	MEF Forum (see https://mef.net/)
MEG	Maintenance Entity Group
MEP	MEG End Point
MFDFr	MatrixFlowDomainFragment
MIP	MEG Intermediate Point
MLSN	MultiLayerSubNetwork [TMF 612]
MP2MP	Multi-Point to Multi-Point
MPLS-TP	Multi-Protocol Label Switching Transport Profile [definition reference RFC6378]
NCD	NetworkControlDomain
NE	NetworkElement
NFV	Network Function Virtualization
NMS	Network Management System
OAM	Operations Administration and Maintenance
OC	Ordinary Clock
OCh	Optical Channel

ODU	Optical Data Unit
OIF	Optical Interworking Forum (see http://www.oiforum.com/)
OMS	Optical Multiplex Section
ONF-CIM	ONF Common Information Model
OPS	Optical Protection Switch
OS	Operations System (same as OSS) OR Optical Section
OSC	Optical Supervisory Channel
OSME	Optical Signal Maintenance Entity
OSS	Operation Support System
OTN	Optical Transport Network
OTS	Optical Transmission Section
OTSi	Optical Tributary Signal
OTSiG	Optical Tributary Signal Group
OTU	Optical channel Transport Unit
P&R	Pruning and Refactoring (Prune and Refactor)
P2MP	Point to Multi-Point
P2P	Point to Point
PC	ProcessingConstruct (defined in the ONF-CIM - see TR-512.11)
PoC	Proof of Concept
PON	Passive Optical Network
PRC	Primary Reference Clock
PTP	Physical Termination Point [TMF 612]
PTP	Precision Time Protocol [IEEE 1588]
RMP	Rooted Multi-Point
SD FEC	Soft Decision Forward Error Correction
SDN	Software Defined Networking [ONF]
SDO	Standards Development Organization
SID	Shared Information and Date model (see TMF)
SNC	SubNetworkConnection [TMF 612]
SNP	SubNetworkPoint [ITU-T G.8081]
SSM	Synchronization Status Message
TAPI	Transport API
TBD	To Be Defined
TC	Transparent Clock
TCP	Termination Connection Point [ITU-T G.805]
TDM	Time Division Multiplex

TMF	TeleManagement Forum (see www.tmforum.org)
TOSCA	[OASIS TOSCA]
TP	Termination Point [ITU-T M.3100]
TPE	TerminationPointEncapsulation [TMF TR215]
TR	Technical Recommendation [ONF] Technical Report [TM Forum]
TRI	Transport Resource Identifier [ITU-T G.8081]
TTP	Trail Termination Point [ITU-T M.3100]
UML	Unified Modelling Language (see www.omg.org)
UUID	Universally Unique IDentifier (see https://en.wikipedia.org/wiki/Universally_unique_identifier)
VCAT	Virtual Concatenation
VM	Virtual Machine
VMM	Virtual Machine Manager
VNE	Virtual Network Element
VNF	Virtual Network Function
XC	CrossConnection
YANG	https://en.wikipedia.org/wiki/YANG

6 Conventions

6.1 Lifecycle Stereotypes

Lifecycle stereotypes (see [ONF TR-514]) are applied to entities in the model to indicate their degree of maturity[13]. These are made visible in many of the figures in this document.

The following stereotypes appear in TR-512:

- «Experimental»: Indicates that the entity is at a very early stage of development and will almost certainly change. The entity is NOT mature enough to be used in implementation[14].
- «Preliminary»: Indicates that the entity is at a relatively early stage of development and is likely to change but is mature enough to be used in implementation.

If no stereotype is shown (or the entity is marked «Mature») the entity is mature. Other Lifecycle Stereotypes are defined in [ONF TR-514].

6.2 Key to diagram symbol set

This document set includes a number of UML diagrams. The UML symbol set is suitably explained in [ONF TR-514]. Many of the UML diagrams in this document have small font (due to density of information conveyed). It will be necessary for the reader to zoom in and pan across the figure to see the detail[15].

This document set also contains a number of non-UML diagrams, which use the symbols highlighted below in pictorial representations of network examples. The symbol set is an advanced partial hybrid of symbols used by other bodies (see [TMF TR215] and [ITU-T G.805]).

[13] The whole model including all degrees of work in progress has been published to allow the user maximum opportunity to set a most consistent direction with the work at hand. It is considered important to expose work in progress especially where this may have an impact on a choice of implementation. There may be some experimental structure that contains some very stable parts, without that structure those parts might be quite uninterpretable. A user who decides to take a low risk approach can ignore preliminary and experimental parts. A user who is more inclined to take a risk or who is looking for inspiration for their work can take the experimental and preliminary parts, understanding the risk involved.

[14] The implementer can clearly choose to use the item at risk (expecting change and accounting for this in deployments etc.)

[15] The aim is to improve the figure readability in future releases.

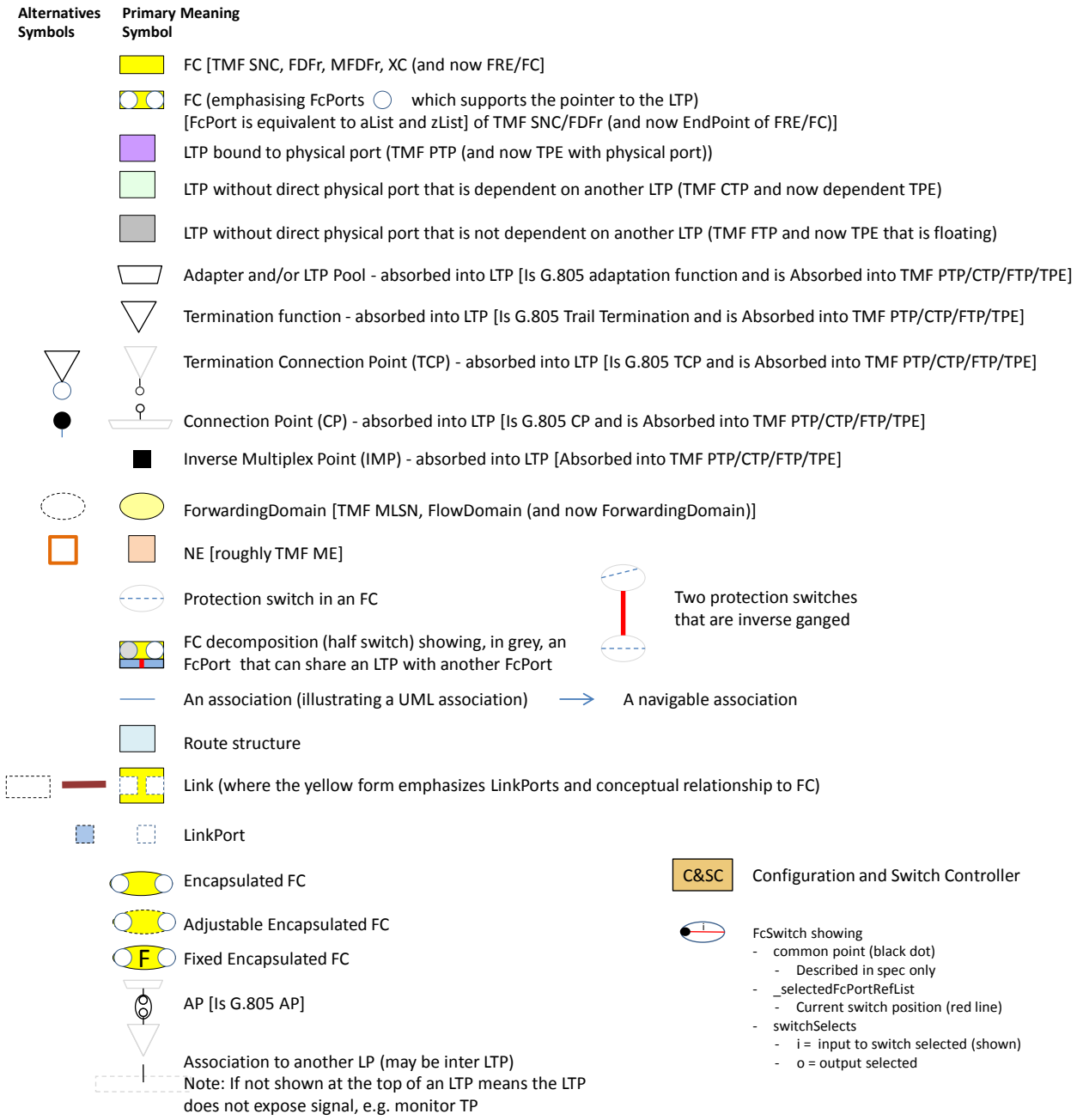


Figure 6-1 Network diagram symbol set[16]

In addition in the diagrams related to media the following symbols and labels are used.

[16] It should be noted that in this version and future versions the terms ForwardingDomain (FD) and ForwardingConstruct (FC) are used in place of SubNetwork (SN) and SubNetworkConnection (SNC) (used in the earlier versions of the ONF-CIM).

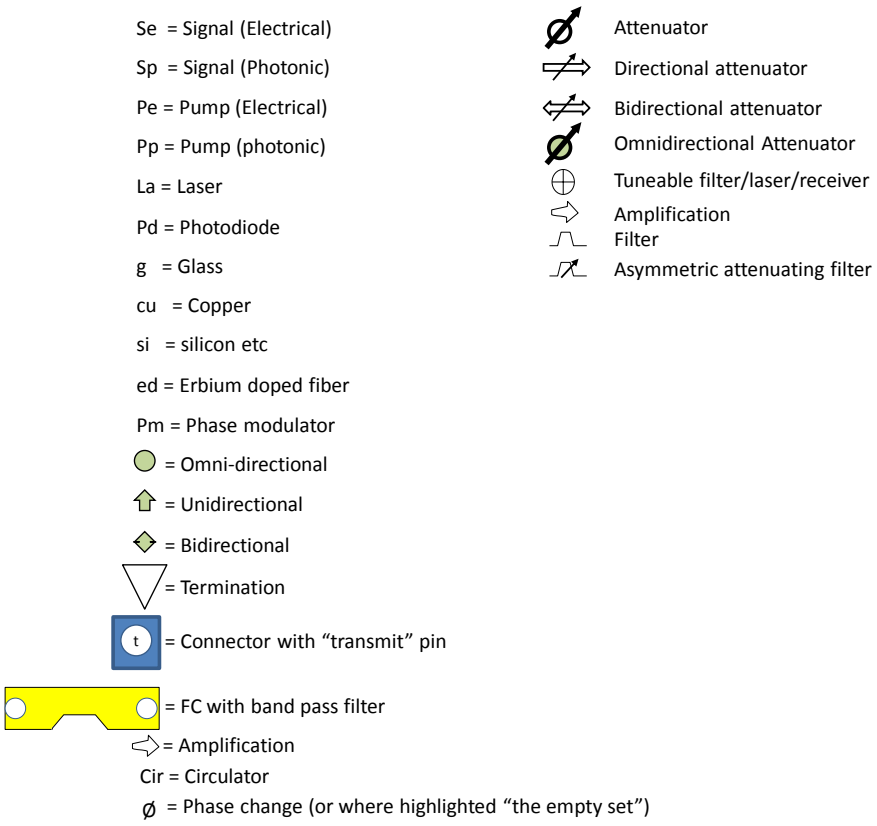


Figure 6-2 Additional media diagram symbol set

7 Future CoreModel work areas

Future work areas are covered in TR-512.FE.

8 Terminology Translation table

The translations provided in this release are early draft (see TR-512.TM). There may be errors in the table and the table is not complete. It should be used for guidance only.

9 Documentation structure

TR-512 is delivered in a .zip file. The file has key documents at the top level and several folders that contain other documents, UML figures and the model.

The .zip file is structured as below:

- ReadMe.txt
- TR-512.1_OnfCoreIm-Overview.pdf (inc. Links to ModelDescription documents and OnfModel folder)
- ModelDescriptions folder (each document includes navigable links to other relevant documents)
    - TR-512.2_OnfCoreIm-ForwardingAndTermination.pdf
    - TR-512.3_OnfCoreIm-Foundation.pdf
    - TR-512.4_OnfCoreIm-Topology.pdf
    - TR-512.5_OnfCoreIm-Resilience.pdf
    - TR-512.6_OnfCoreIm-Physical.pdf
    - TR-512.7_OnfCoreIm-Specification.pdf
    - TR-512.8_OnfCoreIm-Control.pdf
    - TR-512.10_OnfCoreIm-OperationPatterns.pdf
    - TR-512.11_OnfCoreIm-ProcessingConstruct.pdf
    - TR-512.A.1_OnfCoreIm-AppendixOverview.pdf
    - TR-512.A.2_OnfCoreIm-Appendix-ModelStructurePatternsAndArchitecture.pdf
    - TR-512.A.3_OnfCoreIm-Appendix-ModelRationale.pdf
    - TR-512.A.4_OnfCoreIm-Appendix-AnalogueAndMediaExamples-L0.pdf
    - TR-512.A.8_OnfCoreIm-Appendix-TimingAndSynchronizationExamples.pdf
    - TR-512.A.9_OnfCoreIm-Appendix-ProcessingConstructExamples.pdf
    - TR-512.A.10_OnfCoreIm-Appendix-SpecificationExamples.pdf
    - TR-512.A.11_OnfCoreIm-Appendix-ResilienceExamples.pdf
    - TR-512.DD_OnfCoreIm-DataDictionary.pdf
    - TR-512.FE_OnfCoreIm-FutureEnhancements.pdf
    - TR-512.GT_OnfCoreIm-CommonGendocTemplate.pdf
    - TR-512.TM_OnfCoreIm-TerminologyMapping.pdf
- UmlFigures folder (has a subfolder for each document that includes one or more UML figures. These figures have been included to aid viewing as some are very detailed (as the .pdf figures do not scale sufficiently)).
    - TR-512.1
    - TR-512.2
    - TR-512.3
    - TR-512.4
    - TR-512.5
    - TR-512.6
    - TR-512.7
    - TR-512.8
    - TR-512.10
    - TR-512.11
    - TR-512.A.2
    - TR-512.FE
- OnfModel folder
    - .project,
    - CoreModel.di,
    - CoreModel.notation
    - CoreModel.uml
    - OpenModel_Profile.profile.di
    - OpenModel_Profile.profile.notation
    - OpenModel_Profile.profile.uml
    - Experimental.profile.di[17]
    - Experimental.profile.notation
    - Experimental.profile.uml

The Gendoc Templates used to generate the TR-512 documents and other documentation aids are provided via another .zip file. They have been delivered to ensure inter-release continuity and will be used as a basis for the construction of the documentation for the next release of model.

[17] The Experimental profile provides some stereotypes related to experimental rules (e.g. in the Physical model). The relevant stereotypes in this profile will be moved to a formal profile in the next release.

10 Individuals engaged

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End of Document