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Purpose: Proposal

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Abstract: This document contains the editor draft of new Recommendation G.8152.2 "Resilience Information/Data Models for MPLS-TP Network Element", v0.06 for consent.

Document history:

Version	Date	Description
0.01	WD1214-20(01/2019)	The first draft new Recommendation G.8152.2, update clause 6 based on wd1214-36
0.02	WD14-21(04/2019) Xi'an TD378/3 (7/2019) Geneva	Add object classes, attributes and operations of linear protection group in clause 7, based on wd14-38 and wd14-39

Version	Date	Description
0.0.3	WD14-21(7/2019) Geneva	Updates: (1) Add description for figure 7.1.1-2 based on C1441 clause 2.1. (2) Add an appendix I.1 to describe 1+1/1:1 linear protection example based on C1441 clause 2.2. (3) Split clause 7.1 into two sub clauses, 7.1.1 for linear protection, 7.1.2 for shared ring protection (4) Add object classes and relations for shared ring protection in 7.1.2 based on C1304 clause 2.1. (5) Add an appendix I.2 to describe the ring protection examples. And add I.2.1 to describe the wrapping protection group based on C1304 clause 2.2.1.
0.04	WD14-16 (9/2019) Goteborg TD487/WP3 (1/2020)	Updates: (1) Add appendix I.2.2 to describe the short-wrapping and appendix I.2.3 to describe the steering based on wd14-29. (2) In Appendix I.2, revise the name in the text to make sure that they're the same within the figures according to the discussion. (3) Add some description to Figure 7.1.2-1 according to the discussion.
0.05	WD14-22 (2/2020) TD487R1/WP3 (2/2020)	Updates: (1) Per C1884: change Appendix I.2 to Annex A, with adjustment as noted in the discussion. Add a sentence after the last paragraph of clause 7.1.2 according to C1884 (2) Per C1885: Clause 7.1.1 "Linear protection" object classes & relations and clause 7.2.1 "Linear protection" attributes and operations. (3) Per C1886: Clauses 3 and 4, with adjustment as noted in the discussion. (4) Per C1893: Clause 7.1.2 "Shared ring protection" object classes & relations and clause 7.2.2 "Shared ring protection" attributes and operations.
0.06	CD09(6/2020) v0.06-E1	(1) Delete Pseudowire Redundancy in table 6.1-1 (2) Update figure 7.1.1-3, for each object class, change the appearance-Qualified name from None to full. so that it can easily know the object class from which Recommendation. (3) Update figure 7.1.1-4, for each object class, change the appearance-Qualified name from None to full. (4) Update figure 7.1.2-3, for each object class, change the appearance-Qualified name from None to full. (5) Update figure 7.1.2-4, for each object class, change the appearance-Qualified name from None to full. (6) Add UML file to clause 7.3

Version	**Date**	**Description**
	CD09r1 (6/2020) v0.06-E2	(1) Accept all the revision history. (2) Update as per contribution CD11r1.
	CD09r3 (7/2020) v0.06-E3	(1) Update Clause 7 resilience UML model according to CD10r5 and CD10r6：G.8152.2 should has its own UML model, it’s pruned and refactored from core model and G.8152.2. (2) Add a comment for G.8152.2 Fc and FcPort object classes (need to be refactored into UML artifacts which supposed to be re-engineered from the IETF mpls-base & mpls-static RFC yang, which is yet to be finalized.) according to CD10r5 and CD10r6. (3) Update yang model according to the update (1) and (2).
0.07	WD14-57 (9/2020) TD583R1/PLEN (9/2020)	(1) Update UML model and yang model according to WD14-16r2. (2) Add IETF RFC 6991, RFC 7950, RFC 8340, RFC8342 as reference in clause 2.

Table of Contents

Recommendation ITU-T G.8152.2

Resilience Information/Data Models for MPLS-TP Network Element

Summary

This Recommendation specifies the resilience management information model and data models for MPLS-TP Network Element (NE) as defined in [ITU-T G.8131] and [ITU-T G.8132]. 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 the Recommendation [ITU-T G.7711/Y.1702] core information model and Recommendation [ITU-T G.8152/Y.1375] foundation MPLS-TP 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 interface protocols considered in this Recommendation include, but not limited to, NETCONF/YANG.

Keywords

MPLS-TP, Information model, Resilience, UML, Data model YANG.

Introduction

<Optional – This clause should appear only if it contains information different from that in Scope and Summary>

1 Scope

This Recommendation specifies the resilience information models and data models for MPLS-TP transport Network Element (NE) to support specific interface protocols and specific management and control functions. The information models are interface protocol neutral and derived through pruning and refactoring from the [ITU-T G.7711] core information model and [ITU-T G.8152] foundation MPLS-TP NE information model. The data models are interface protocol specific and translated from these information models. The specific interface protocols considered include, but not limited to, NETCONF/YANG. The specific management and control functions for resilience covered by this Recommendation include the [ITU-T G.8131] MPLS-TP Linear protection switching and [ITU-T G.8132] MPLS-TP Shared Ring protection switching.

The YANG modules of this Recommendation are aimed to be compatible with and when necessary extend the relevant IETF base generic YANG modules for the [ITU-T G.8131] and [ITU-T G.8132] resilience functions.

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.7711] Recommendation ITU-T G.7711/Y.1702 (3/2018), *Generic protocol-neutral information model for transport resources*.

[ITU-T G.780] Recommendation ITU-T G.780/Y.1351 (07/2010), *Terms and definitions for synchronous digital hierarchy (SDH) networks*.

[ITU-T G.806] Recommendation ITU-T G.806 (08/17), *Characteristics of transport equipment – Description methodology and generic functionality*.

[ITU-T G.808] Recommendation ITU-T G.808 (11/2016), *Terms and definitions for network protection and restoration.*

[ITU-T G.8131] Recommendation ITU-T G.8131/Y.1382 (7/2014), *Linear protection switching for MPLS transport profile*.

[ITU-T G.8132] Recommendation ITU-T G.8132/Y.1383 (8/2017), *MPLS-TP shared ring protection*.

[ITU-T G.8152] Recommendation ITU-T G.8152/Y.1735 (10/2018), *Protocol-neutral management information model for the MPLS-TP network element*.

[IETF RFC 8227] RFC IETF RFC8227 (08/17), *MPLS-TP Shared-Ring Protection (MSRP) Mechanism for Ring Topology*.

[IETF RFC 6991] RFC IETF RFC6991 (07/13), *Common YANG Data Types.*

[IETF RFC 7950] RFC IETF RFC7950 (08/16), *The YANG 1.1 Data Modeling Language.*

[IETF RFC 8340] RFC IETF RFC8340 (03/18), *YANG Tree Diagrams.*

[IETF RFC 8342] RFC IETF RFC8342 (03/18), *Network Management Datastore Architecture (NMDA).*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 1+1 protection architecture [ITU-T G.808]

3.1.2 1:n protection architecture [ITU-T G.808]

3.1.3 forced switch [ITU-T G.808]

3.1.4 hold-off time [ITU-T G.808]

3.1.5 manual switch [ITU-T G.808]

3.1.6 protection [ITU-T G.808]

3.1.7 protection group [ITU-T G.808]

3.1.8 signal degrade (SD) [ITU-T G.806]

3.1.9 signal fail (SF) [ITU-T G.806]

3.1.10 switch [ITU-T G.808]

3.1.11 unidirectional protection switching [ITU-T G.780]

3.1.12 wait-to-restore time [ITU-T G.808]

3.1.13 clear: [ITU-T G.808]

3.1.14 exercise signal: [ITU-T G.808]

3.1.15 server signal fail (SSF): [ITU-T G.806]

3.1.16 steering: [ITU-T G.808]

3.1.17 wrapping: [ITU-T G.808]

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CTP	Connection Termination Point
EXER	Exercise
FC	Forwarding Construct
FS	Forced Switch
MPLS	Multi-Protocol Label Switching
MPLS-TP	Multi-Protocol Label Switching-Transport profile
MS	Manual Switch
MSRP	MPLS-TP Shared Ring Protection
MT	MPLS-TP
OAM	Operations, Administration and Maintenance

SD	Signal Degraded
SF	Signal Fail
Sk	Sink
SNC	Subnetwork Connection
SNCP	Subnetwork Connection Protection
SNC/S	SNCP with Sublayer monitoring
So	Source
TT	Trail Termination
WTR	Wait-to-Restore

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].

5.1.2 Model Artefact Lifecycle Stereotypes conventions

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

5.1.3 Forwarding entity terminology conventions

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

5.1.4 Conditional package conventions

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

5.1.5 Pictorial diagram conventions

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

5.2 Equipment function conventions

See clause 5.3 of [ITU-T G.8152].

5.3 Conventions defined in this Recommendation

See clause 5.3 of [ITU-T G.8152].

6 MPLS-TP Resilience Functions

This clause identifies the MPLS-TP Resilience functions that are modelled by the information model and data models of this Recommendation.

6.1 Linear Protection Functions

MPLS-TP linear protection function is defined in [ITU-T G.8131]. For protection type characteristic, it includes the following types:

Table 6.1-1 MPLS-TP Linear Protection type

Protection type	**Source**
Unidirectional 1+1 SNC/S protection switching	ITU-T G.8131
Bidirectional 1+1 SNC/S protection switching	ITU-T G.8131
Bidirectional 1:1 SNC/S protection switching	ITU-T G.8131
MPLS-TP trail protection	ITU-T G.8131

6.2 Ring Protection Functions

MPLS-TP ring protection function is defined in [ITU-T G.8132]. For protection type characteristic, it includes the following types:

Table 6.2-1 MPLS-TP Ring Protection type

Protection type	**Source**
Wrapping	ITU-T G.8132
Short wrapping	ITU-T G.8132
Steering	ITU-T G.8132

7 MPLS-TP Resilience Information Model

This clause contains the UML information model of the MPLS-TP Protection functions identified in Clause 6. The information model is derived through pruning and refactoring the Recommendation [ITU-T G.7711/Y.1702] core information model and Recommendation [ITU-T G.8152/Y.1375 (12/2016)] MPLS-TP base information model.

7.1 Required Object Classes and relations

7.1.1 Linear protection

[ITU-T G.8131] clause 6.1 describes the protection switching architecture for the MPLS-TP linear protection group, including Unidirectional 1+1 SNC/S protection switching, bidirectional 1+1 SNC/S protection switching, and bidirectional 1:1 SNC/S protection switching. All these architectures can be modelled by using the same set of object classes, so we choose the Unidirectional 1+1 SNC/S protection switching as an example to describe the MPLS-TP linear protection object classes. Annex E of [ITU-T G.7711] has the generic resilience model applicable for the linear protection switching schemes. The following Figure 7.1.1-1 and Table 7.1.1-1 show the mapping between the [ITU-T G.8131] functions and the [ITU-T G.7711] and the [ITU-T G.8152] object classes for the MPLS-TP linear protection.

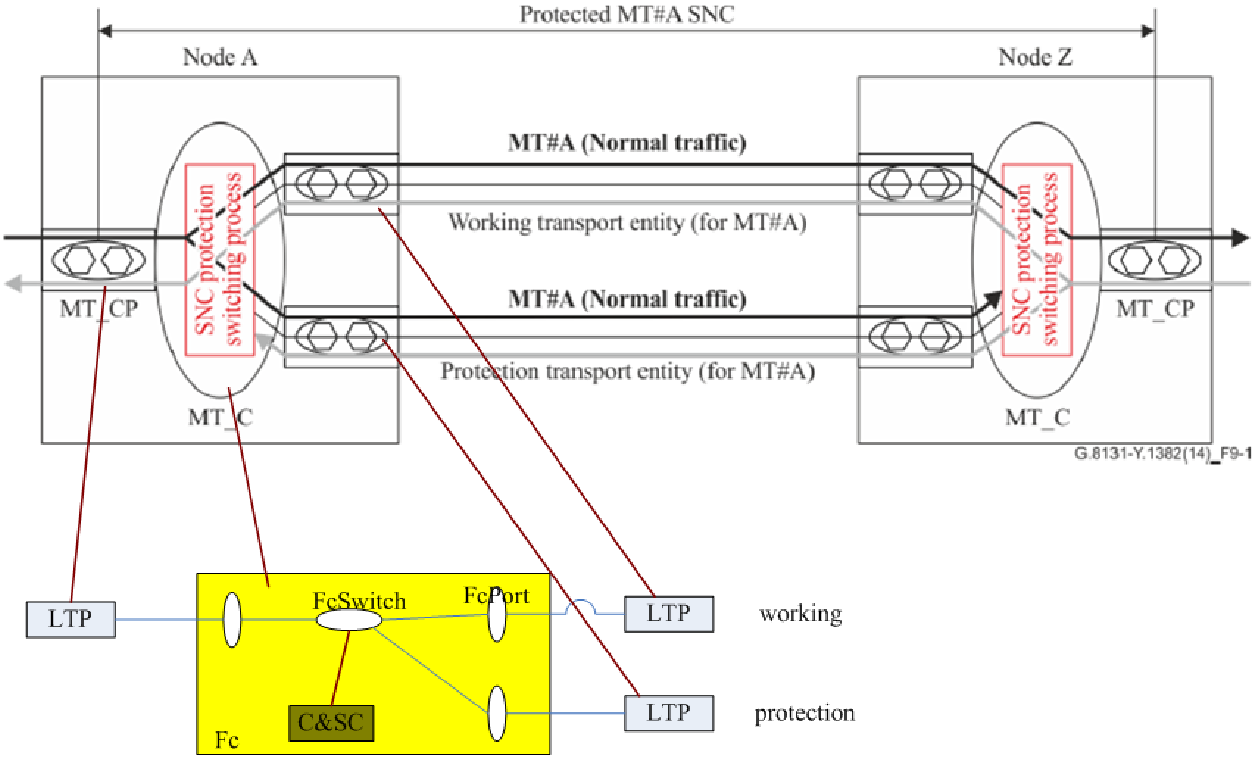


Figure 7.1.1-1Mapping between G.8131 and G.7711 for MPLS-TP linear protection model

Table 7.1.1-1 Mapping between G.8131, G.8152 and G.7711 for MPLS-TP linear protection

G.8131	**G.8152**	**G.7711**
SNC protection switching process	MT_SubnetworkConnectionProtectionGroup	FcSwitch+CASC+ Spec
MT_C	MT_CrossConnection	FC+FcPort+Spec
MT_CP	MT_ConnectionTerminationPoint	LTP+Spec

The simplified resilience model for MPLS-TP linear protection can be expressed as in Figure 7.1.1-2. The upper part of this figure is from Figure E.1-1 of [ITU-T G.7711], which shows the basic resilience pattern.

As shown in Figure 7.1.1-2, object classes FcSwitch, ConfigurationAndSwitchControl (CASC), and ControlParameters_Pac are used to support resilience.

The FcSwitch object class models the switched forwarding of traffic (traffic flow) between FcPorts and is present where there is protection functionality in the FC. The FcSwitch represents and defines a protection switch structure encapsulated in the FC and essentially performs one of the functions of the protection group in a traditional information model.

The CASC represents the capability to control and coordinate switches, to add/delete/modify FCs and to add/delete/modify LTPs/LPs so as to realize a protection scheme. The CASC can be composed of CASCs allowing for expression of complex control structures, which is called encapsulation of the CASC. There are several degrees of CASC: CASC encapsulated in an FcSwitch, CASC encapsulated in an FC and CASC encapsulated in a CASC.

The ControlParameters_Pac defines a list of control parameters to apply to a switch.

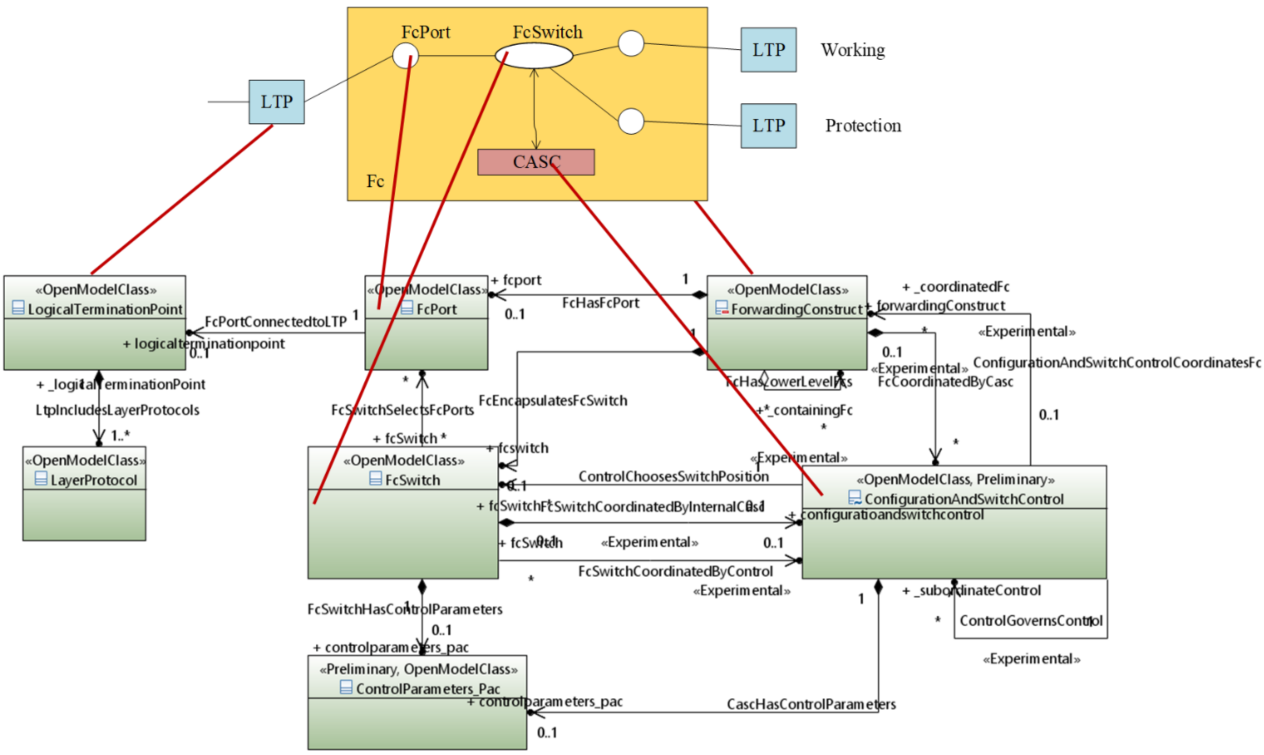


Figure 7.1.1-2 Simplified resilience model for MPLS-TP Linear protection

The following text describes the MPLS-TP linear protection spec model.

In Figure 7.1.1-3 below, the following colour convention is used for the object classes. The orange classes are from the [ITU-T G.7711] core model. The blue ones are defined in [ITU-T G.8152.2]. The pink ones are pruned & refactored from [ITU-T G.7711] but need to be further refactored. And the yellow one is from [ITU-T G.8152].

In [ITU-T G.8152.2], the LinearProtection object class models the switched forwarding of traffic (traffic flow) for linear protection, and it’s pruned and refactored from [ITU-T G.7711] and [ITU-T G.8152]. And it is used to control and coordinate linear protection groups, to add/delete/modify FCs and to add/delete/modify LTPs/LPs so as to realize a protection scheme. It also defines a list of control parameters to apply to a switch.

The Actions interface class defines the operations for linear protection, and they are pruned and refactored from [ITU-T G.8152].

For the pink ones, they need to be further refactored into UML artifacts which supposed to be re-engineered from the IETF mpls-base & mpls-static RFC yang, which are yet to be finalized.

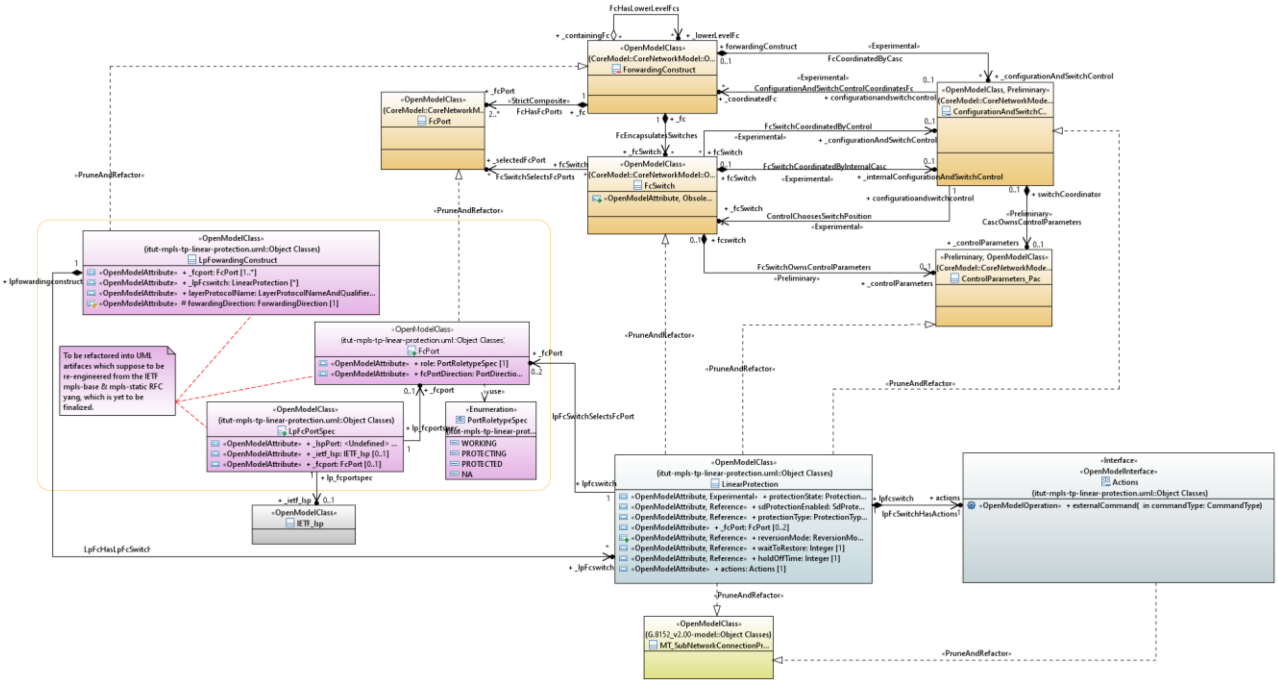


Figure 7.1.1-3 MPLS-TP linear protection spec model

7.1.2 Shared ring protection

[ITU-T G.8132] Figure 8-1 presents the function model of MSRP (see the upper part of Figure 7.1.2 1). [ITU-T G.7711] Annex E specifies the generic resilience information model. Figure 7.1.2-1 below shows the mapping between the [ITU-T G.8132] MSRP functions and the [ITU-T G.7711] information model artifacts for the MPLS-TP shared ring protection.

An MSRP ring tunnel is modelled as a server sub-layer for the MPLS-TP LSP sub-layer. Figure 8-1 of [ITU-T G.8132] shows the sub-layer functional model. The MSRP_C shows all the possible working and protection connections that can be setup in the MSRP sub-layer.

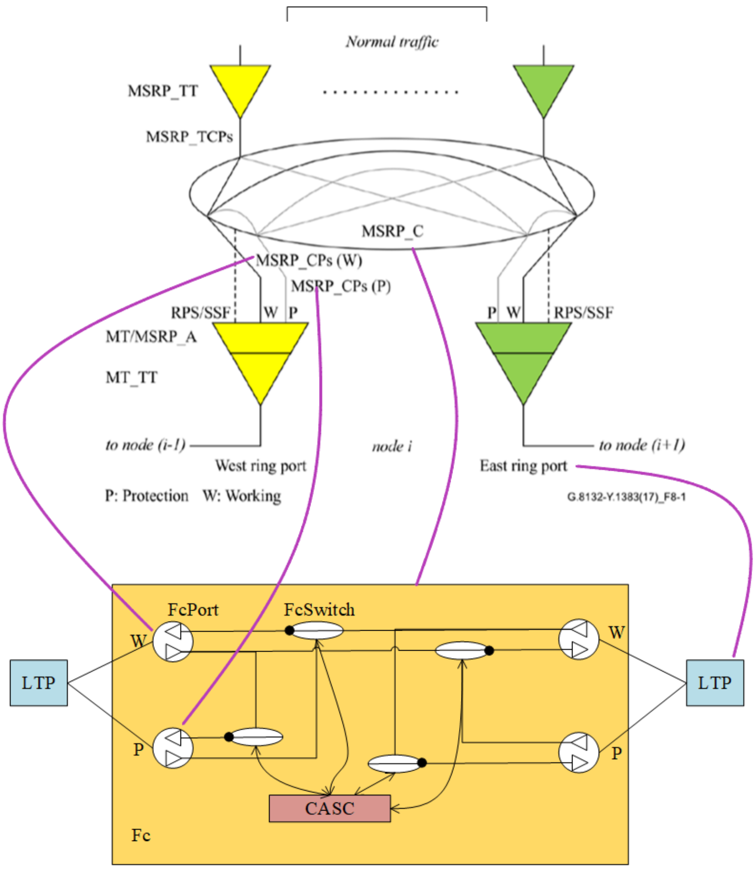


Figure 7.1.2-1 Mapping between MSRP functions and information model artifacts

Table 7.1.2-1 Mapping between ITU-TG.8132, ITU-T G.8152 and ITU-T G.7711 for MSRP

ITU-T G.8132	**ITU-T G.8152**	**ITU-T G.7711**
MSRP switching process	Not defined yet	FcSwitch+CASC+ Spec
MSRP_C	Not defined yet	FC+ Spec
MSRP_CP	Not defined yet	FcPort +Spec
West ring port/East ring port	MT_TrailTerminationPoint	LTP +Spec

The simplified resilience model for MSRP can be expressed as in the Figure 7.1.2-2.

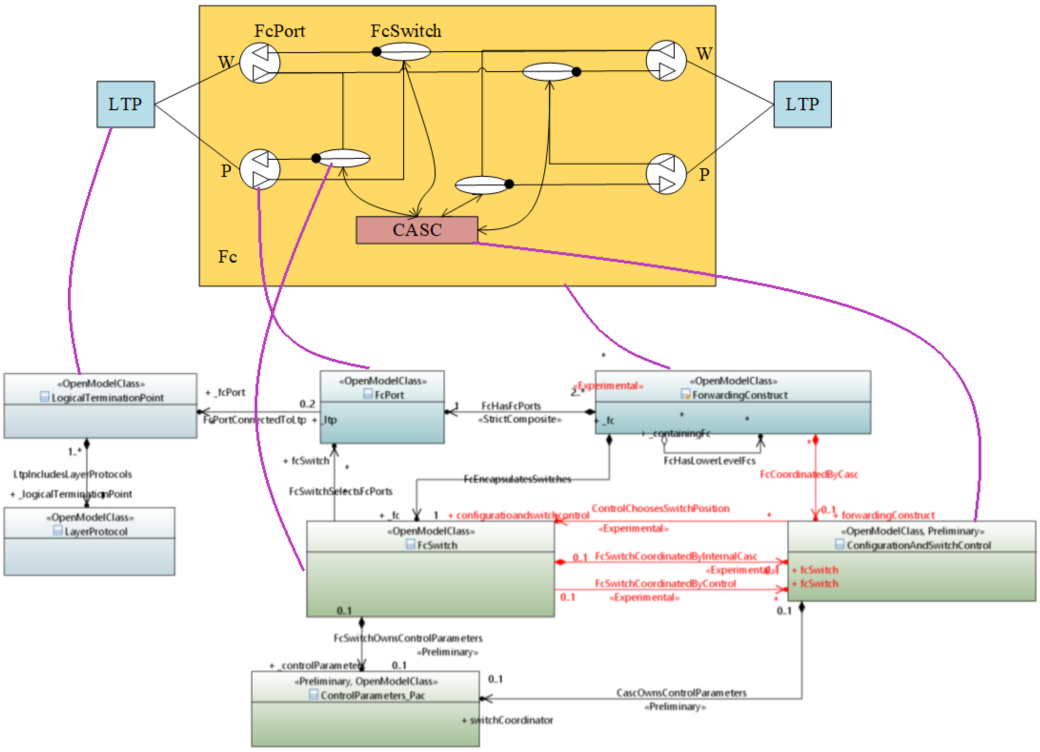


Figure 7.1.2-2 Simplified resilience model for MSRP

The descriptions for the FcSwitch, CASC, and ControlParameters_Pac object classes are the same in Clause 7.1.1.

The following text describes the MSRP spec models. The same color convention of Figure 7.1.1-3 is used for Figure 7.1.2-3 below.

The Srp_FcSwitch object class models the switched forwarding of traffic (traffic flow), and it's pruned and refactored from [ITU-T G.7711] and [ITU-T G.8152]. The Srp_casc is used to control and coordinate Fcswitches, to add/delete/modify FCs and to add/delete/modify LTPs/LPs so as to realize a protection scheme. The ControlParameters_Pac defines a list of control parameters to apply to a switch. The SRP_CascActions interface class defines the operations for shared ring protection.

For the pink object classes, they need to be further refactored into UML artifacts which supposed to be re-engineered from the IETF mpls-base & mpls-static RFC yang, which are yet to be finalized.

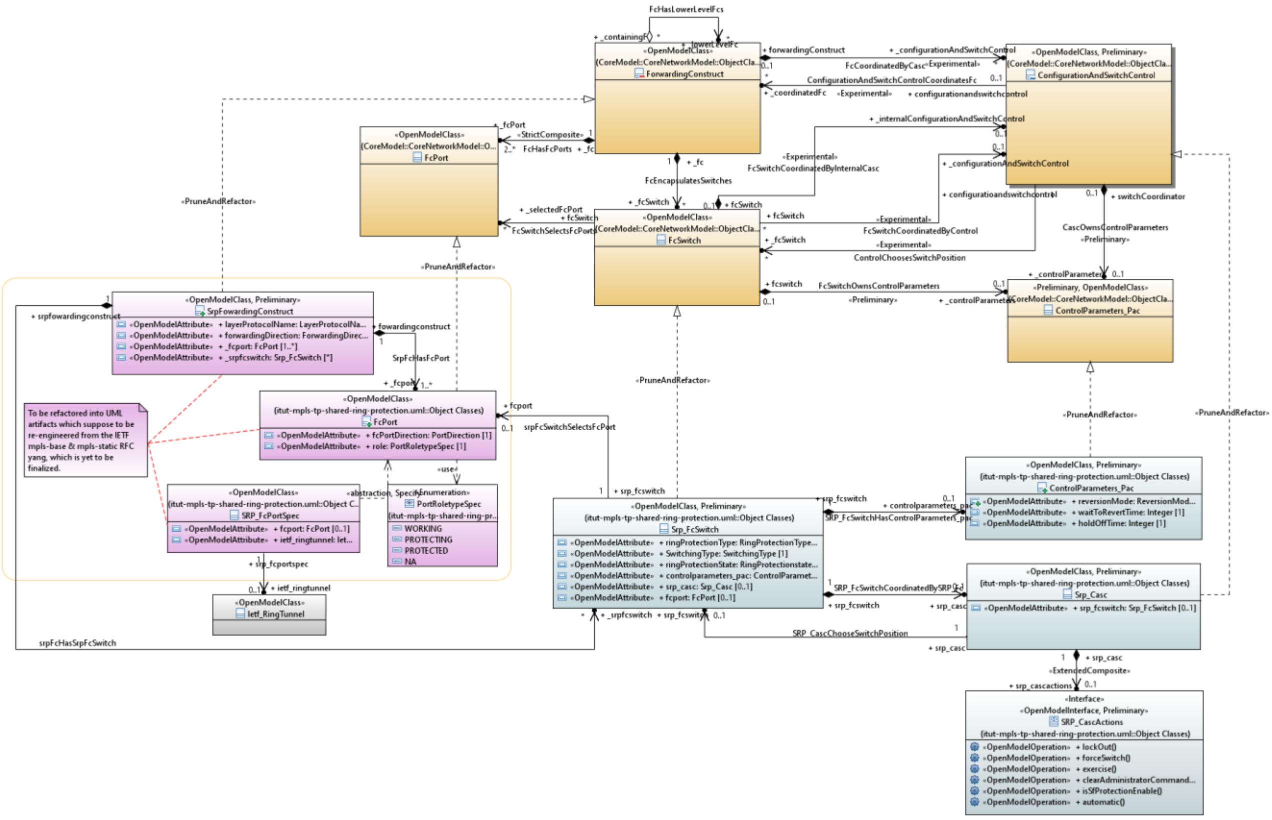


Figure 7.1.2-3 MSRP spec model

Figure 7.1.2-4 shows the Fc instance model. It used to describe the relationship between ring tunnel and LSP. MSRP ring tunnel is modelled as a server sub-layer for the MPLS-TP LSP sub-layer. As shown in the figure, RingTunnelFc instance has lower level LSPFc instance.

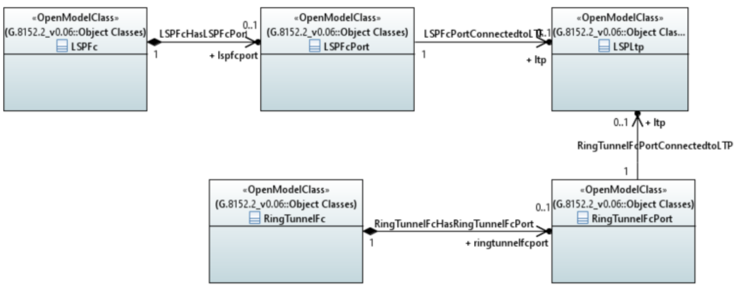


Figure 7.1.2-4 Fc instance

Annex A describes the principles of MSRP, and it describes how to use MSRP resilience model to represent the MSRP, and how to switch according to failures.

7.2 Required Attributes and Operations

7.2.1 Linear protection

This clause shows how the required [ITU-T G.7711] and [ITU-T G.8152] object classes are pruned/refactored for linear protection.

In [ITU-T G.8152], the MPLS-TP linear protection is modelled by the MT_SNCP_Group object class. The following tables verify the compatibility in attribute and operation level between [ITU-T G.8152] and [ITU-T G.7711].

Table 7.2.1-1 Linear protection attributes mapping

	Attributes in G.8152	Corresponding attributes in G.7711	Attributes for G.8152.2
1.	MT_SubNetworkConnectionProtectionGroup::ProtectionType	It could be modelled as ControlParameters_Pac specified attribute. Since this attribute indicates the protection type of the SNCP Group.	LpFcSwitch::protectionType. The datatype for protectionType is pruned and refactored from [ITU-T G8152].
2.	MT_SubNetworkConnectionProtectionGroup::holdOffTime	This attribute already exists in the ControlParameters_Pac.	LpFcSwitch::protectionType. The datatype for protectionType is pruned and refactored from [ITU-T G8152].
3.	MT_SubNetworkConnectionProtectionGroup::sncpGroupState	It could be modelled as FcSwitch specified attribute ProtectionState. Since this attribute indicates the protection state of the SNCP Group.	LpFcSwitch::protectionState, which is Experimental.
4.	MT_SubNetworkConnectionProtectionGroup::isSdProtectionEnabled	It could be modelled as FcSwitch specified attribute isSdProtectionEnabled.	LpFcSwitch::sdProtectionEnabled, The datatype for protectionType is pruned and refactored from [ITU-T G8152].

Table 7.2.1-2 Linear protection operations mapping

	Operations in G.8152	Corresponding attributes in G.7711	Operations for G.8152.2
1.	MT_SubNetworkConnectionProtectionGroup::lockoutProtection()	It could be considered by setting FcSwitch as lockout. So it may use CASC specified operations to describe. **[ITU-T G.7711] clause E.1.2.6:** The FC switch represents and defines a protection switch structure encapsulated in the FC and essentially performs one of the functions of the protection group in a traditional model. It may be locked out (prevented from switching), force switched or manual switched.	Action Command, with one input parameter (commandType) defining the type of command. For this one, the command type is LOCKOUT_OF_PROTECTION.
2.	MT_SubNetworkConnectionProtectionGroup::forceSwitch()	It could be considered by setting FcSwitch as forceSwitch. CASC is the control component for	Action Command, with one input parameter (commandType) defining the type of command. For

		FcSwitch.So it may use CASC specified operations to describe.	this one, the command type is FORCED_SWITCH.
3.	MT_SubNetworkConnectionProtectionGroup::clearExternalCommandAndWTRstate()	It could be considered by setting FcSwitch::switchcontrol to the clear. May need to add “clear” to FcSwitch::Switchcontrol. So it may use CASC specified operations to describe. ControlParameters_Pac already has WaitToRestoreTime attributes	Action Command, with one input parameter (commandType) defining the type of command. For this one, the command type is CLEAR.
4.	MT_SubNetworkConnectionProtectionGroup:::manualSwitch()	It could be considered by setting FcSwitch::_SelectedFcPort to the designated switching port(the protecting port or the working port). So it may use CASC specified operations to describe the command. Switchcontrol already has the value MANUAL	Action Command, with one input parameter (commandType) defining the type of command. For this one, the command type are MANUAL_SWITCH_TO_WORKING, MANUAL_SWITCH_TO_PROTECTION.
5.	MT_SubNetworkConnectionProtectionGroup::exercise()	Need more discussion in [ITU-T G.7711]	Action Command, with one input parameter (commandType) defining the type of command. For this one, the command type is EXERCISE.
6.	MT_SubNetworkConnectionProtectionGroup::localFreeze()	It could be considered by setting ConfigurationAndSwitchControl::isFroze as true.	Action Command, with one input parameter (commandType) defining the type of command. For this one, the command type is FREEZE.
7.	MT_SubNetworkConnectionProtectionGroup::clearLocalFreeze()	It could be considered by setting ConfigurationAndSwitchControl::isFroze as false.	Action Command, with one input parameter (commandType) defining the type of command. For this one, the command type is CLEAR_FREEZE.

In [ITU-T G.8152], it only describes these attributes and operations in table 7.2.1-1 and table 7.2.1-2. But according to [ITU-T G.8131], it may also include the following attributes. See table 7.2.1-3.

Table 7.2.1-3 Linear protection attributes verification

	Attributes in ITU-T G.8131	Corresponding attributes in ITU-T G.7711	Attributes for ITU-T G.8152.2
1	In clause 7, it has described the selector chooses working or protection connection. For the port of the connection, it has role.	It could be considered by FcPort. And FcPort already has an attribute “role” to describe the role of the port.	FcPort::role, specify the data type of attribute role, the specified value include: WORKING, PROTECTING, PROTECTED， NA.
2	Clause 9	This already exists in the ControlParameters_Pac.	LpFcSwitch:: reversionMode.

7.2.2 Shared ring protection

This clause shows how the required [ITU-T G.7711] and [ITU-T G.8152] object classes are pruned/refactored for MSRP.

In [ITU-T G.8152], there is no object class defined for MSRP. The following tables provides the mapping between the [ITU-T G.8132] MSRP characteristics and the information artifacts according to the MSRP model in clause 7.1.2.

Table 7.2.2-1 MSRP attributes mapping

	Attributes in [ITU-T G.8132]	Corresponding attributes in [ITU-T G.7711]	Attributes for [ITU-T G.8152.2]
5.	Three types of ring protection mechanisms are specified: wrapping, short wrapping and steering	This attribute already exists in the ControlParameters_Pac::prottype. But the values of prottype are not defined. So it should specify the it’s values.	ControlParameters_Pac::prottype. As CIM doesn’t descirbe the data type values for prottype, the values are specified from [ITU-T G8132].
6.	MSRP supports only the bi-directional protection switching type	It could be modelled as FcSwitch Specified attribute Switchingtype.	FcSwitch::Switchingtype, this attribute is specified from [ITU-TG.8132].
7.	revertive protection operation type	It already exists in ControlParameters_Pac::reversionMode	ControlParameters_Pac::reversionMode
8.	ring protection switch state	It could be modelled as FcSwitch Specified	FcSwitch::RingProtectionState, this attribute is

		attribute RingProtectionState.	specified from [ITU-T G.8132].
9.	Wait-to-Restore	It already exists in ControlParameters_Pac::waitToRevertTime.	ControlParameters_Pac::waitToRevertTime

Table 7.2.2-2 MSRP operations mapping

	Operations in [ITU-T G.8132]	Corresponding attributes in [ITU-T G.7711]	Operations for [ITU-T G.8152.2]
1.	Lockout of Protection(LP), Lockout of Working(LW)	It could be considered by setting FcSwitch as lockout. CASC is the control component for FcSwitch. So it may use CASC specified operations to represent.	CASC specified operations::lockout() , specified parameter lockOutType will describe the type: lockout to protection or lockout to working.
2.	Forced Switch (FS)	It could be considered by setting FcSwitch as forceSwitch. CASC is the control component for FcSwitch. So it may use CASC specified operations to describe.	CASC specified operations::forceSwitch()
3.	Manual Switch (MS)	It could be considered by setting FcSwitch as manual switch. CASC is the control component for FcSwitch. So it may use CASC specified operations to describe.	CASC specified operations::manualSwitch()
4.	Exercise (EXER)	It could be considered by setting FcSwitch as manual switch. CASC is the control component for FcSwitch. So it may use CASC specified operations to describe.	CASC specified operations::exercise()
5.	Clear: clears the administrative command and WTR timer	It could be considered by setting FcSwitch as clear. CASC is the control component for FcSwitch. So it may use CASC specified operations to describe.	CASC specified operations::clearAdministratorCommandAndWTRstate()
6.	Automatically Command	It could be considered by setting FcSwitch as automatically.	CASC specified operations::automatic()

7.3 UML model files

7.3.1 Linear protection

This sub-clause contains the linear protection UML model files developed using the Papyrus open-source modelling tool.

itut-mpls-tp-linear-protection.zip

This zip contains the ITU-T G.8152.2 linear protection model files (i.e., the .project, .di, .notation and .uml files) and the profiles.

The linear protection model uses the following modelling tool and profiles

- Eclipse 4.9 (i.e. version 2018.09)
- Papyrus 4.1.0,
- OpenModel_Profile 0.2.17,
- OpenInterfaceModel_Profile 0.0.10,
- ProfileLifecycle_Profile 0.0.4.

7.3.2 Ring protection

This sub-clause contains the shared ring protection UML model files developed using the Papyrus open-source modelling tool. Note that it needs further discussion, so the shared ring protection UML is preliminary.

itut-mpls-tp-shared-ring-protection.zip

8 MPLS-TP Resilience Data Models

This clause contains the interface-protocol-specific data models of the MPLS-TP resilience functions identified in Clause 6. These data models are translated from the interface-protocol-neutral UML information specified in Clause 7.

8.1 YANG Data Model

This clause contains the YANG Data Model.

The YANG data models defined in this Recommendation uses the YANG 1.1 language defined in [IETF RFC 7950]. The YANG data types defined in [IETF RFC 6991] is used for the YANG data types representation. The tree format defined in [IETF RFC 8340] is used for the YANG data model tree representation.

The YANG data models defined in this Recommendation conforms to Network Management Datastore Architecture in [IETF RFC 8342].

8.1.1 Linear protection

This clause contains the G.8152.2 linear protection YANG data model. The G.8152.2 linear protection YANG model is translated from the UML information provided in Clause 7.3.1. The translation is done with the assistance of the Open Source translation tooling xmi2yang, which is developed according to the [b-ONF TR-531] Mapping Guidelines.

1) The yang generated by the xmi2yang mapping tool directly from the uml:

itut_mpls-tp_linear_protection_2020-09-16_yang_gen.zip

2) As the time of publication of this Recommendation, the xmi2yang mapping tool is still working in progress. Therefore manual modifications on the tool-generated yang are necessary. Embedded below is the yang with such manual modifications.

itut_mpls-tp_linear_protection_2020-09-16_yang.zip

The YANG tree is as below:

itut_mpls-tp_linear_protection_2020-09-16_yang_tree.zip

8.1.2 Ring protection

Since the base UML model of shared ring protection is still preliminary, the yang model is also preliminary. It needs further discussion. The G.8152.2 shared ring protection YANG model is translated from the UML information provided in Clause 7.3.2. The translation is done with the assistance of the Open Source translation tooling xmi2yang, which is developed according to the [b-ONF TR-531] Mapping Guidelines.

itut-mpls-tp-shared-ring-protection.uml@2020-09-16_yang_gen.zip

8.2 Other Data Model

None.

Annex A
MSRP information model

(This annex forms an integral part of this Recommendation.)

The focus of this annex is the modelling of shared ring protection. It:
– introduces the MSRP resilience principle
– shows how the model deals with failures

The MSRP architecture is specified in ITU-T Recommendation [ITU-T G.8132]. This section gives an overview of the architecture to be used to describe the MSRP management information model. As shown in figure A-1 below, the new logical layer consists of ring tunnels that provide a server layer for the LSPs traversing the ring. The notation used for a ring tunnel is: R<d><p>_<X> where <d> = c (clockwise) or a (anticlockwise), <p> = W (working) or P (protecting), and <X> =the node name.

Once a ring tunnel is established, the forwarding and protection switching of the ring are all performed at the ring tunnel level. MPLS-TP section layer OAM is needed for continuity check, remote defect indication and fault detection, and protection operations are controlled by the RPS protocol as described in IETF RFC 8227. A port can carry multiple ring tunnels, and a ring tunnel can carry multiple LSPs.

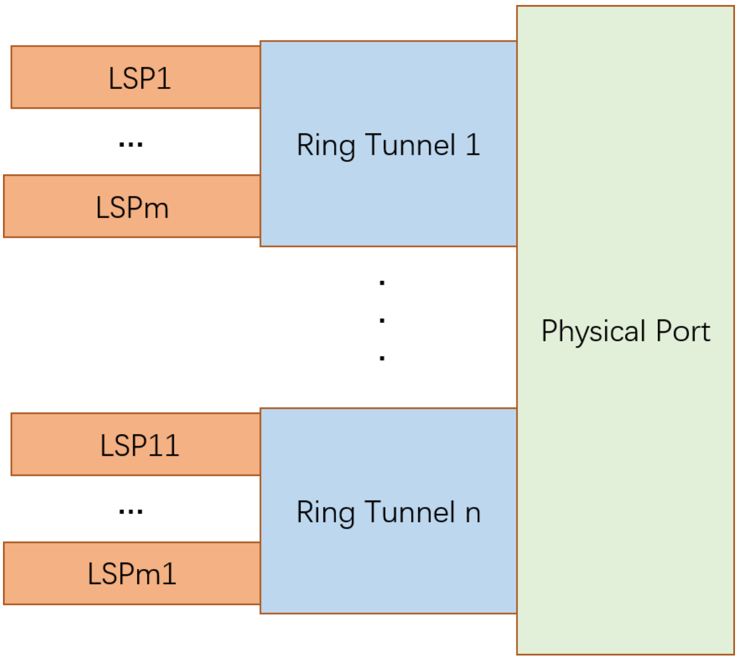


Figure A-1 The Logic Layers of The Ring

The Ring tunnels are established based on the egress nodes. The egress node is the node where traffic leaves the ring. LSPs that have the same egress node on the ring and travel along the ring in the same direction (clockwise or anticlockwise) share the same ring tunnels. For each egress node four ring tunnels are established:

(1) one clockwise working ring tunnel, which is protected by the anticlockwise protection ring tunnel.
(2) one anticlockwise protection ring tunnel.

(3) one anticlockwise working ring tunnel, which is protected by the clockwise protection ring tunnel.
(4) one clockwise protection ring tunnel.

The principle of the protection tunnels is determined by the selected protection mechanism (wrapping, short-wrapping, steering). This will be detailed in the following sections.

As shown in Figure A-2, LSP1, LSP2, and LSP3 enter the ring from Node A, Node E, and Node B respectively, and all leave the ring at Node D. To protect these LSPs that traverse the ring, a clockwise working ring tunnel (RcW_D) via E->F->A->B->C->D and its anticlockwise protection ring tunnel (RaP_D) via D->C->B->A->F->E->D are established. Also, an anticlockwise working ring tunnel (RaW_D) via C->B->A->F->E->D and its clockwise protection ring tunnel (RcP_D) via D->E->F->A->B->C->D are established. For simplicity, Figure A-2 only shows RcW_D and RaP_D. A similar provisioning should be applied for any other node on the ring. In summary, for each node in Figure A-2, when acting as an egress node, the ring tunnels are created as follows:
(1) To Node A: RcW_A, RaW_A, RcP_A, RaP_A
(2) To Node B: RcW_B, RaW_B, RcP_B, RaP_B
(3) To Node C: RcW_C, RaW_C, RcP_C, RaP_C
(4) To Node D: RcW_D, RaW_D, RcP_D, RaP_D
(5) To Node E: RcW_E, RaW_E, RcP_E, RaP_E
(6) To Node F: RcW_F, RaW_F, RcP_F, RaP_F

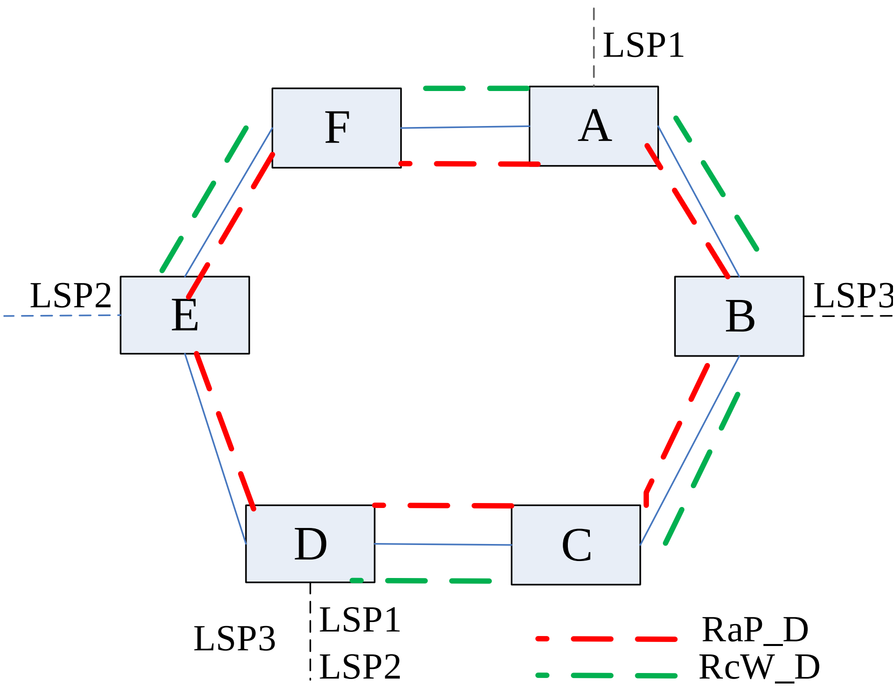


Figure A-2 Ring tunnels in MSRP
Following sections specifies the ring protection mechanisms in detail. In general, the description uses the clockwise working ring tunnel and the corresponding anticlockwise protection ring tunnel as an example, but the mechanism is applicable in the same way to the anticlockwise working and clockwise protection ring tunnels.

A.1 wrapping

Figure A.3 shows a view a basic network. A signal is passing from port3 node A to port 3 node D. LSP1 is through the path A-B-C-D.

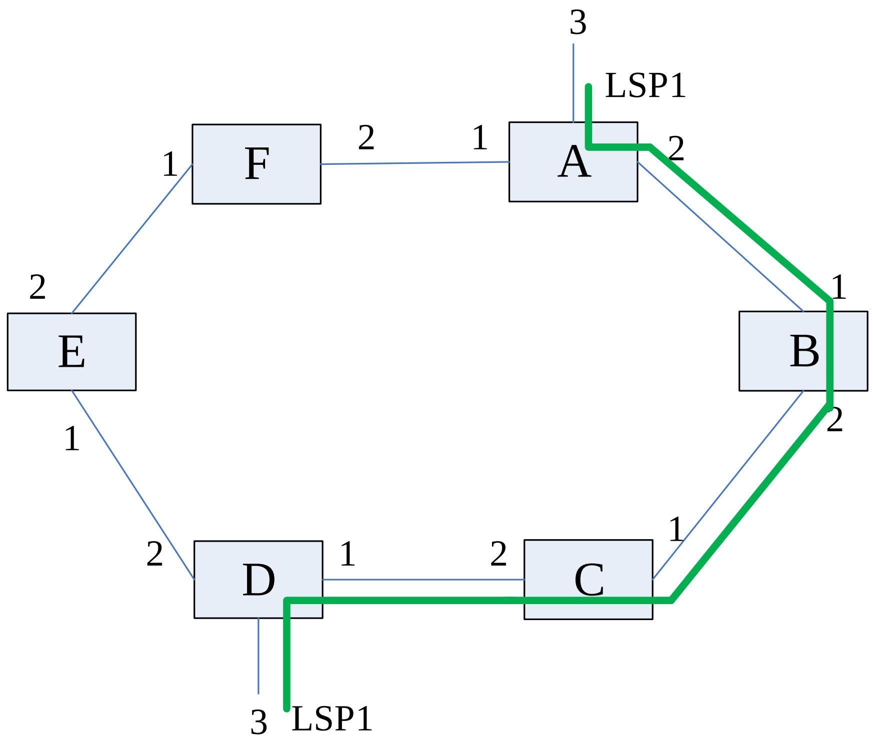


Figure A-3 basic network

When a link failure between node B and node C occurs, see the following Figure A-4. Node B switches the clockwise working ring tunnel to the anticlockwise protection ring tunnel, and sends a status message to the node C along the ring away from the link failure, notifying node C to switch from the working tunnel to the corresponding protection tunnel. Then signal then will follow the path A-B-A-F-E-D-C-D.

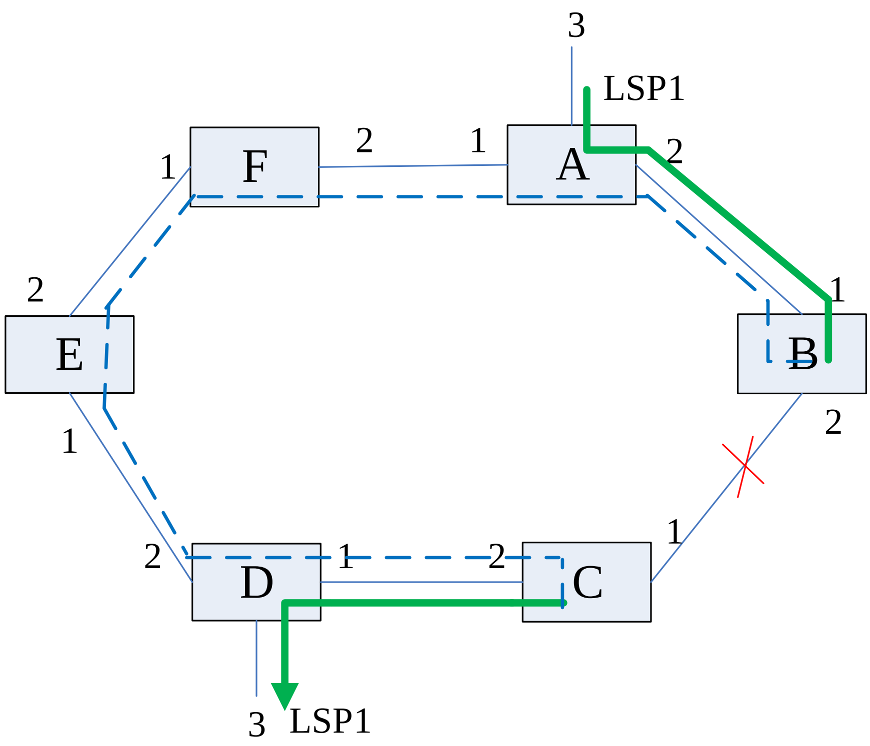


Figure A-4 Wrapping for link failure

The following figures show the object classes (LTP and FC, FcSwitch, CASC) configurations for nodes in the ring under normal and failure condition.

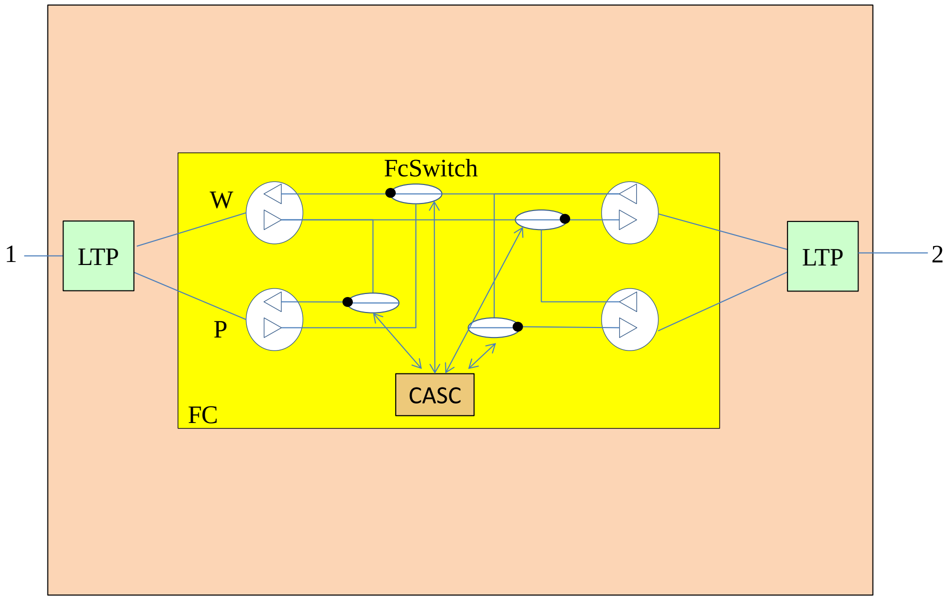


Figure A-5 Wrapping: node B and node C (no failure in ring)

Figure A-5 above shows the configurations of Node B and Node C with the switches set to normal position. There is an actual FC allowing signal to flow between the Working ring tunnel.

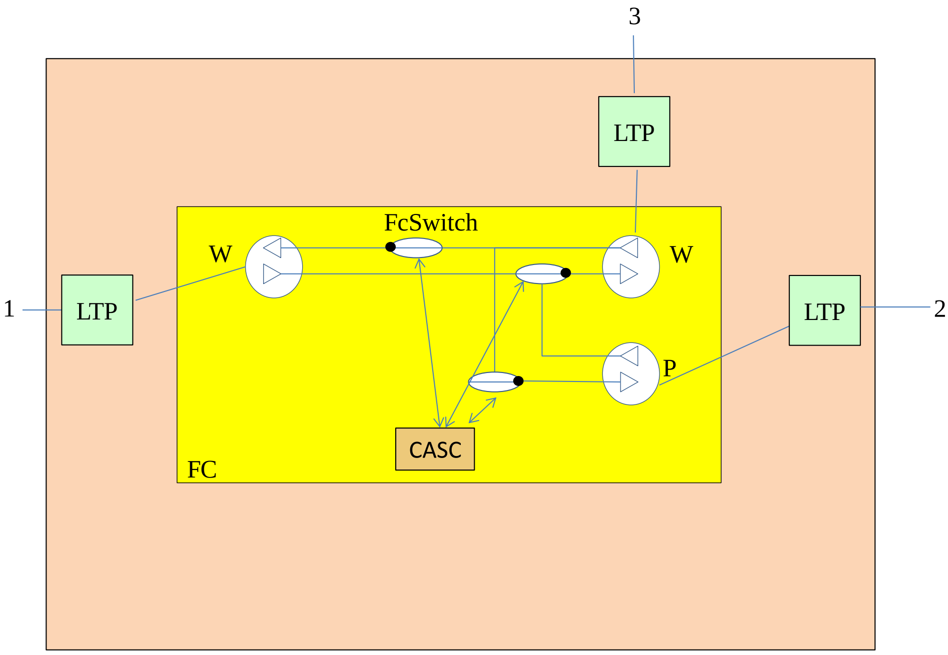


Figure A-6 Wrapping: node D (no failure in ring)

Figure A-6 above shows the configurations of Node D with the switches set to normal position. There is an actual signal to flow between port1 to port3 on the working ring tunnel.

Note that Node A has the same configuration, except that port 2 is used for normal signal flow and the protection faces port 1 not port2.

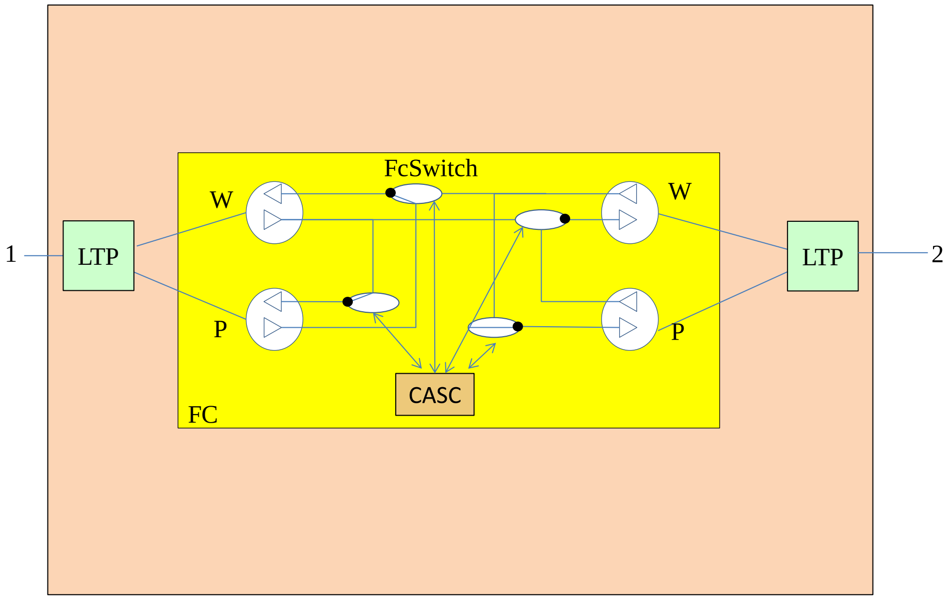


Figure A-7 Wrapping: node B with failure on link between node B and node C

Figure A-7 above shows the configurations of Node B with a failure on link between Node B and Node C, such that the switches on the port1 have been set to the protection ring tunnel. The FC allows signal to flow between the working and protection on port1, such that the signal is wrapped back to port1.

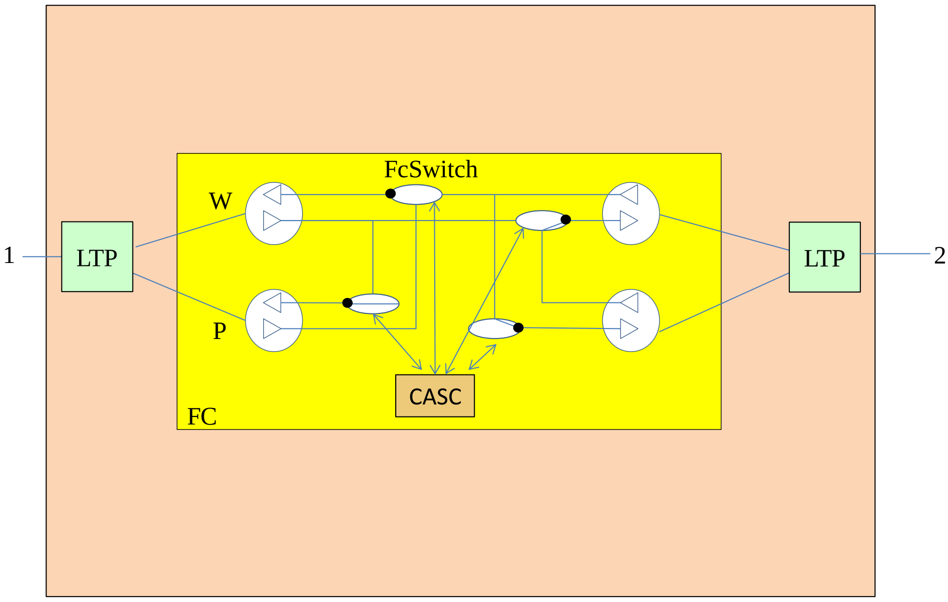


Figure A-8 Wrapping: node C with failure on link between node B and node C

Figure A-8 above shows the configurations of node C with a failure on link between node B and node C. It is the same to node B, except that in node C the switching position is on port 2.

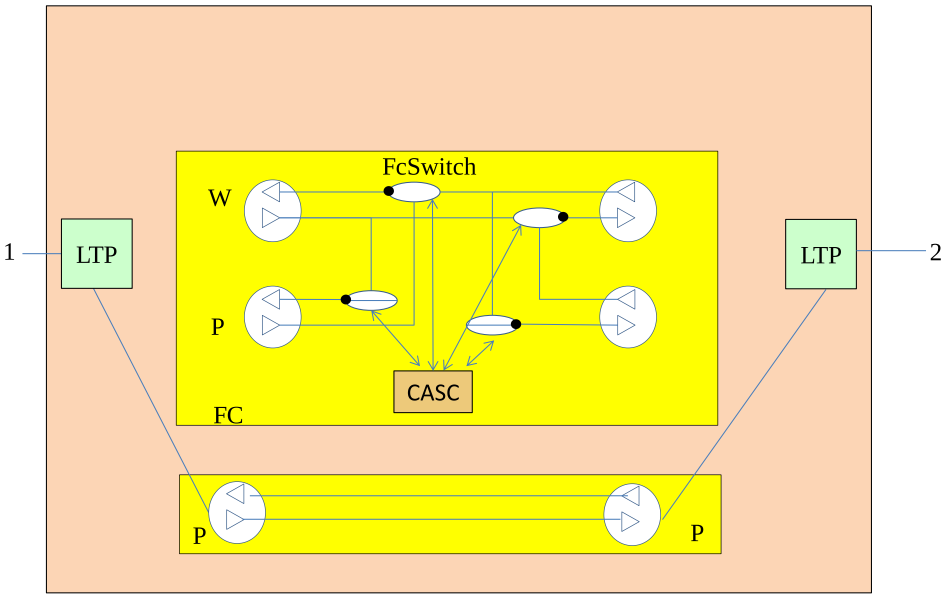


Figure A-9 Wrapping: node E and node F with failure on link between node B and node C

Figure A-9 above shows the configurations on node E and node F for the failure on link between node B and node C. There is an actual Fc allows signal to flow between the protection-ring tunnel on port1 and port2 due to the wrap in node B shown in the previous figure.

Node A and node D do not need to switch to the protection ring runnel as node B and node C perform the protection function in this case. In general, for the wrapping scheme, the Nodes on either side of the failure perform the protection function.

A.3 Steering

With the steering ring scheme, the ingress node performs switching from working to the protection ring, and at the egress node, the traffic leaves from the ring from the protection ring tunnel.

Figure A-15 shows a view of the basic network. This figure is the same to A-3 A signal is passing from port3 node A to port 3 node D. LSP1 is through the path A-B-C-D.

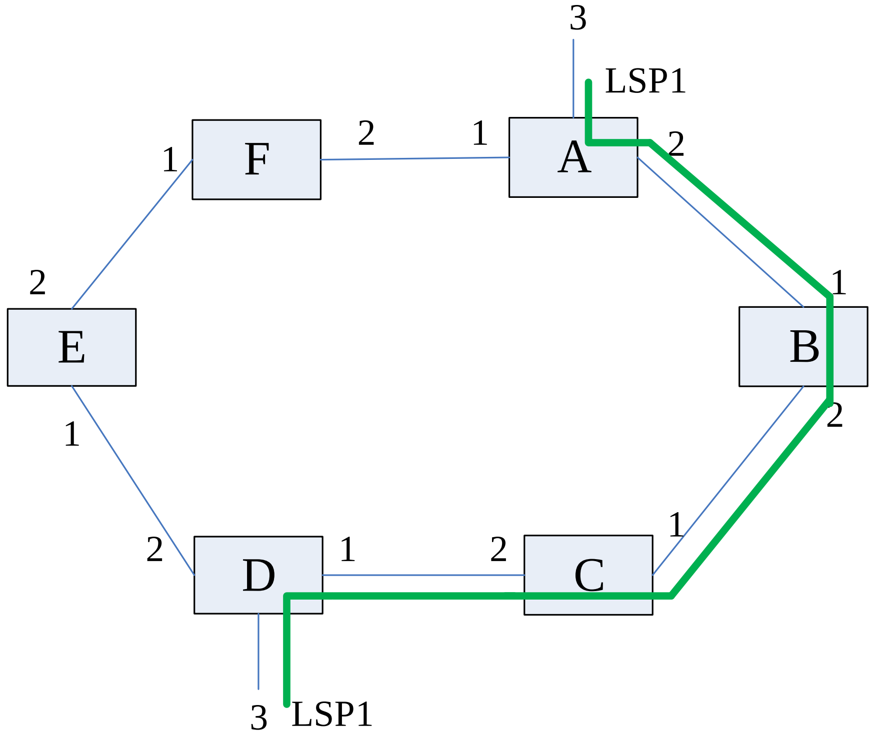


Figure A-15 basic network

When a link failure between node B and node C occurs, as shown in the following Figure A-16, node A switches the signal from the clockwise working ring tunnel to the anticlockwise protection ring tunnel, and leaving at node D on the protection ring tunnel. The signal then will follow the path A-F-E-D.

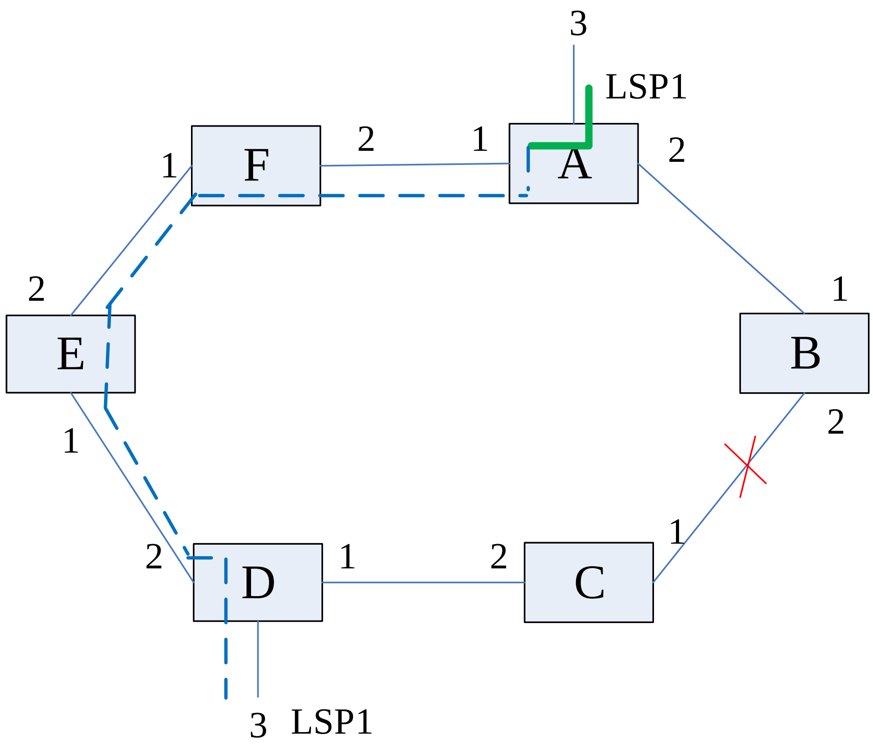


Figure A-16 Steering for link failure

The following figures show the LTP and FC configurations for nodes in the ring under normal and failure condition.

For the normal condition, the switches in node B, node C, node D and node A are the same to the wrapping situation as shown in Figure A-5 and Figure A-6.

When there is a failure on link between Node B and Node C, the ring nodes may work as shown in the following figures.

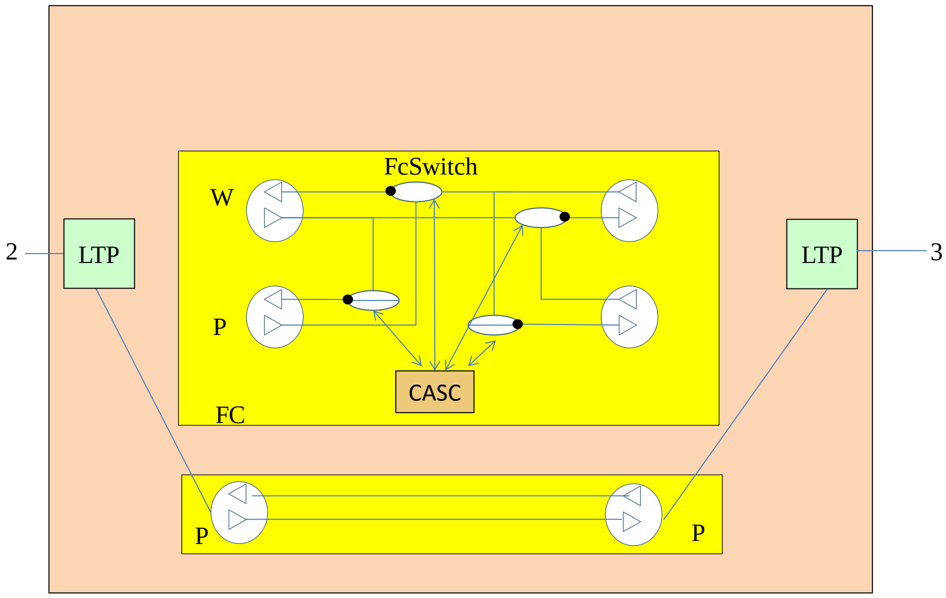


Figure A-17 Steering: node D with failure on link between node B and node C

Figure A-17 above shows the configurations of Node D with a failure on link between Node B and Node C, there is an actual FC that allows signal to flow between the protection path on port2 and port3.

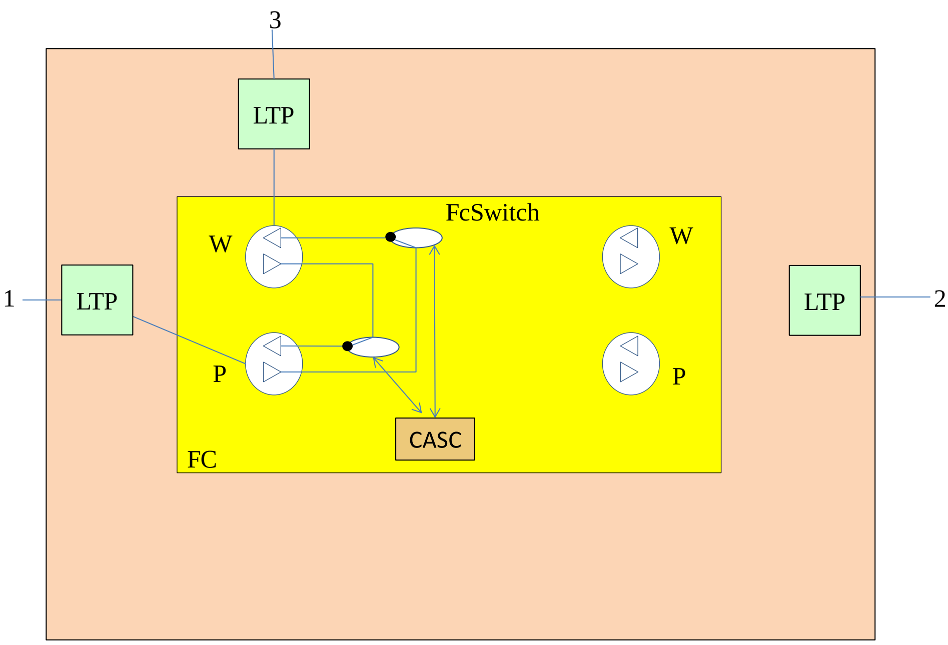


Figure A-18 Steering: node A with failure on link between node B and node C

Figure A-18 above shows the configurations of Node A with a failure on link between Node B and Node C, such that the signal is switched to flow between protection port1 and working port3.

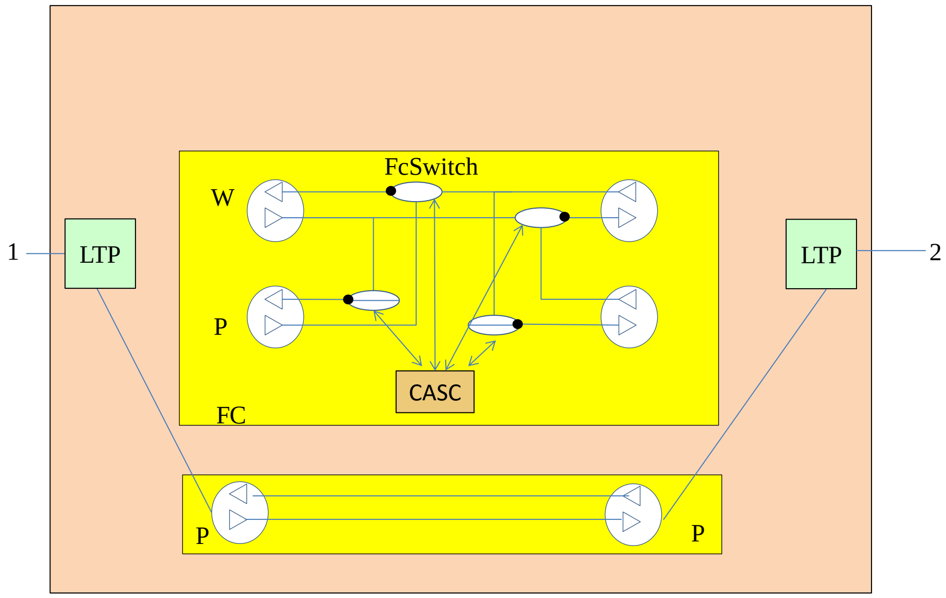


Figure A-19 Steering: node E and node F with failure on link between node B and node C

Figure A-19above shows the configurations on node E and node F for the failure on link between node B and node C. There is an actual FC that allows signal to flow between the protection path on port1 and port2 due to the switching in node A shown in the previous figure.

Node B and node C are not involved in the switching.

A.2 short-wrapping

With the wrapping ring scheme, protection switching is executed at both nodes adjacent to the failure. But with the short-wrapping ring scheme, protection switching is executed only at the node upstream to the failure. And the packet leaves the protection ring at the egress end. Figure A-10 shows a view of a basic network. This figure is the same to A-3. A signal is passing from port3 node A to port 3 node D. LSP1 is through the path A-B-C-D.

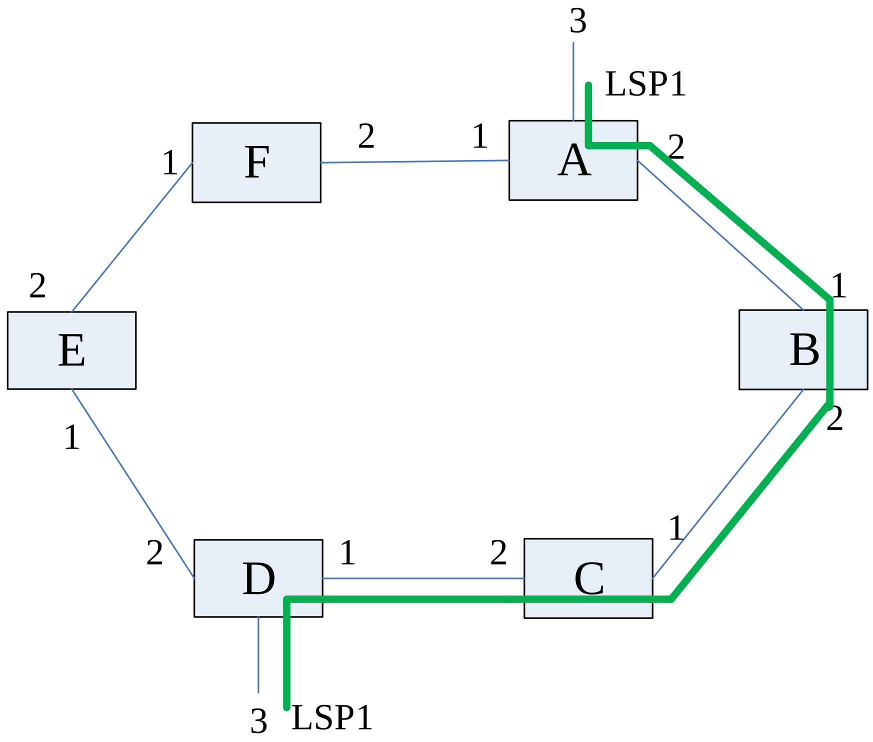


Figure A-10 basic network

When a link failure between node B and node C occurs, see the following Figure A-11. Node B switches the clockwise working ring tunnel to the anticlockwise protection ring tunnel, and leaves at node D on the protection ring tunnel. The signal then will follow the path A-B-A-F-E-D.

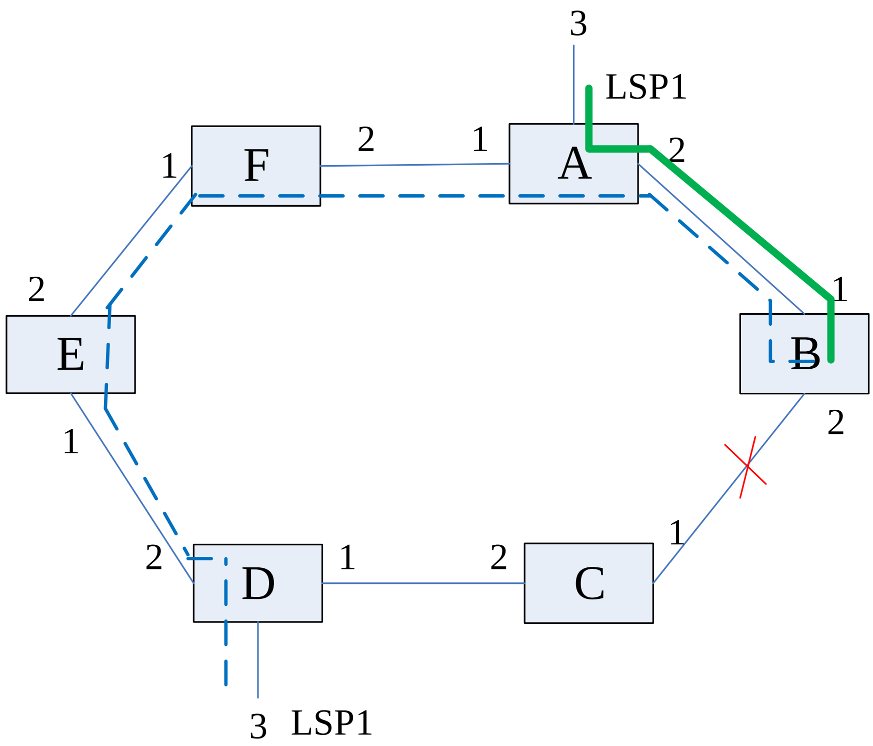


Figure A-11 short-wrapping for link failure

The following figures show the LTP and FC configurations for nodes in the ring under normal and failure condition.

For the normal condition, the switches in nodes B, C, D and A are the same to the wrapping situation as shown in Figure A-5 and Figure A-6.

When there is a failure on the link between Node B and Node C, the nodes will work as shown in the following figures.

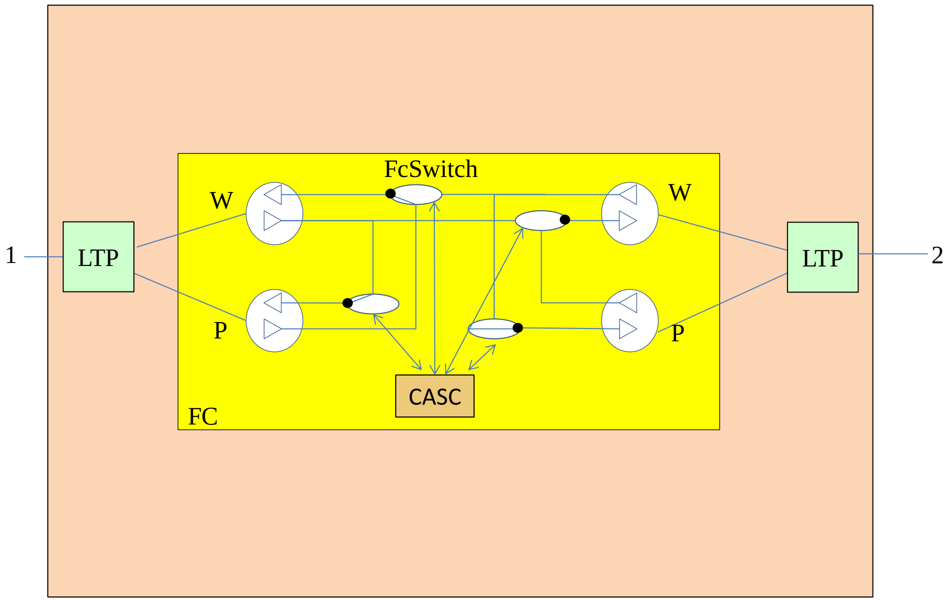


Figure A-12Wrapping: node B with failure on link between node B and node C

Figure A-12 above shows the configurations of Node B with a failure on the link between Node B and Node C, such that the switches on the port1 have been set to the protection path. The FC allows signal to flow between the working and protection on port1, such that the signal is wrapped back to port1. For this node, it is the same to Figure A-7 wrapping scheme.

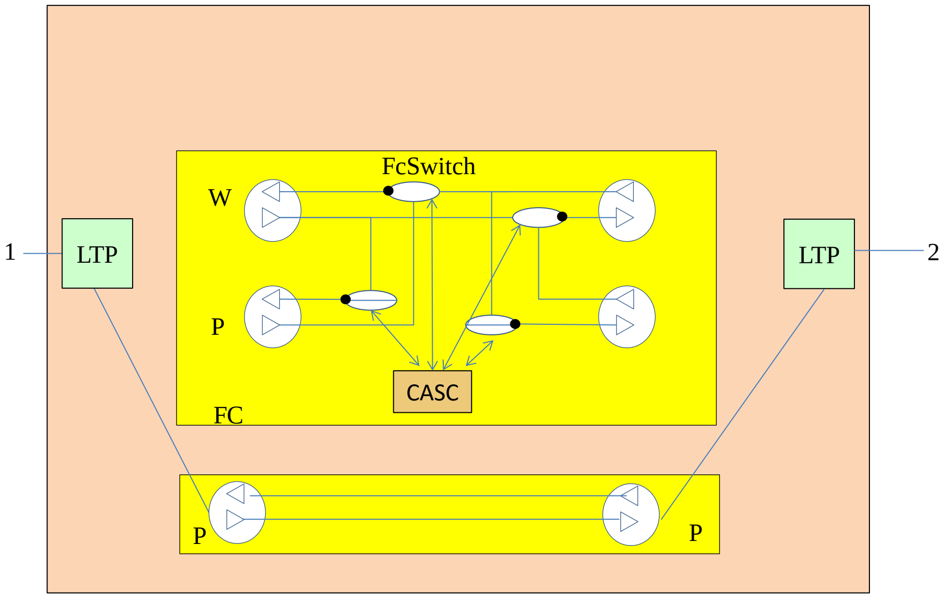


Figure A-13 short-wrapping: node E and node F with failure on link between node B and node C

Figure A-13 above shows the configurations on node E and node F for the failure on the link between node B and node C. There is an actual FC that allows signal to flow between the protection path on port1 and port2 due to the wrapping in node B as shown in the previous figure.

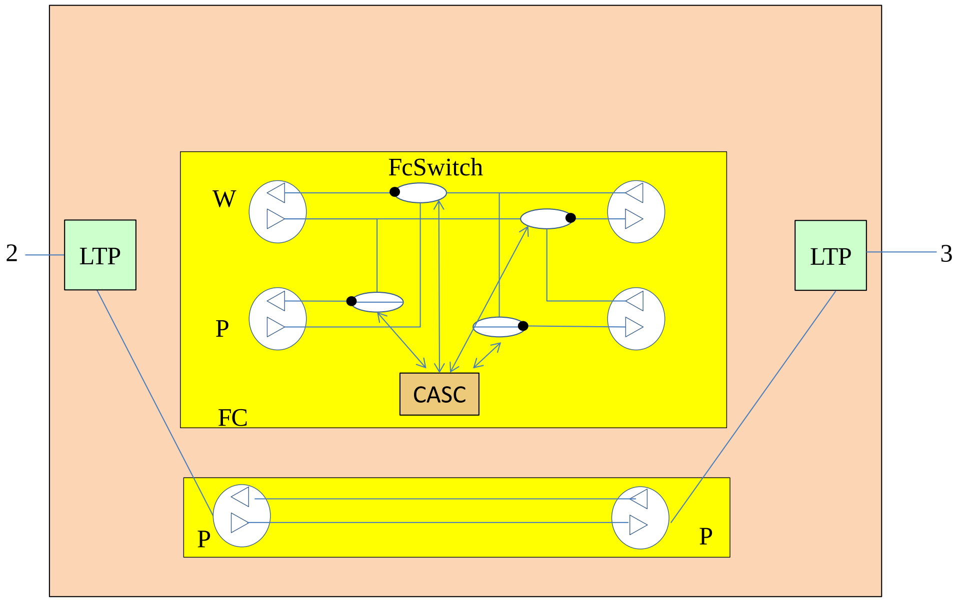


Figure A-14 short-wrapping: node D with failure on the link between node B and node C

Figure A-14 above shows the configurations on node D for the failure on the link between node B and node C. There is an actual FC that allows signal to flow between the protection path on port2 and port3 due to the wrap in node B as shown in the previous figure.
Node A does not need to switch as node B performs the protection function in this case. Node C does not include in this scheme because the signal leaves through node D. In general, for the short-wrapping scheme, only the node on the upstream side of the failure performs the protection function. However, the two directions of a protected bidirectional LSP are no longer co-routed under the protection-switching conditions.

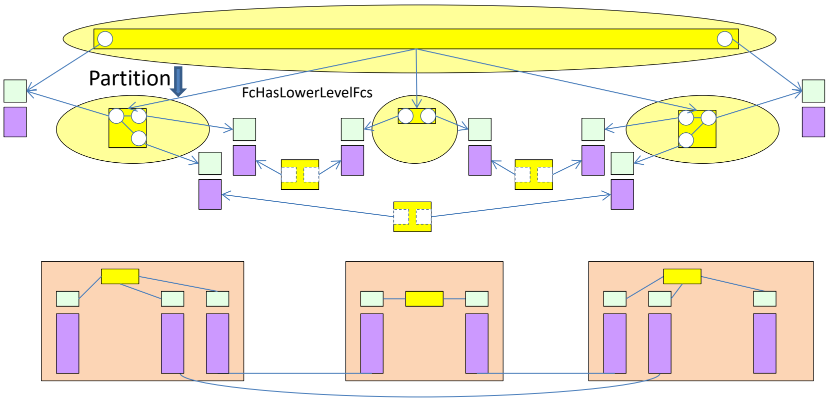
Appendix I

Linear protection examples

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

I.1 1+1/1:1 cases

This clause deals with MPLS-TP 1+1/1:1 protection group and shows how they can be represented.



FigureI.1-1 simple example of Linear 1+1/1:1(from [ITU-T G.7711] Figure XIV.1-1)

Figure I.1-1shows a simple example of a 1+1/1:1 case in a basic network with three NEs. Of course this can be generalized to more NEs. The end-end FC is partitioned into subordinate (via FcHasLowerLevelFcs). MPLS-TP SNC/S protection and trail protection all can be represented by this common example.

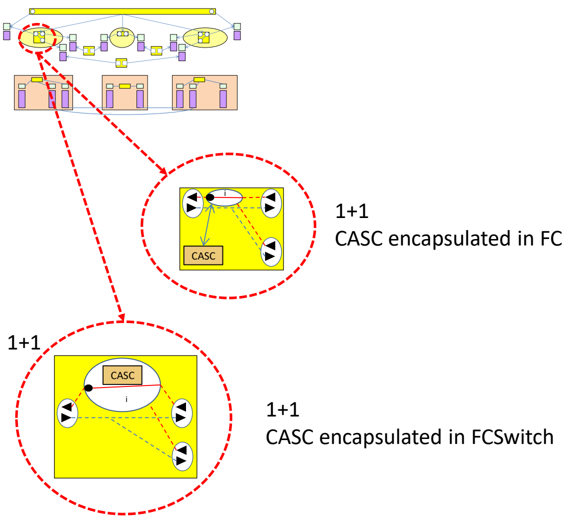


Figure I.1-2 detail of a nodal view of 1+1 switches

Figure I.1-2 above shows a nodal view of 1+1 switches. It describes the ConfiguraionAndSwitchControllers (CASC) encapsulated in the Fc (the upper part of the figure) and ConfiguraionAndSwitchControllers encapsulated in the FcSwitch (the below part of the figure). The encapsulation type depends upon the scope of control of the CASC. The encapsulation is via FcSwitchCoordinatedByInternalControl when in the FcSwitch and FcSwitchesInFcCoordinatedBySwitchCoordinator when in the FC.

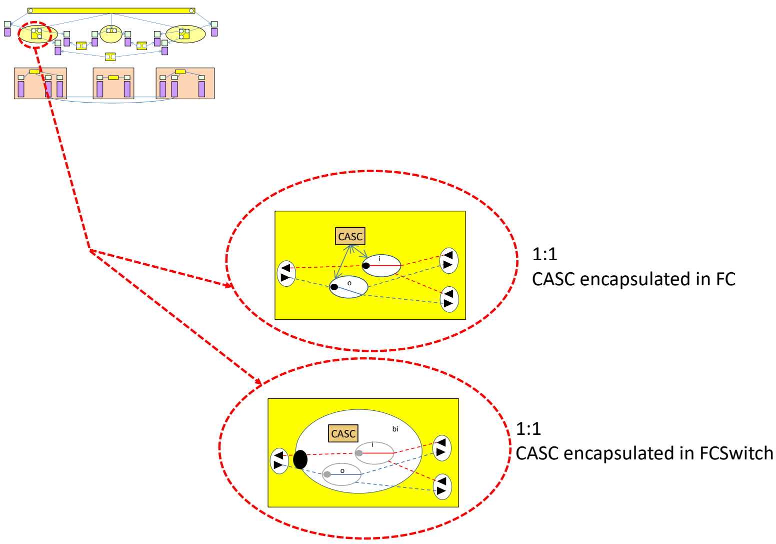
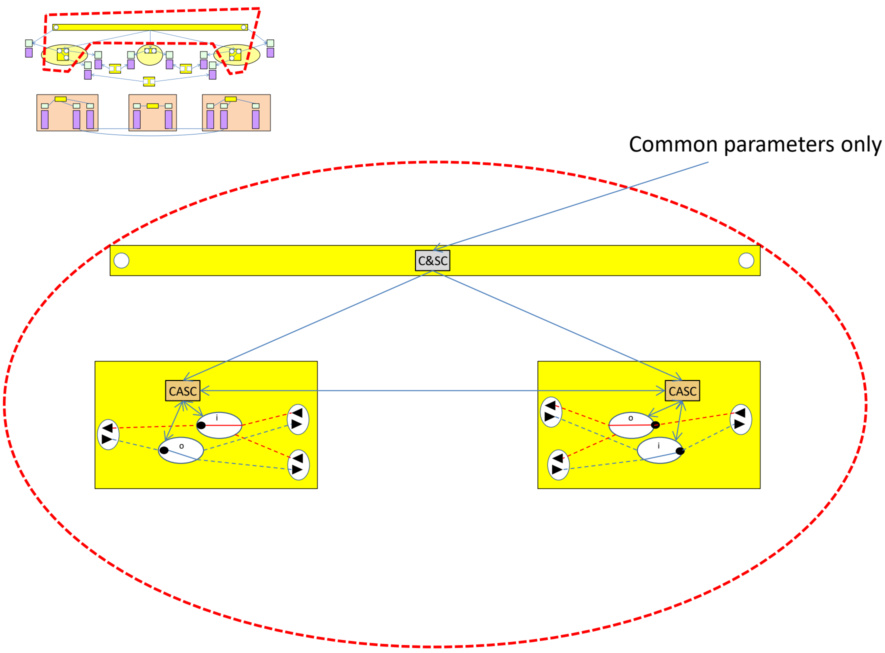


Figure I.1-3 detail of a nodal view of 1:1 switches

Figure I.1-3 above shows a nodal view of 1:1 switches. It describes the ConfiguraionAndSwitchControllers (CASC) encapsulated in the Fc (the upper part of the figure) and ConfiguraionAndSwitchControllers encapsulated in the FcSwitch (the below part of the figure).



FigureI.1-4 Showing a high-level abstract controller in a 1:1 case

Figure I.1-4 shows a case of 1:1 independent switching, in which the two directions of traffic are switched independently. The figure assumes that the CASCs in the FCs at each end are distributed. It highlights a high-level CASC which can be used to collect common parameters that should be set to the same value at both ends. In this case, the high level CASC governs the lower level CASC.

Bibliography

[b-ONF TR-531] ONF TR-531_UML-YANG Mapping Guidelines (https://3vf60mmveq1g8vzn48q2o71a-wpengine.netdna-ssl.com/wp-content/uploads/2014/10/TR-531_UML-YANG_Mapping_Guidelines_v1.0.pdf)

[b- IETF-mpls-base] YANG Data Model for MPLS Base (work in progress) (March 2020), (https://tools.ietf.org/html/draft-ietf-mpls-base-yang-14)

[b-IETF-mpls-static] YANG Data Model for MPLS Static LSPs (work in progress) (April 2020), (https://tools.ietf.org/html/draft-ietf-mpls-static-yang-11)

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