International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.8152.2/Y.1375.2

(01/2021)

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Resilience information/data models for the MPLS-TP network element

Recommendation ITU-T G.8152.2/Y.1375.2

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Recommendation ITU-T G.8152.2/Y.1375.2

Resilience information/data models for the MPLS-TP network element

Summary

Recommendation ITU-T G.8152.2/Y.1375.2 specifies resilience management information and data models for a multi-protocol label switching-transport profile (MPLS-TP) network element (NE) as specified in Recommendations 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 in Recommendation G.8152.2/Y.1375.2 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 data models considered in Recommendation ITU-T G.8152.2/Y.1375.2 include, but are not limited to, those of the yet another next generation (YANG) type.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.8152.2/Y.1375.2	2021-01-13	15	11.1002/1000/14560

Keywords

Data model YANG, information model, MPLS-TP, resilience, UML.

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Recommendation ITU-T G.8152.2/Y.1375.2

Resilience information/data models for the MPLS-TP network element

1 Scope

This Recommendation specifies resilience information models and data models for a multi-protocol label switching-transport profile (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 data models considered in this Recommendation include, but are not limited to, those of the yet another next generation (YANG) type. The specific management and control functions for resilience covered by this Recommendation include ITU-T G.8131 MPLS-TP linear protection switching and ITU-T G.8132 MPLS-TP shared ring protection (MSRP) switching.

The YANG modules of this Recommendation aim to be compatible with and when necessary extend the relevant generic ones developed by the Internet Engineering Task Force (IETF) 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.780] Recommendation ITU-T G.780/Y.1351 (2010), *Terms and definitions for synchronous digital hierarchy (SDH) networks*.

[ITU-T G.806] Recommendation ITU-T G.806 (2012), *Characteristics of transport equipment – Description methodology and generic functionality.*

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

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

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

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

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

[IETF RFC 7950] IETF RFC 7950 (2016), *The YANG 1.1 data modeling language*.

[IETF RFC 8340] IETF RFC 8340 (2018), *YANG tree diagrams*.

[IETF RFC 8342] IETF RFC 8342 (2018), *Network management datastore architecture (NMDA)*.

[IETF RFC 8227] IETF RFC 8227 (2017), *MPLS-TP shared-ring protection (MSRP) mechanism for ring topology*.

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 (*n* ≥ 1): [ITU-T G.808]

3.1.3 clear: [ITU-T G.808]

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

3.1.5 forced switch: [ITU-T G.808]

3.1.6 hold-off time: [ITU-T G.808]

3.1.7 manual switch: [ITU-T G.808]

3.1.8 protection: [ITU-T G.808]

3.1.9 protection group: [ITU-T G.808]

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

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

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

3.1.13 steering: [ITU-T G.808]

3.1.14 switch: [ITU-T G.808]

3.1.15 unidirectional protection switching: [ITU-T G.780]

3.1.16 wait-to-restore time: [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:

EXER	Exercise
FC	Forwarding Construct
FS	Forced Switch
LP	Layer Protocol
LP	Lockout of Protection
LSP	Label Switched Path
LTP	Logical Termination Point

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
NE	Network Element
OAM	Operations, Administration and Maintenance
SD	Signal Degrade
SF	Signal Fail
SNC/S	SNCP with Sublayer monitoring
SNCP	Subnetwork Connection Protection
SSF	Server Signal Fail
UML	Unified Modelling Language
WTR	Wait-to-Restore
YANG	Yet Another Next Generation

5 Conventions

5.1 Information modelling conventions

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

5.1.1 Unified modelling language 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].

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

The MPLS-TP linear protection function is specified in [ITU-T G.8131]. The linear protection type characteristic can be of the types listed in Table 6-1.

Table 6-1 – 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

The MPLS-TP ring protection function is specified in [ITU-T G.8132]. The ring protection type characteristic can be of the types listed in Table 6-2.

Table 6-2 – 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 unified modelling language (UML) information model of the MPLS-TP protection functions identified in clause 6. The information model is derived through pruning and refactoring the ITU-T G.7711 core information model and ITU-T G.8152 MPLS-TP base information model.

7.1 Required object classes and relations

7.1.1 Linear protection

Clause 6.1 of [ITU-T G.8131] describes the protection switching architecture for the MPLS-TP linear protection group, including unidirectional 1+1 subnetwork connection protection (SNCP) with sublayer monitoring (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 unidirectional 1+1 SNC/S protection switching is chosen 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 to the linear protection switching schemes. Figure 7-1 and Table 7-1 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.

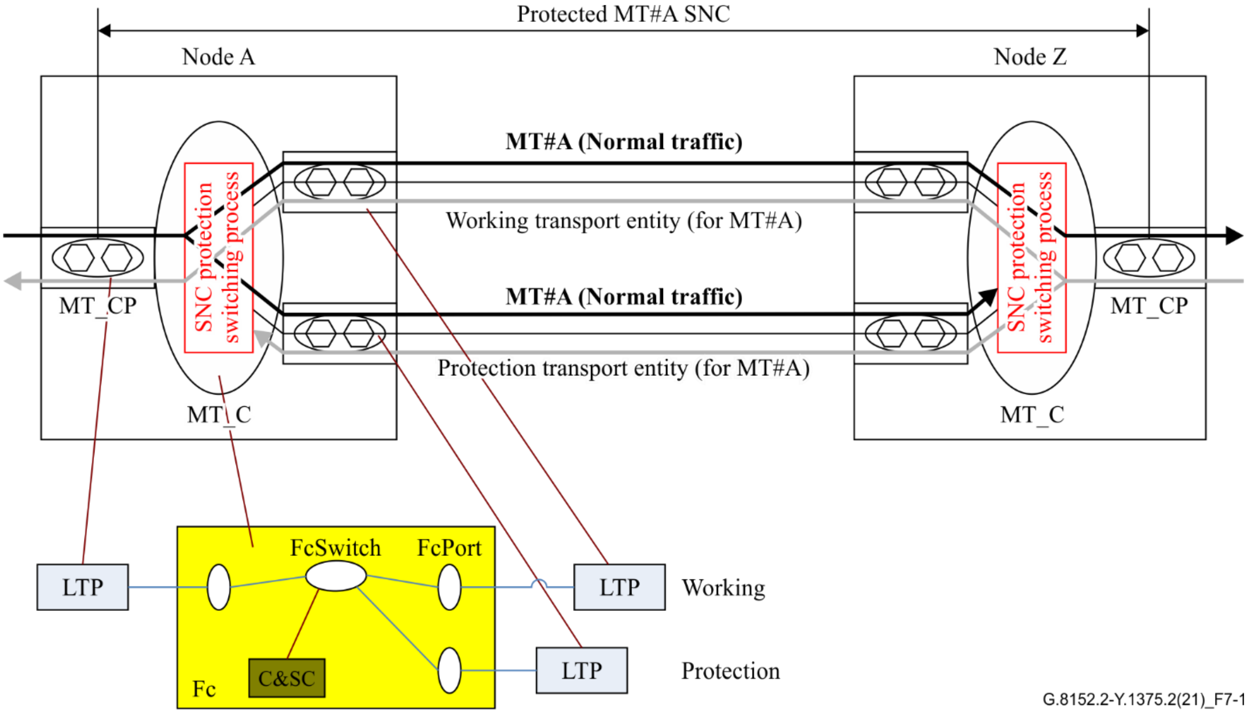

Figure 7-1 – Mapping between [ITU-T G.8131] and [ITU-T G.7711] for MPLS-TP linear protection model

Table 7-1 – Mapping between [ITU-T G.8131], [ITU-T G.8152] and [ITU-T G.7711] for MPLS-TP linear protection

[ITU-T G.8131]	[ITU-T G.8152]	[ITU-T G.7711]
SNCP 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 7-2, whose upper part is taken from Figure E.1-1 of [ITU-T G.7711], which shows the basic resilience pattern.

As shown in Figure 7-2, 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 forwarding construct (FC). The FcSwitch represents and determines 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 or modify FCs and logical termination points/layer protocols (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 determines a list of control parameters to apply to a switch.

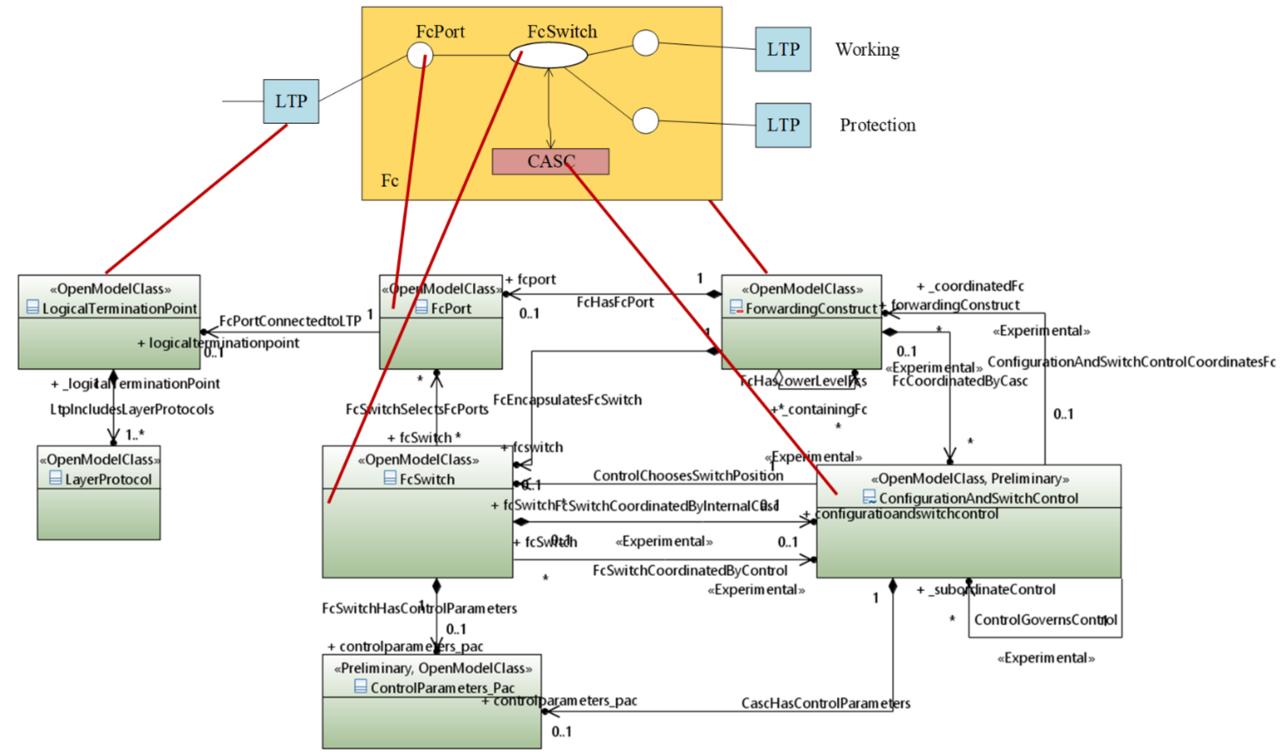

Figure 7-2 – Simplified resilience model for MPLS-TP linear protection

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

In Figure 7-3, the following colour convention is used for the object classes: orange –from the ITU-T G.7711 core model; blue – specified in this Recommendation; pink – pruned and refactored from [ITU-T G.7711], but in need of further refactoring; and yellow – from [ITU-T G.8152].

In this Recommendation, the LinearProtection object class models the switched forwarding of traffic (traffic flow) for linear protection, and is pruned and refactored from [ITU-T G.7711] and [ITU-T G.8152]. Additionally, it is used to control and coordinate linear protection groups, to add, delete or modify FCs and LTPs/LPs so as to realize a protection scheme. It also determines a list of control parameters to apply to a switch.

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

The pink object classes need to be further refactored into UML artefacts that are supposed to be re-engineered from [b-IETF-mpls-base] and [b-IETF-mpls-static].

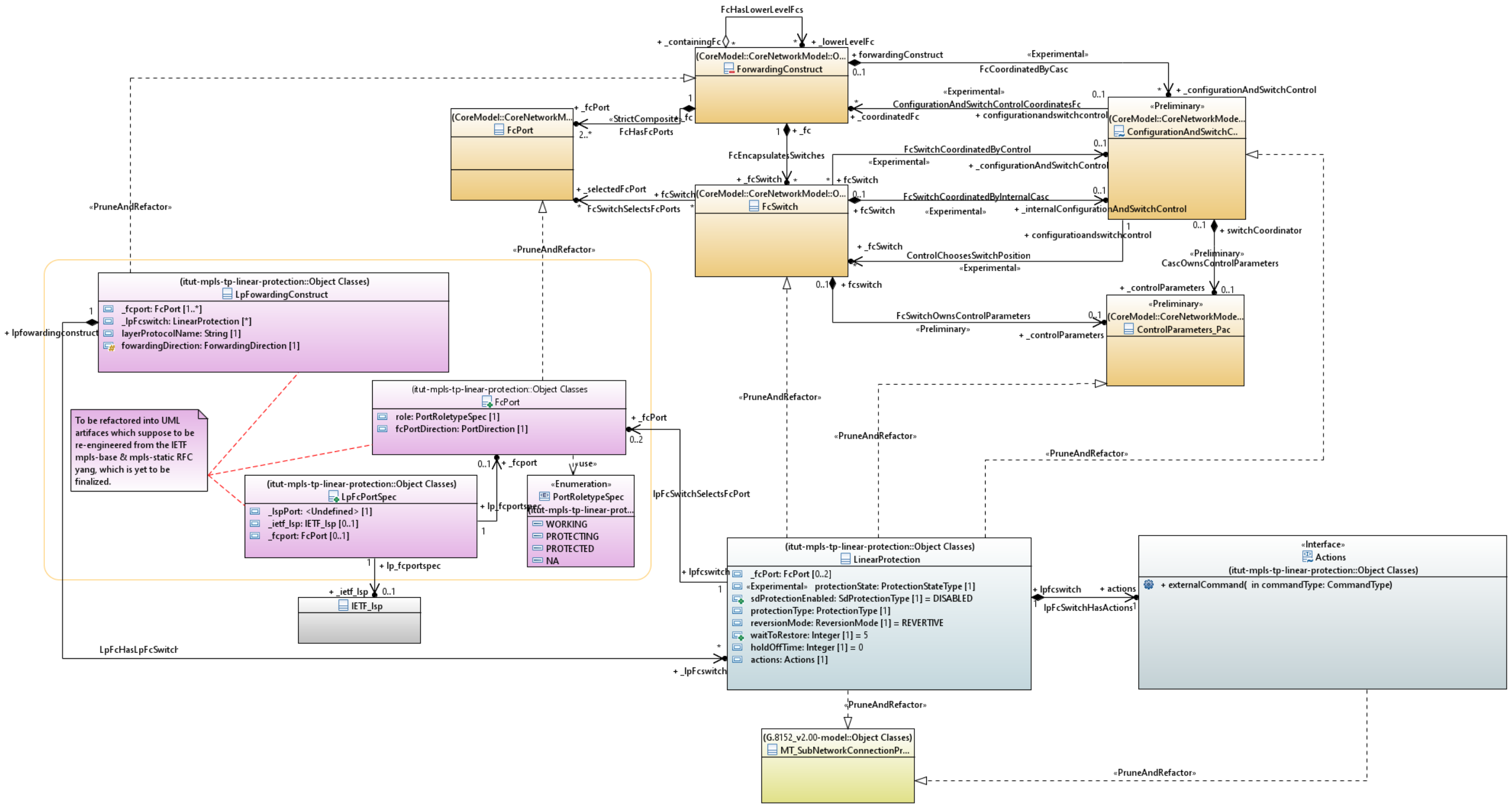

Figure 7-3 – MPLS-TP linear protection specification model

7.1.2 Shared ring protection

Figure 8-1 of [ITU-T G.8132] presents the function model of MSRP (see the upper part of Figure 7-4). Annex E of [ITU-T G.7711] specifies the generic resilience information model. Figure 7-4 shows the mapping between the ITU-T G.8132 MSRP functions and the ITU-T G.7711 information model artefacts for the MSRP.

An MSRP ring tunnel is modelled as a server sub-layer for the MPLS-TP label switched path (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 set up in the MSRP sub-layer. See Table 7-2.

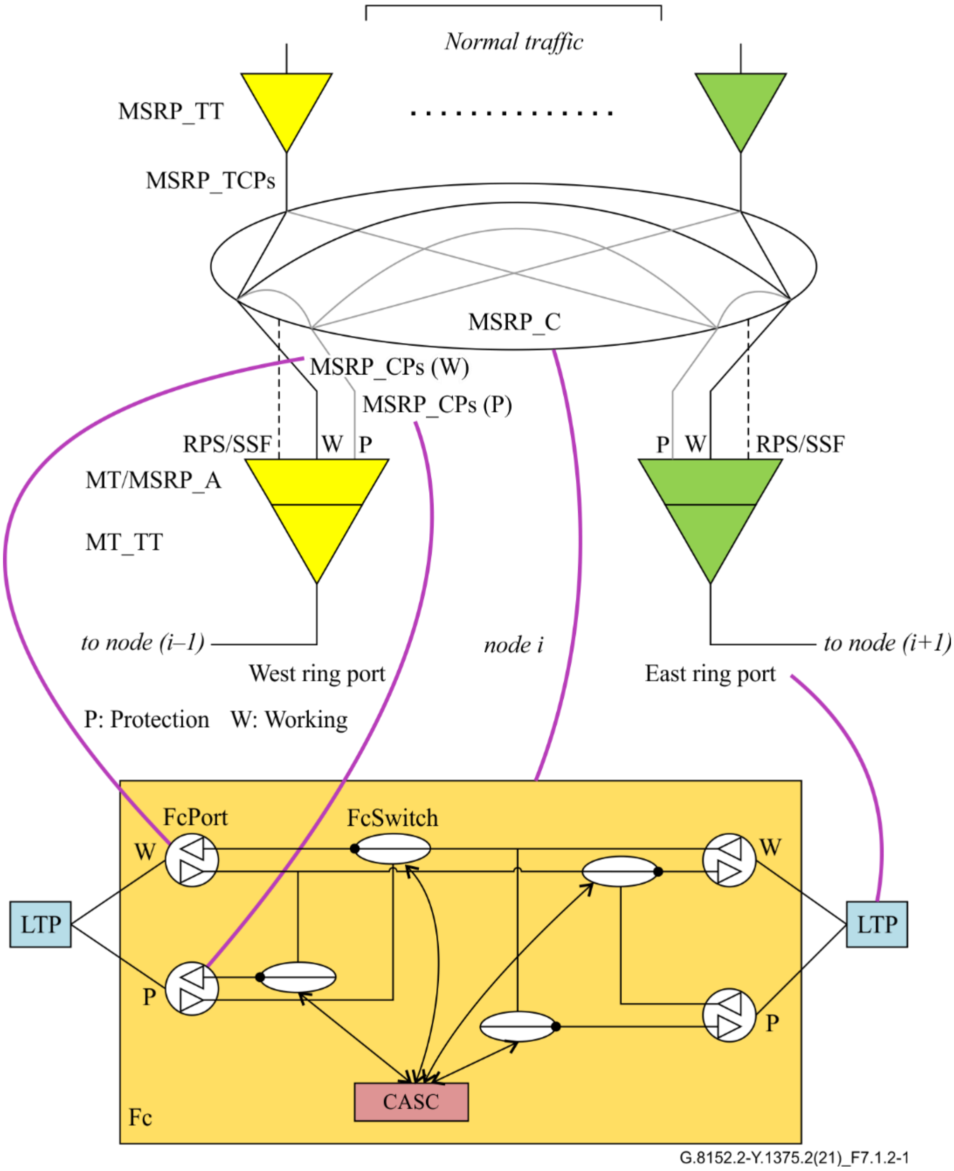

Figure 7-4 – Mapping between MSRP functions and information model artefacts

Table 7-2 – Mapping between [ITU-T G.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 yet determined	FcSwitch+CASC+ Spec
MSRP_C	Not yet determined	FC+ Spec
MSRP_CP	Not yet determined	FcPort +Spec
West ring port/East ring port	MT_TrailTerminationPoint	LTP +Spec

The simplified resilience model for MSRP can be expressed as in Figure 7-5.

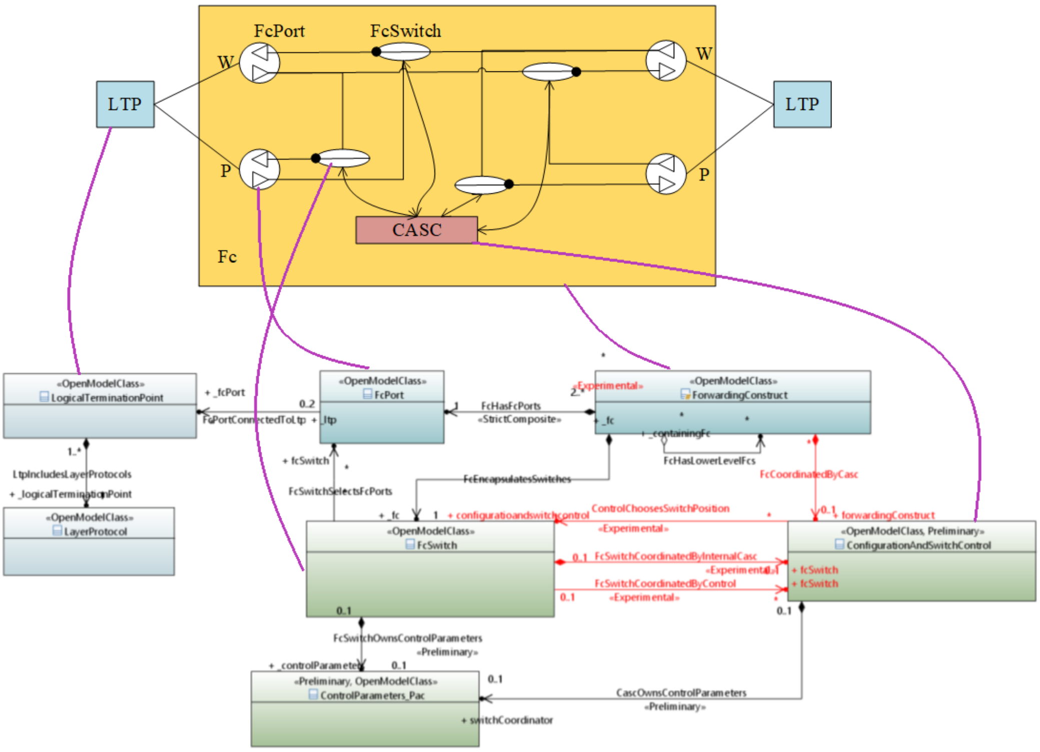

Figure 7-5 – Simplified resilience model for MSRP

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 specification models. The colour convention of Figure 7-3 is used in Figure 7-6.

The Srp_FcSwitch object class models the switched forwarding of traffic (traffic flow), and is pruned and refactored from [ITU-T G.7711] and [ITU-T G.8152]. The Srp_casc is used to control and coordinate instances of FcSwitch, to add, delete or modify FCs and LTPs/LPs so as to realize a protection scheme. The ControlParameters_Pac determines a list of control parameters to apply to a switch. The SRP_CascActions interface class determines the operations for shared ring protection.

The pink object classes need to be further refactored into UML artefacts that are supposed to be re-engineered from [b- IETF-mpls-base] and [b-IETF-mpls-static].

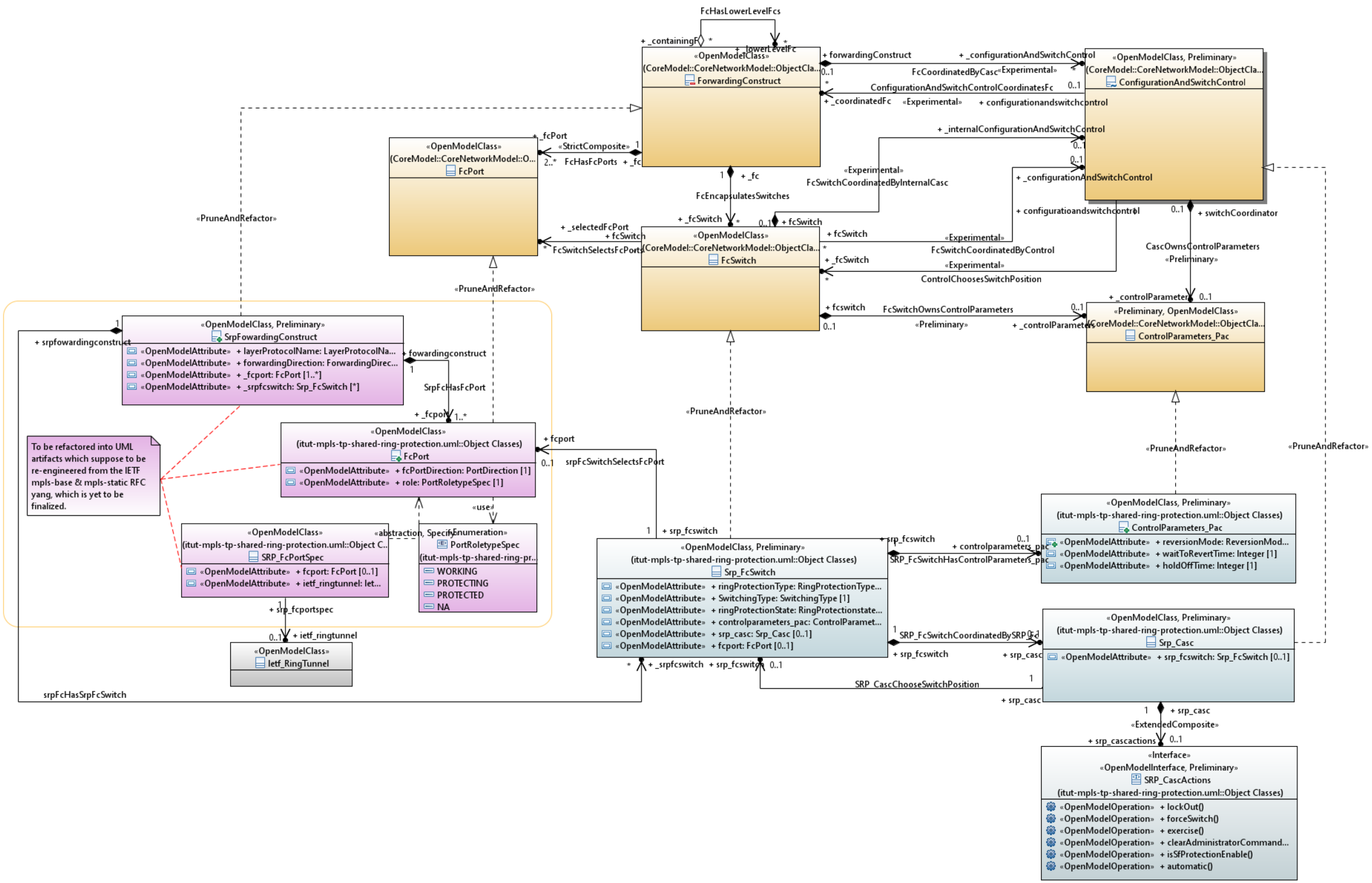

Figure 7-6 – MSRP specification model

Figure 7-7 shows the Fc instance model that is used to describe the relationship between the ring tunnel and LSP. The MSRP ring tunnel is modelled as a server sub-layer for the MPLS-TP LSP sub-layer. As shown in Figure 7-7, a RingTunnelFc instance has a lower level LSPFc instance.

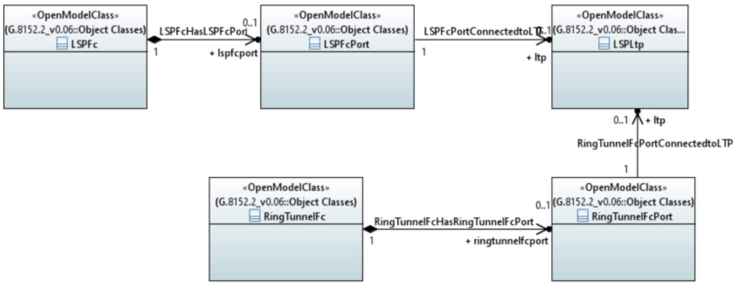

Figure 7-7 – Fc instance

Annex A describes the principles of MSRP and a method of using the MSRP resilience model to represent the MSRP, as well as a switching method 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 or refactored for linear protection.

In [ITU-T G.8152], MPLS-TP linear protection is modelled by the MT_SNCP_Group object class. Tables 7-3 to 7-5 verify the compatibility at the attribute and operation level between [ITU-T G.8152] and [ITU-T G.7711].

Table 7-3 – Linear protection attribute mapping

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

Table 7-4 –Linear protection operations mapping

	Operations in [ITU-T G.8152]	Corresponding attributes in [ITU-T G.7711]	Operations for this Recommendation
1	MT_SubNetworkConnectionProtectionGroup::lockoutProtection()	Use the operation of CASC to set FcSwitch to *lockout*. In clause E.1.2.6 of [ITU-T G.7711], the FC switch represents and determines 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) determining the type of command. For this one, the command type is LOCKOUT_OF_PROTECTION.
2	MT_SubNetworkConnectionProtectionGroup::forceSwitch()	Use the operation of CASC to set FcSwitch to *force switch*.	Action Command, with one input parameter (commandType) determining the type of command. For this one, the command type is FORCED_SWITCH.
3	MT_SubNetworkConnectionProtectionGroup::clearExternalCommandAndWTRstate()	Use the operation of CASC to set FcSwitch to *clear*. May need to add "clear" to FcSwitch::Switchcontrol. So, it may be described by the operations pf CASC. ControlParameters_Pac already has WaitToRestoreTime attributes.	Action Command, with one input parameter (commandType) determining the type of command. For this one, the command type is CLEAR.
4	MT_SubNetworkConnectionProtectionGroup:::manualSwitch()	Set the selectedFcPort attribute of FcSwitch to the designated switching port (either the protecting port or the working port). The attribute switchControl of FcSwitch already has the value MANUAL.	Action Command, with one input parameter (commandType) determining the type of command. For this one, the command type are MANUAL_SWITCH_TO_WORKING, MANUAL_SWITCH_TO_PROTECTION.
5	MT_SubNetworkConnectionProtectionGroup::exercise()	No description of exercise in [ITU-T G.7711].	Action Command, with one input parameter (commandType) determining the type of command. For this one, the command type is EXERCISE.
6	MT_SubNetworkConnectionProtectionGroup::localFreeze()	Set the isFroze attribute of ConfigurationAndSwitchControl to *true*.	Action Command, with one input parameter (commandType) determining the type of command. For this one,

Table 7-4 –Linear protection operations mapping

	Operations in [ITU-T G.8152]	Corresponding attributes in [ITU-T G.7711]	Operations for this Recommendation
			the command type is FREEZE.
7	MT_SubNetworkConnectionProtectionGroup::clearLocalFreeze()	Set the isFroze attribute of ConfigurationAndSwitchControl to *false*.	Action Command, with one input parameter (commandType) determining the type of command. For this one, the command type is CLEAR_FREEZE.

[ITU-T G.8152] only describes the attributes and operations in Table 7-3 and Table 7-4. However, according to [ITU-T G.8131], this Recommendation may also include the attributes listed in Table 7-5.

Table 7-5 – Linear protection attributes verification

	Attributes in [ITU-T G.8131]	Corresponding attributes in [ITU-T G.7711]	Attributes for this Recommendation
1	Clause 7 of [ITU-T G.8131] describes the selection of the working connection or protection connection	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 including: WORKING, PROTECTING, PROTECTED， NA.
2	Clause 6.3.2 of [ITU-T G.8131] on revertive operation	Use the ControlParameters_Pac.	LinearProtection:: 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 or refactored for MSRP.

In [ITU-T G.8152], there is no object class specified for MSRP. Tables 7-6 and 7-7 provide the mapping between the ITU-T G.8132 MSRP characteristics and the information artefacts according to the MSRP model in clause 7.1.2.

Table 7-6 – MSRP attribute mapping

	Attributes in [ITU-T G.8132]	Corresponding attributes in [ITU-T G.7711]	Attributes for this Recommendation
1	Three types of ring protection mechanism are specified: wrapping; short wrapping; and steering	Use ControlParameters_Pac::protType. But the values of protType are not defined	ControlParameters_Pac::protType. As CIM does not describe the data type values for protType, the values are those specified in [ITU-T G.8132].
2	MSRP supports only the bi-directional protection switching type	Use the switchingType attribute of FcSwitch	FcSwitch::Switchingtype, this attribute is specified from [ITU-T G.8132].
3	Revertive protection operation type	Use ControlParameters_Pac::reversionMode.	ControlParameters_Pac::reversionMode
4	Ring protection switch state	Use the ringProtectionState attribute of FcSwitch	FcSwitch::RingProtectionState, this attribute is specified from [ITU-T G.8132].
5	Wait-to-restore	Use ControlParameters_Pac::waitToRevertTime	ControlParameters_Pac::waitToRevertTime

Table 7-7 – MSRP operations mapping

	Operations in [ITU-T G.8132]	Corresponding attributes in [ITU-T G.7711]	Operations for this Recommendation
1	Lockout of Protection(LP), Lockout of Working(LW)	Use the operation of CASC to set FcSwitch to *lockout*	CASC specified operations::lockout() and specified parameter lockOutType will describe the type: lockout to protection or lockout to working.
2	Forced switch (FS)	Use the operation of CASC to set FcSwitch to *forceSwitch*	CASC specified operations::forceSwitch()
3	Manual switch (MS)	Set the _selectedFcPort attribute of FcSwitch	CASC specified operations::manualSwitch()
4	Exercise (EXER)	No description of *exercise* in [ITU-T G.7711]	CASC specified operations::exercise()
5	Clear: clears the administrative command and WTR timer	Use the operation of CASC to set FcSwitch to *clear*	CASC specified operations::clearAdministratorCommandAndWTRstate()
6	Automatically initiated command	Set FcSwitch automatically.	CASC specified operations::automatic()

7.3 UML model files

7.3.1 Linear protection

The linear protection UML model developed using the Papyrus open-source modelling tool can be found at: https://www.itu.int/ITU-T/formal-language/itu-t/g/g8152.2/2021/g8152.2_v1.00_uml.zip.

This zip file contains the following:

- The UML model consisting of the following files.
  - The Papyrus project file;
    - .project;
  - The .di, .notation, and .uml files of the linear protection module;
    - itut-mpls-tp-linear-protection.di;
    - itut-mpls-tp-linear-protection.notation;
    - itut-mpls-tp-linear-protection.uml;
- The UML profiles that determine the properties of the UML artefact.
  - The OpenModelProfile folder, which contains the .di, .notation, and uml of the open model profile.
  - The OpenInterfaceModelProfile folder, which contains the .di, .notation, and uml of the open model interface profile.
  - The ProfileLifecycleProfile folder, which contains the .di, .notation, and uml of the profile lifecycle profile.
  - The ClassDiagramStyleSheet.css style sheet.
- The UML models that are needed (i.e., imported) by this model.
  - ITU-T G.7711 core information model;
  - ITU-T G.8152-based MPL-TP information model.

7.3.2 Ring protection

The zip file containing the shared ring protection UML model developed using the Papyrus open-source modelling tool can be found at: https://www.itu.int/ITU-T/formal-language/itu-t/g/g8152.2/2021/itut-mpls-tp-shared-ring-protection.zip. Note that this model is preliminary and still requires further development.

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 MPLS-TP YANG data model

This clause contains the YANG data model.

The YANG data models specified in this Recommendation use the YANG 1.1 language specified in [IETF RFC 7950]. The tree format specified in [IETF RFC 8340] is used for the YANG data model tree representation. The YANG data models specified in this Recommendation conform to the network management datastore architecture specified in [IETF RFC 8342].

8.1.1 Linear protection

The 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 has been developed according to the mapping guidelines of [b-ONF TR-531].

At the time of publication of this Recommendation, the xmi2yang mapping tool is still work in progress. Therefore, manual modifications of the tool-generated yang are necessary. The yang with such manual modifications can be found at https://www.itu.int/ITU-T/formal-language/itu-t/g/g8152.2/2021/g8152.2_v1.00_yang.zip.

8.1.2 Ring protection

Since the base UML model of shared ring protection is still preliminary, the YANG model is also preliminary and needs further study.

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 G.8132]. This clause gives an overview of the architecture to be used to describe the MSRP management information model. As shown in Figure A.1, 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 operations, administration and maintenance (OAM) is needed for continuity check, remote defect indication and fault detection, and protection operations are controlled by the ring protection switching protocol described in [IETF RFC 8227]. A port can carry multiple ring tunnels, and a ring tunnel can carry multiple LSPs.

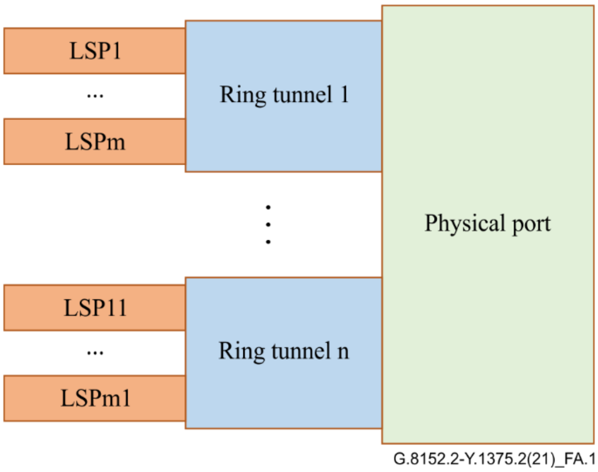

Figure A.1 – The logic layers of the ring

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 is described in subsequent clauses.

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 the 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.

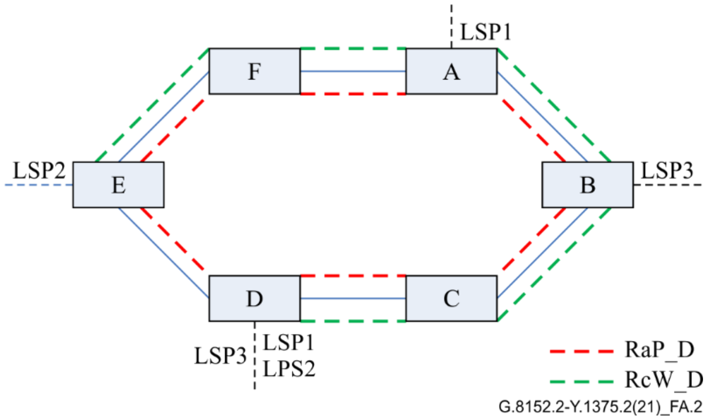

Figure A.2 – Ring tunnels in MSRP

Subsequent clauses specify 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 is a view of a basic network. A signal passes from port 3 node A to port 3 node D. LSP1 is A-B-C-D.

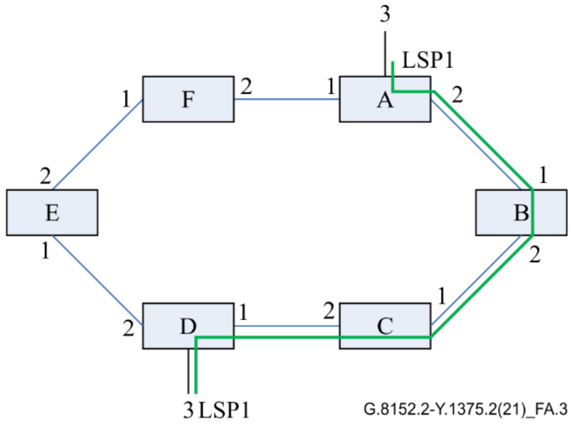

Figure A.3 – Basic network

When a link failure occurs between node B and node C, see Figure A.4. Node B switches the clockwise working ring tunnel to the anticlockwise protection ring tunnel, and sends a status message to 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 follows the path A-B-A-F-E-D-C-D.

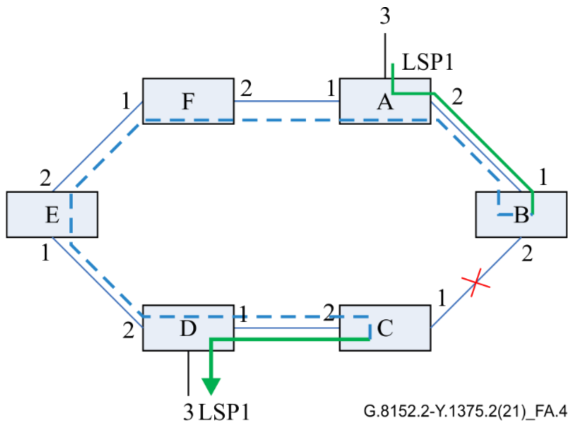

Figure A.4 – Wrapping for link failure

Figures A.5 to A.9 show the object classes (LTP and FC, FcSwitch, CASC) configurations for nodes in the ring under normal and failure condition.

Figure A.5 shows the configurations of node B and node C with the switches set to normal position. There is an actual FC that allows a signal to flow between the working ring tunnels.

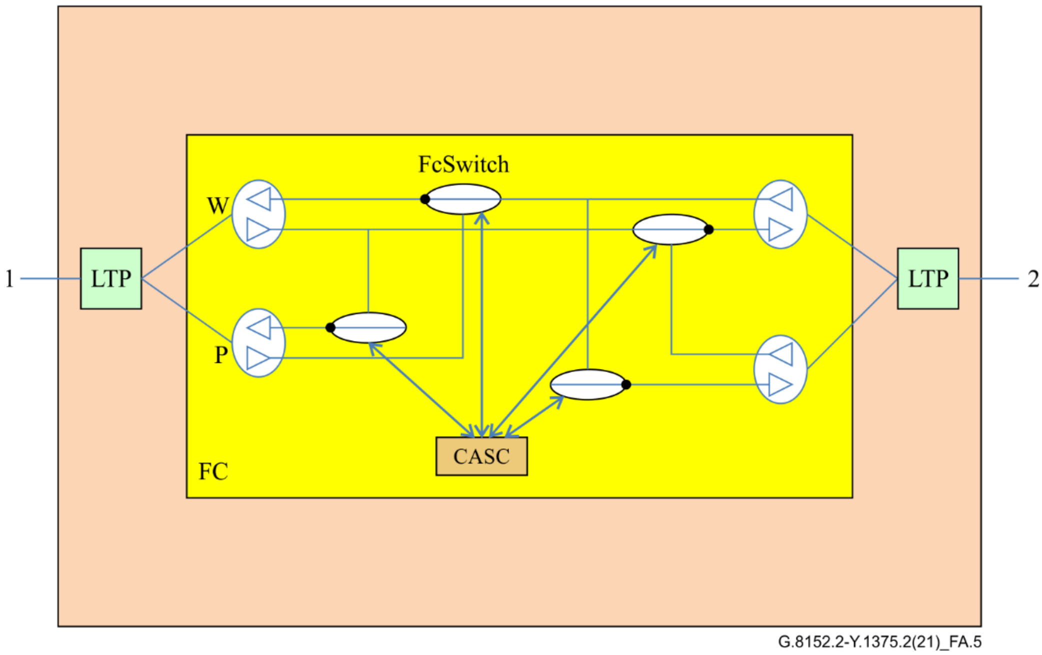

Figure A.5 – Wrapping: Node B and node C (no failure in ring)

Figure A.6 shows the configurations of node D with the switches set to normal position. There is an actual signal to flow between port 1 and port 3 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 port 2.

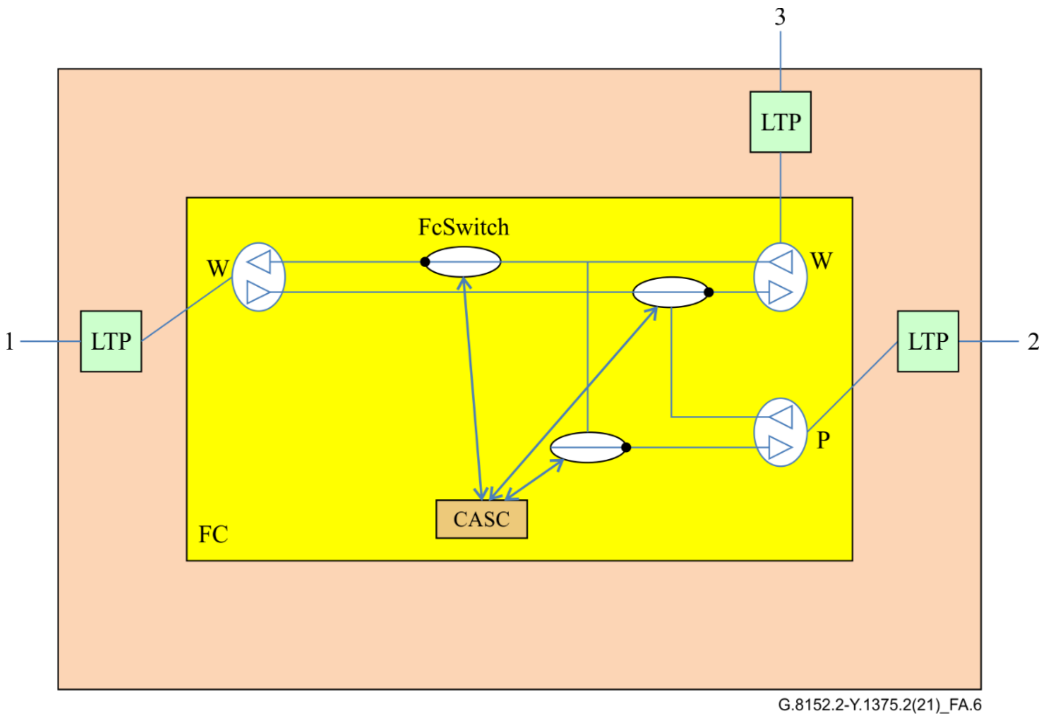

Figure A.6 – Wrapping: Node D (no failure in ring)

Figure A.7 shows the configurations of node B with a failure on link between node B and node C, such that the switches on port 1 have been set to the protection ring tunnel. The FC allows a signal to flow between the working and protection FcPort on port 1, such that the signal is wrapped back to port 1.

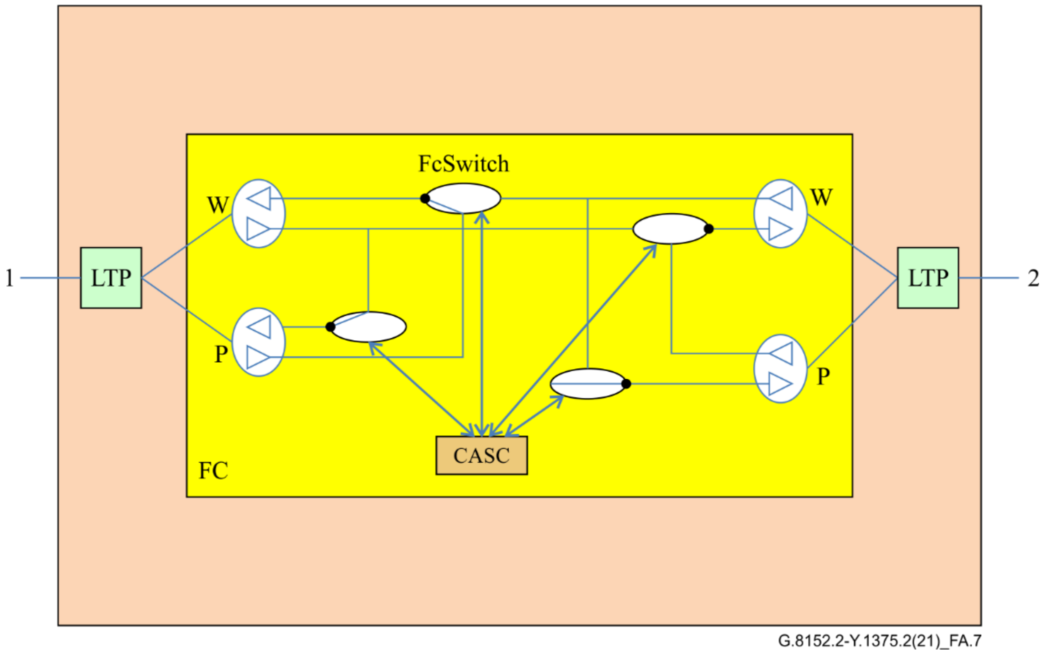

Figure A.7 – Wrapping: Node B with failure on link between node B and node C

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

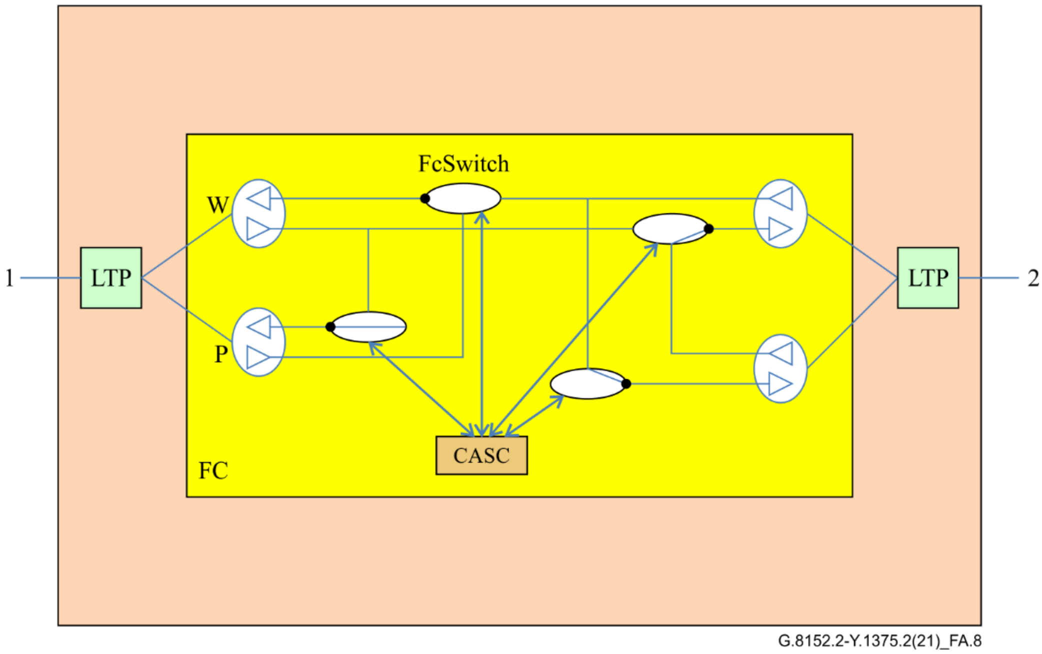

Figure A.8 – Wrapping: Node C with failure on link between node B and node C

Figure A.9 shows the configurations on node E and node F for a failure on the link between node B and node C. There is an actual FC that allows a signal to flow between the protection-ring tunnel on port 1 and port 2 due to the wrap in node B shown in Figure A.8.

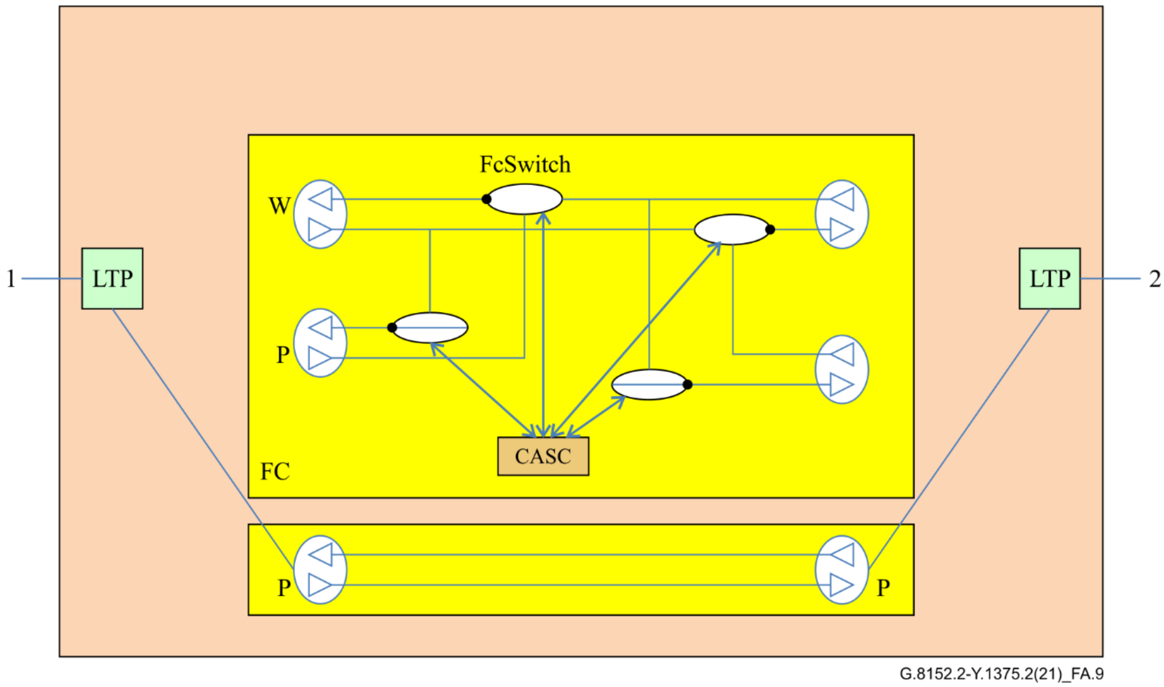

Figure A.9 – Wrapping: Node E and node F with failure on link between node B and node C

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.2 Steering

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

Figure A.10 shows a view of the basic network. Figure A.10 is the same as Figure A.3. A signal passes from port 3 node A to port 3 node D. LSP1 is A-B-C-D.

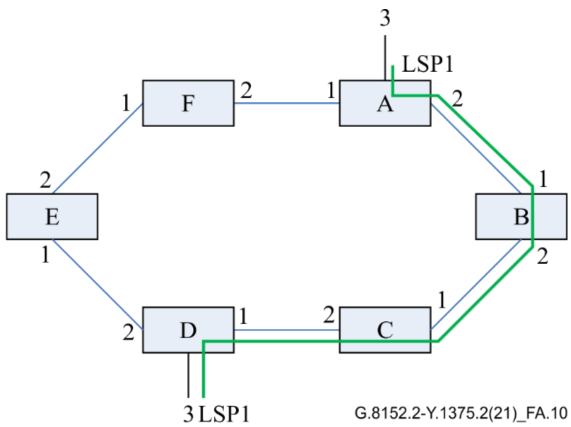

Figure A.10 – Basic network

When a link failure occurs between node B and node C, as shown in Figure A.11, node A switches the signal from the clockwise working ring tunnel to the anticlockwise protection ring tunnel, and leaves at node D on the protection ring tunnel. The signal then follows the path A-F-E-D.

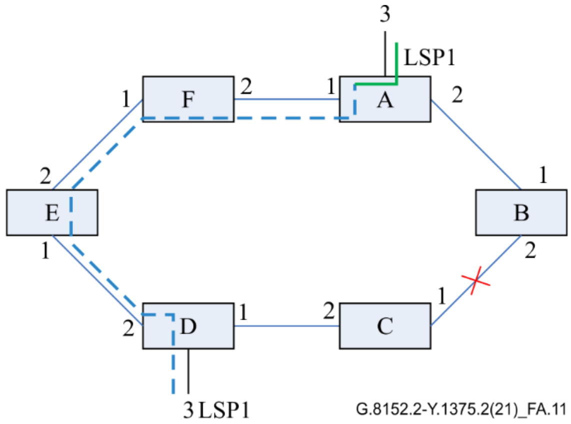

Figure A.11 – Steering for link failure

Figures A.12 to A.14 show the LTP and FC configurations for nodes in the ring under normal and failure conditions.

For the normal condition, the switches in nodes B, C, D and A are the same as in the wrapping situation 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 Figures A.12 to A.14.

Figure A.12 shows the configurations of node D with a failure on the link between node B and node C, there is an actual FC that allows a signal to flow between the protection paths on port 2 and port 3.

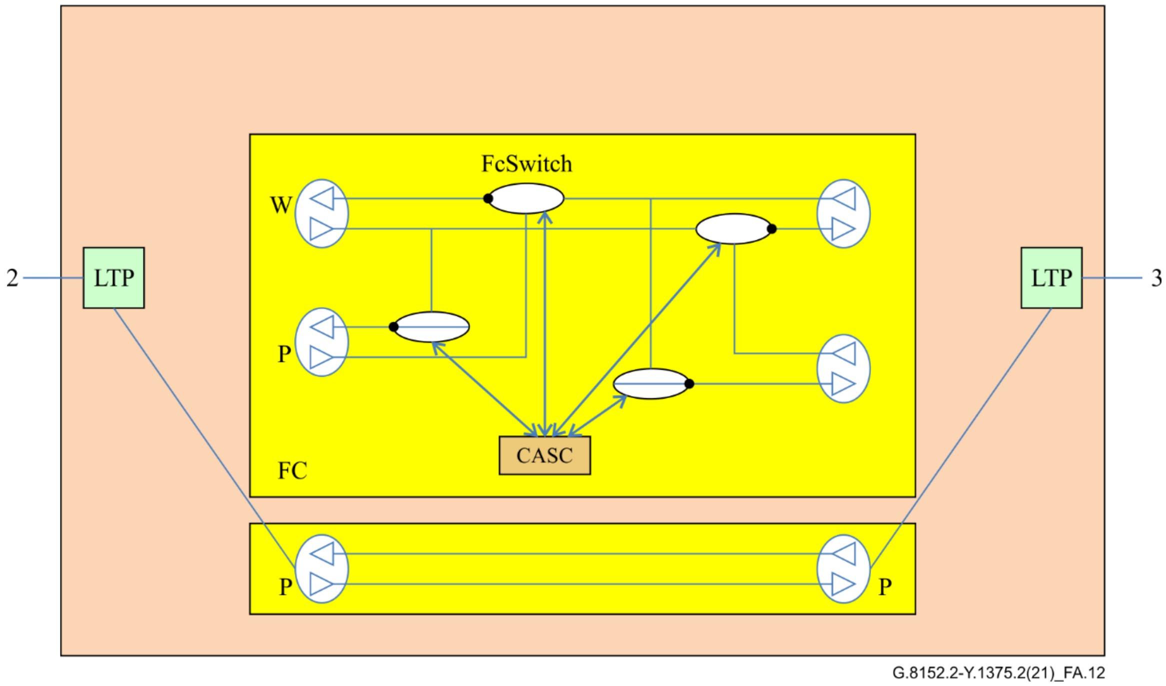

Figure A.12 – Steering: Node D with failure on link between node B and node C

Figure A.13 shows the configurations of node A with a failure on the link between node B and node C, such that the signal is switched to flow between protection port 1 and working port 3.

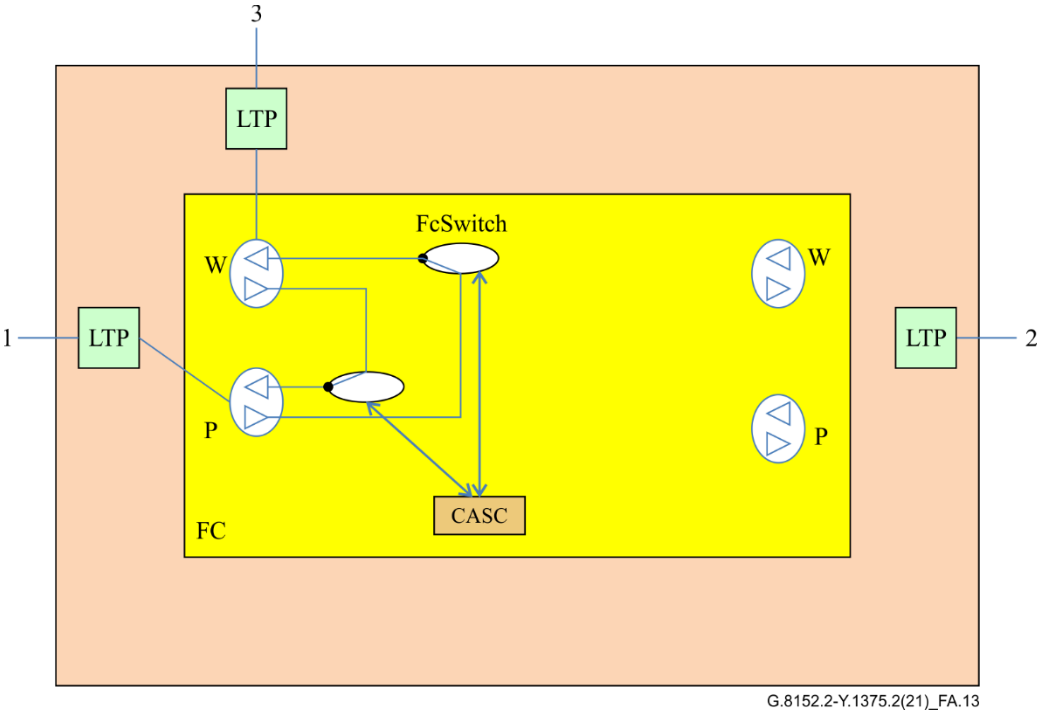

Figure A.13 – Steering: Node A with failure on link between node B and node C

Figure A.14 shows the configurations on node E and node F for a failure on the link between node B and node C. There is an actual FC that allows a signal to flow between the protection path on port 1 and port 2 due to the switching in node A shown in Figure A.13.

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

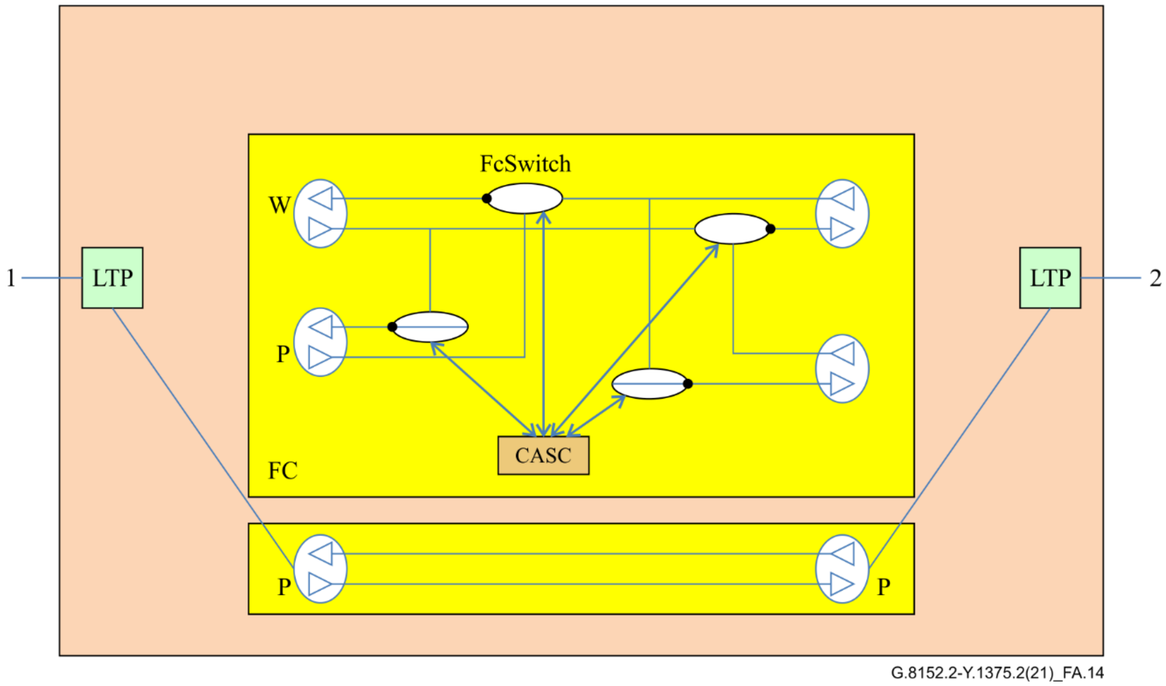

Figure A.14 – Steering: Node E and node F with failure on link between node B and node C

A.3 Short-wrapping

With the wrapping ring scheme, protection switching is executed at both nodes adjacent to the failure. However, with the short-wrapping ring scheme, protection switching is executed only at the node upstream to the failure. Additionally, the packet leaves the protection ring at the egress end. Figure A.15 is a view of a basic network. Figure A.15 is the same as Figure A.3. A signal passes from port 3 node A to port 3 node D. LSP1 is A-B-C-D.

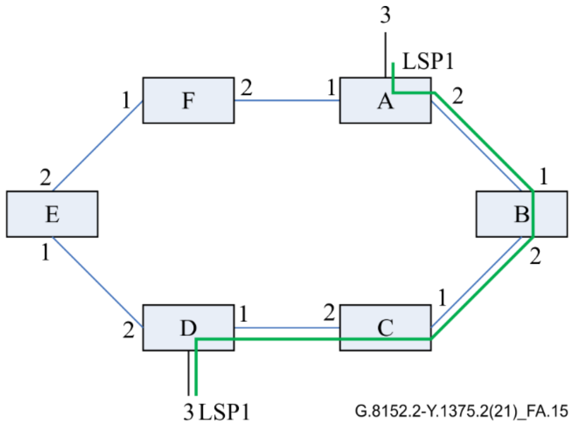

Figure A.15 – Basic network

When a link failure occurs between node B and node C, see Figure A.16. 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 follows the path A-B-A-F-E-D.

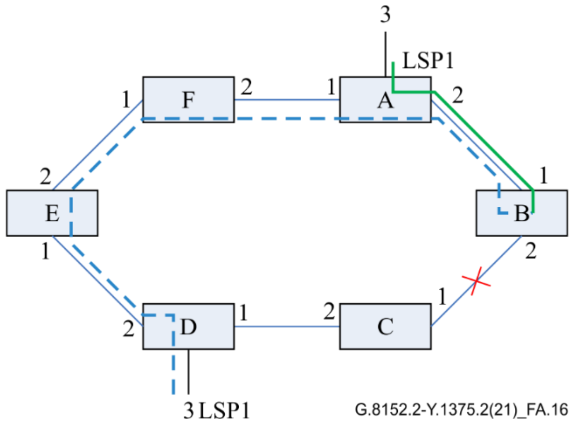

Figure A.16 – Short-wrapping for link failure

Figures A.17 to A.19 show the LTP and FC configurations for nodes in the ring under normal and failure conditions.

For the normal condition, the switches in nodes B, C, D and A are the same as in the wrapping situation 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 work as shown in Figures A.17 to A.19.

Figure A.17 shows the configurations of node B with a failure on the link between node B and node C, such that the switches on port 1 have been set to the protection path. The FC allows a signal to flow between the working and protection on port 1, such that the signal is wrapped back to port 1. For this node, the wrapping scheme is the same as that in Figure A.7.

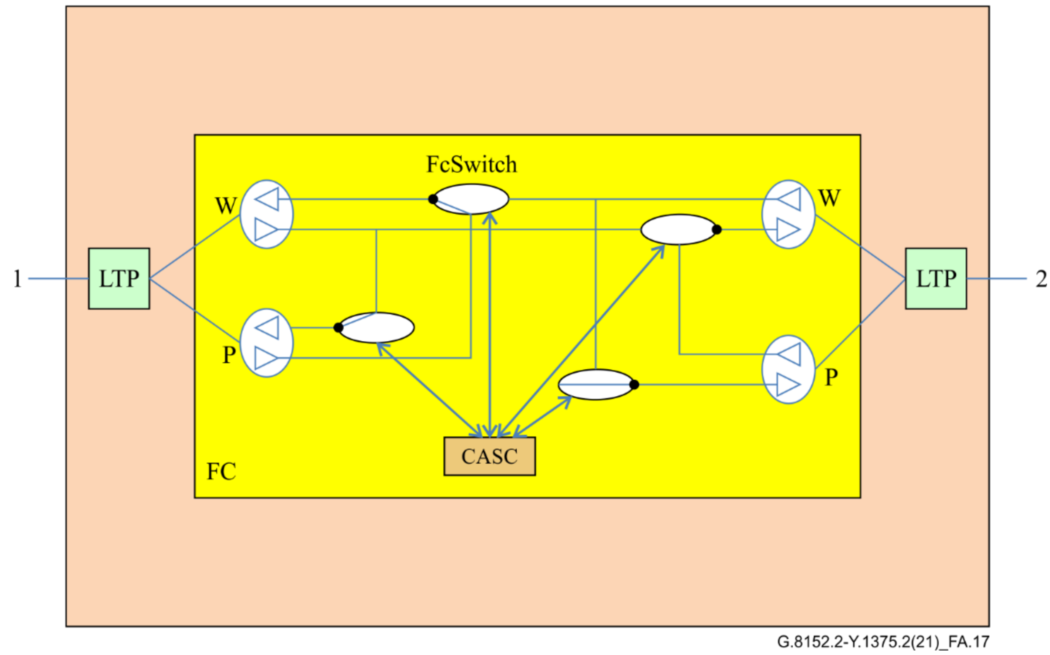

Figure A.17 – Wrapping: Node B with failure on link between node B and node C

Figure A.18 shows the configurations on node E and node F for a failure on the link between node B and node C. There is an actual FC that allows a signal to flow between the protection path on port 1 and port 2 due to the wrapping in node B as shown in Figure A.17.

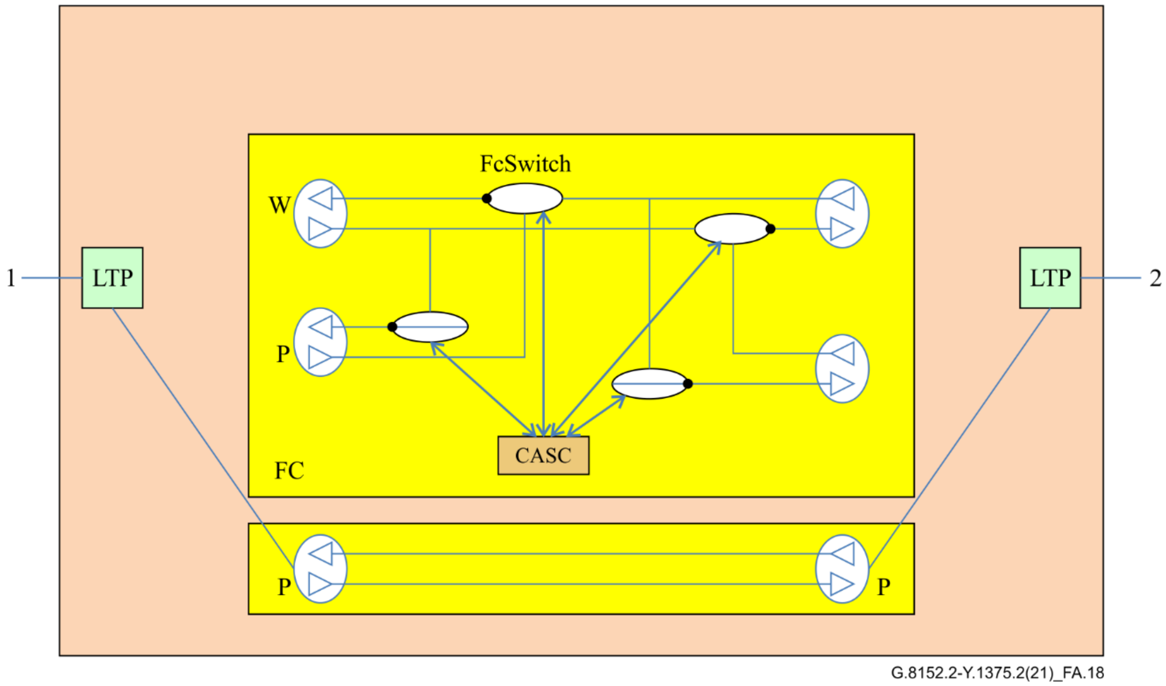

Figure A.18 – Short-wrapping: Node E and node F with failure on link between node B and node C

Figure A.19 shows the configurations on node D for a failure on the link between node B and node C. There is an actual FC that allows a signal to flow between the protection path on port 2 and port 3 due to the wrap in node B as shown in Figure A.18.

Node A does not need to switch as node B performs the protection function in this case. Node C is not included 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 protection-switching conditions.

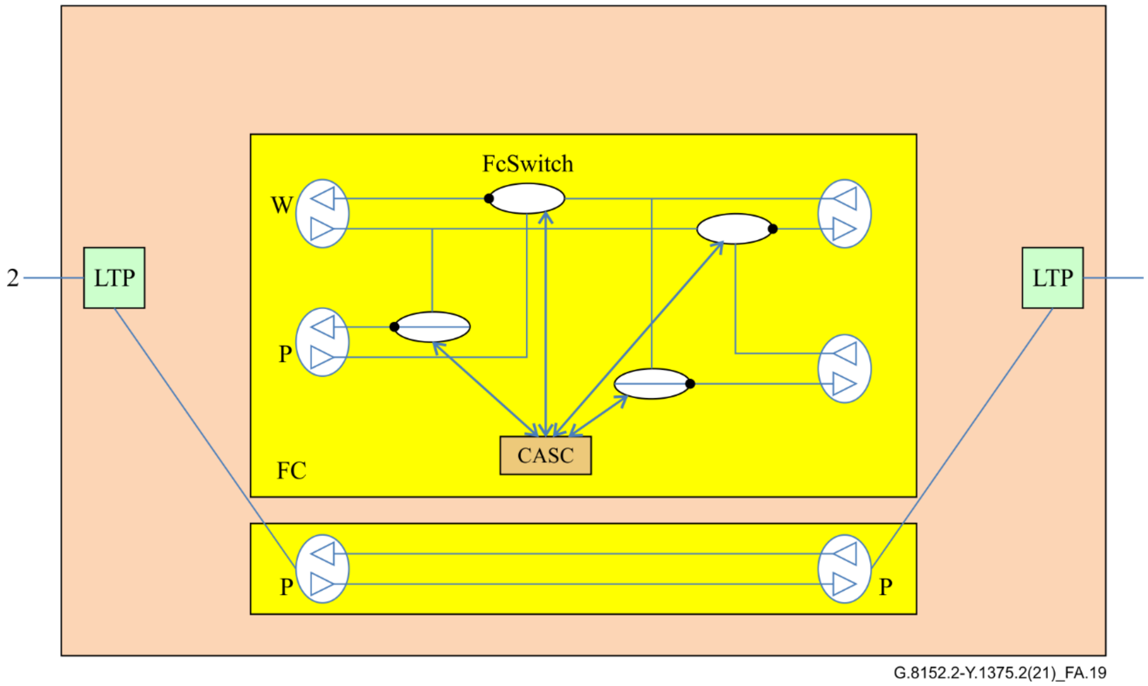

Figure A.19 – Short-wrapping: Node D with failure on the link between node B and node C

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 an MPLS-TP 1+1/1:1 protection group and shows how it can be represented.

Figure I.1 shows 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-to-end FC is partitioned into subordinate constructs (via FcHasLowerLevelFcs). MPLS-TP SNC/S protection and trail protection can be represented by this common example.

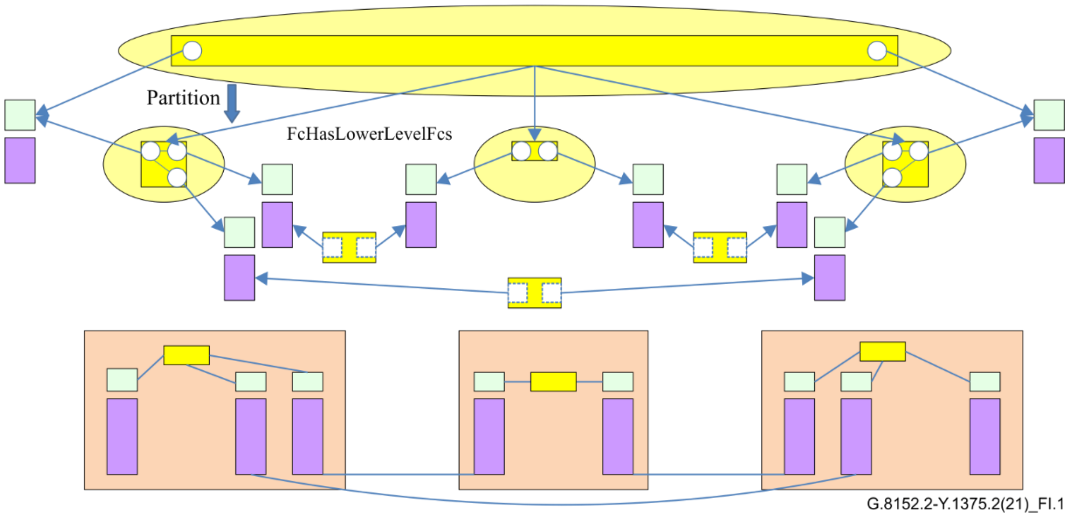

Figure I.1 – Simple example of linear 1+1/1:1(from Figure XIV.1-1 of [ITU-T G.7711])

Figure I.2 shows a nodal view of 1+1 switches. It describes the ConfigurationAndSwitchControllers (CASC) encapsulated in the FC (upper part) and ConfigurationAndSwitchControllers encapsulated in the FcSwitch (lower part). 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.

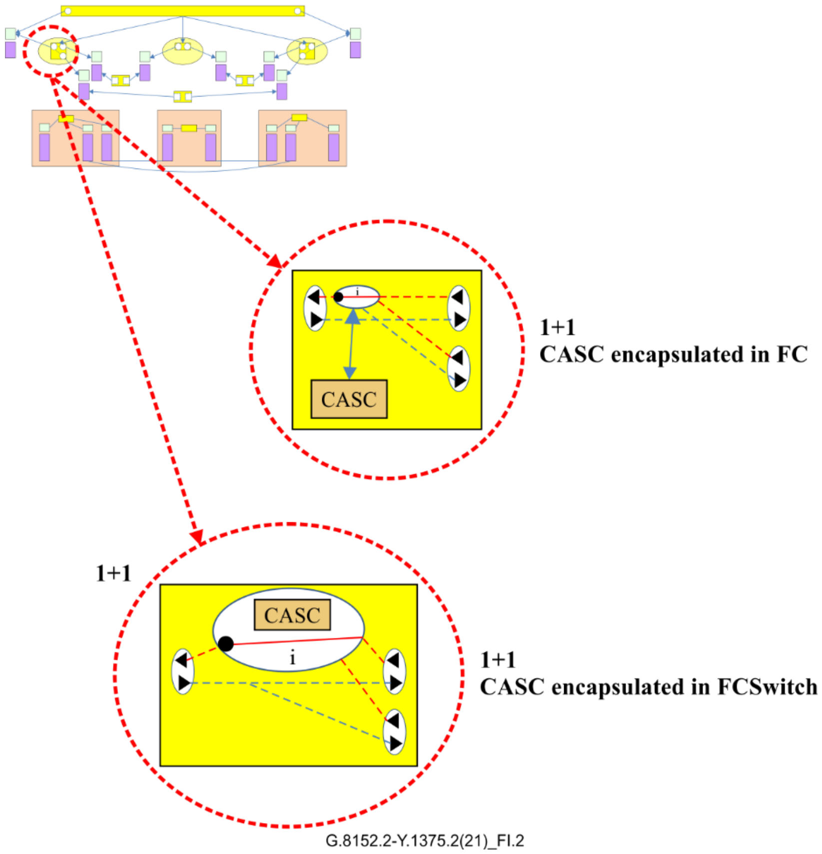

Figure I.2 – Detail of a nodal view of 1+1 switches

Figure I.3 shows a nodal view of 1:1 switches. It describes the ConfigurationAndSwitchControllers (CASC) encapsulated in the FC (upper part) and ConfigurationAndSwitchControllers encapsulated in the FcSwitch (lower part).

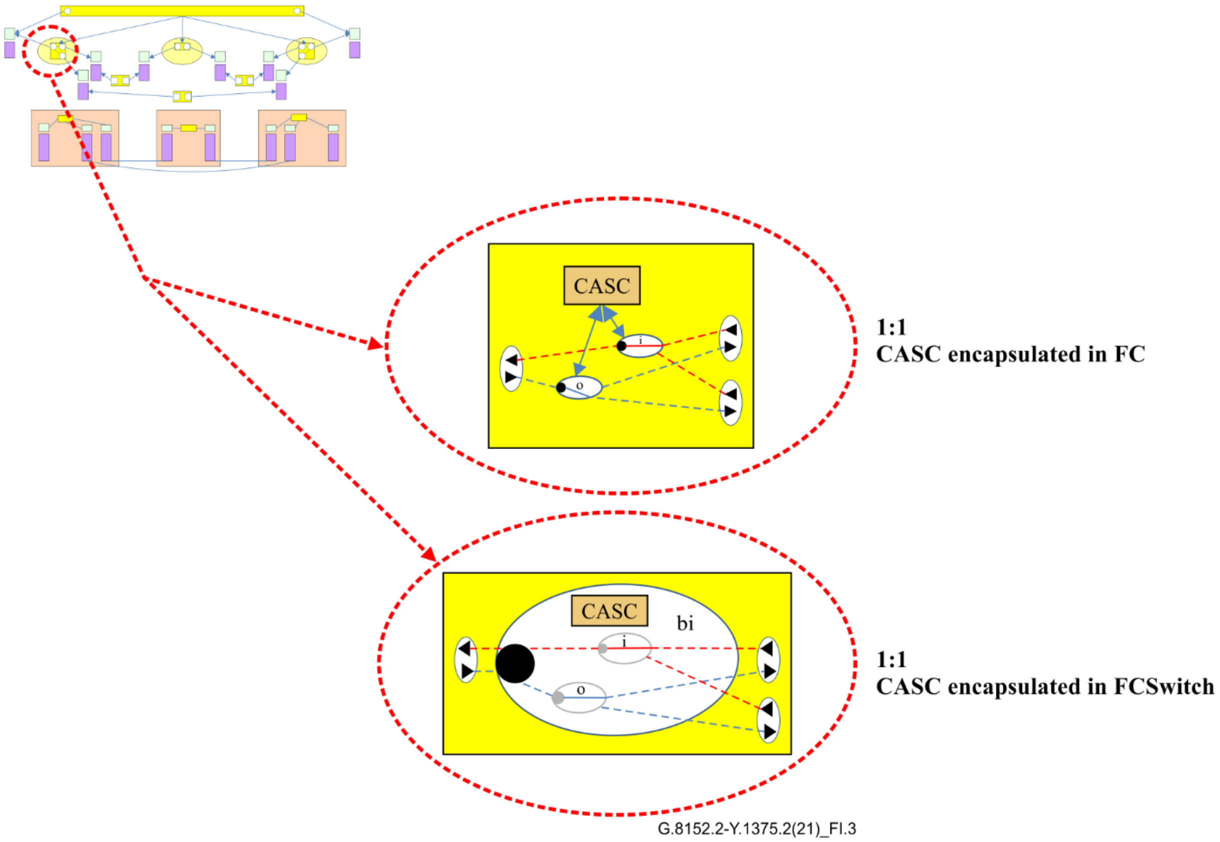

Figure I.3 – Detail of a nodal view of 1:1 switches

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

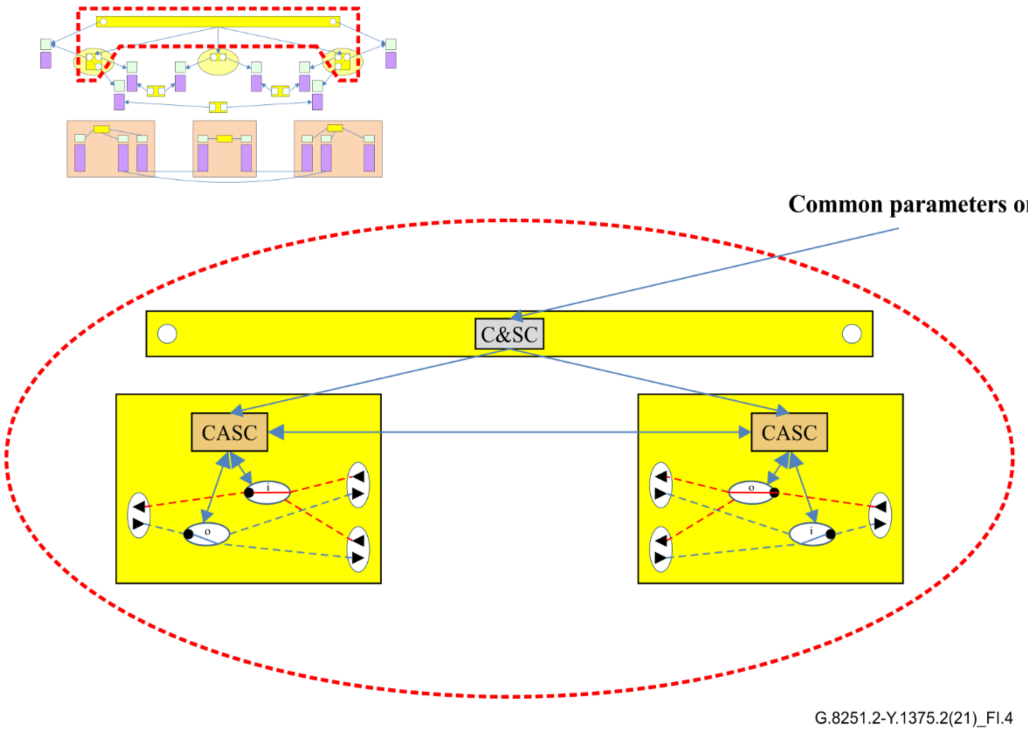

Figure I.4 – Showing a high-level abstract controller in a 1:1 case

Bibliography

[b-IETF-mpls-base] MPLS Working Group, Internet draft, version 17 (October 2020), *A YANG data model for MPLS base: draft-ietf-mpls-base-yang-17* (work in progress). Available [viewed 2021-04-16] at: https://tools.ietf.org/html/draft-ietf-mpls-base-yang-17

[b-IETF-mpls-static] MPLS Working Group, Internet draft, version 12 (April 2020), *A YANG data model for MPLS static LSPs: draft-ietf-mpls-static-yang-11* (work in progress). Available [viewed 2021-04-16] at: https://tools.ietf.org/html/draft-ietf-mpls-static-yang-11

[b-ONF TR-531] Technical Recommendation ONF TR-531 v1.1-info (2018), *UML to YANG mapping guidelines.* Available [viewed 2021-04-16] at: https://onfstaging1.opennetworking.org/wp-content/uploads/2018/08/TR-531_UML-YANG_Mapping_Gdls_v1.1-1-1.pdf .

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Printed in Switzerland
Geneva, 2021