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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", v0.04.

**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<br>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:<br>(1) Add description for figure 7.1.1-2 based on C1441 clause 2.1.<br>(2) Add an appendix I.1 to describe 1+1/1:1 linear protection examples based on C1441 clause 2.2.<br>(3) Split clause 7.1 into two sub clauses, 7.1.1 for linear protection, 7.1.2 for shared ring protection<br>(4) Add object classes and relations for shared ring protection in 7.1.2 based on C1304 clause 2.1.<br>(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<br>TD487/WP3 (1/2020) | Updates:<br>(1) Add appendix I.2.2 to describe the short-wrapping and appendix I.2.3 to describe the steering based on wd14-29.<br>(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.<br>(3) Add some description to Figure 7.1.2-1 according to the discussion. |
| 0.05 | WD14-22 (2/2020)<br>TD487R1/WP3 (2/2020) | Updates:<br>(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<br>(2) Per C1885: Clause 7.1.1 "Linear protection" object classes & relations and clause 7.2.1 "Linear protection" attributes and operations.<br>(3) Per C1886: Clauses 3 and 4, with adjustment as noted in the discussion.<br>(4) Per C1893: Clause 7.1.2 "Shared ring protection" object classes & relations and clause 7.2.2 "Shared ring protection" attributes and operations. |

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# Recommendation ITU-T G.8152.2

## Resilience Information/Data Models for MPLS-TP Network Element

**Summary**

This Recommendation specifies the operation, resilience management information model and data models for MPLS-TP Network Element (NE) as defined in[ITU-T G.8131,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 G.7711/Y.1702 core information model and Recommendation 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 will specify 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 will be interface protocol neutral and will be derived through pruning and refactoring from the G.7711 core information model and G.8152 foundation MPLS-TP NE information model. The data models will be interface protocol specific and will be 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 such as G.8131 – MPLS-TP Linear protection switching and G.8132 – MPLS-TP Shared Ring protection switching.

The eventual YANG modules of this Recommendation are aimed to be compatible with and when necessary extend the relevant base generic YANG modules from the IETF for resilience functionality such as G.8131 and G.8132.

## 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.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.8151] Recommendation ITU-T G.8151/Y.1374 (10/2018), *Management aspects of the MPLS-TP network element*.

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

## 3 Definitions

### 3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

~~<Editor Note: Details are to be provided. >~~

**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.880]**

**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

~~This Recommendation defines the following terms:~~

~~**3.2.1 <Term 1>: <definition>.**~~

~~<Editor Note: Details are to be provided. >~~

~~**3.2.2 <Term 2>: <definition>.**~~

~~<Editor Note: Details are to be provided. >~~

None.

## 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

~~<Editor Note: Details are to be provided. >~~

MPLS Multi-Protocol Label Switching

MPLS-TP Multi-Protocol Label Switching-Transport profile

MSRP MPLS-TP Shared Ring Protection

MT MPLS-TP

SF Signal Fail

SD Signal Degraded

Sk Sink

So Source

TT Trail Termination

CTP Connection Termination Point

EXER Exercise

FS Forced Switch

MS Manual Switch

SNC Subnetwork Connection

SNCP Subnetwork Connection Protection

SNC/S SNCP with Sublayer monitoring

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

~~The~~ MPLS-TP linear protection function is defined in [ITU-T G.8131]. For protection type characteristic, it is proposed to include 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 |
| Pseudowire Redundancy | IETF RFC6718 |

### 6.2 Ring Protection Functions

**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. This information model is derived through pruning and refactoring the Recommendation G.7711/Y.1702 core information model and Recommendation G.8152/Y.1375 (12/2016), Protocol-neutral management information model for the MPLS-TP network element.

### 7.1 Required Object Classes and relations

<Editor Note: : (1) This is just a sample. Details are to be providedFor linear protection, it also need to consider the trail protection. (2) Give some describtion for Figure 7-2 the simplified resilience model; and give some usecase for CascEncapsulatesCase>

#### 7.1.1 Linear protection

In G.8131 clause 6.1, it gives some 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, bidirectional 1:1 SNC/S protection switching. These three architectures all including the same objects, so we choose the Unidirectional 1+1 SNC/S protection switching to describe the MPLS-TP linear protection object classes. Annex E of G.7711 has the generic resilience model applicable for the linear protection switching schemes. The following Figure 7-1 shows the mapping between G.8131 and G.7711 for the MPLS-TP linear protection.

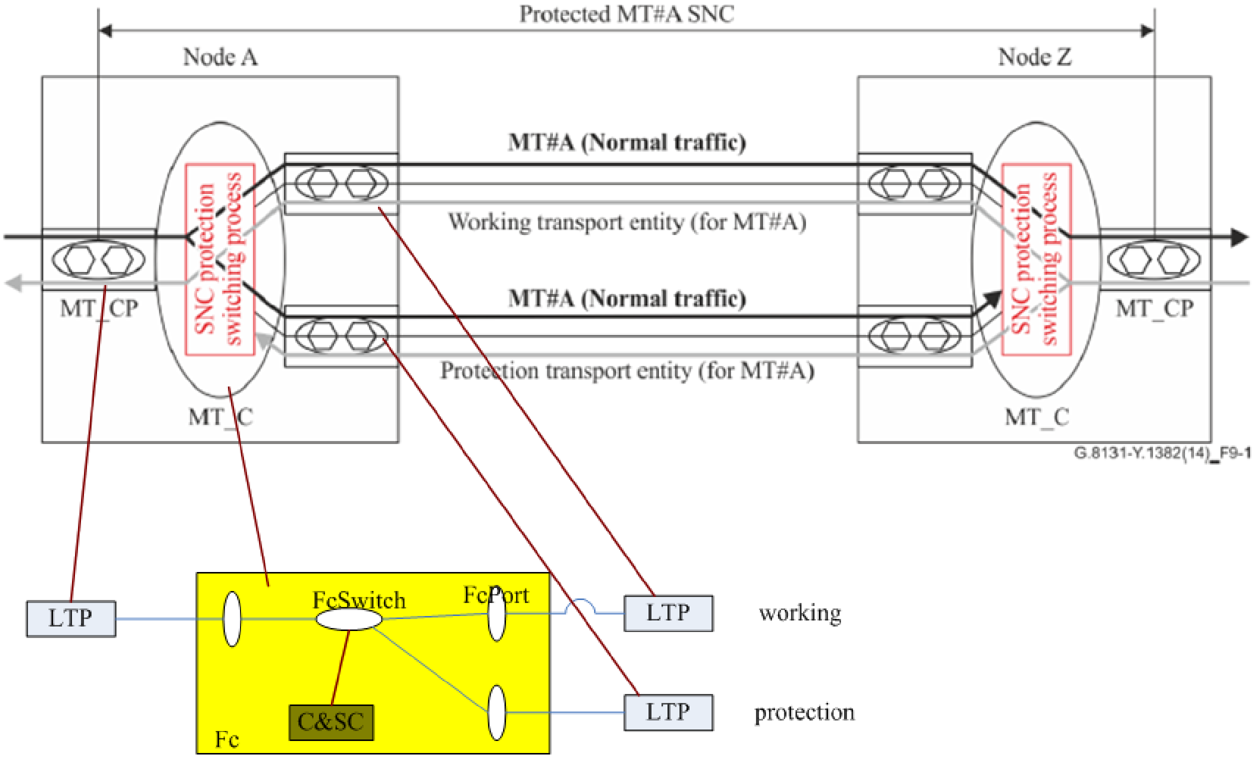



Figure 7.1.1-1 mapping between G.8131 and G.7711 for MPLS-TP linear protection model

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 |

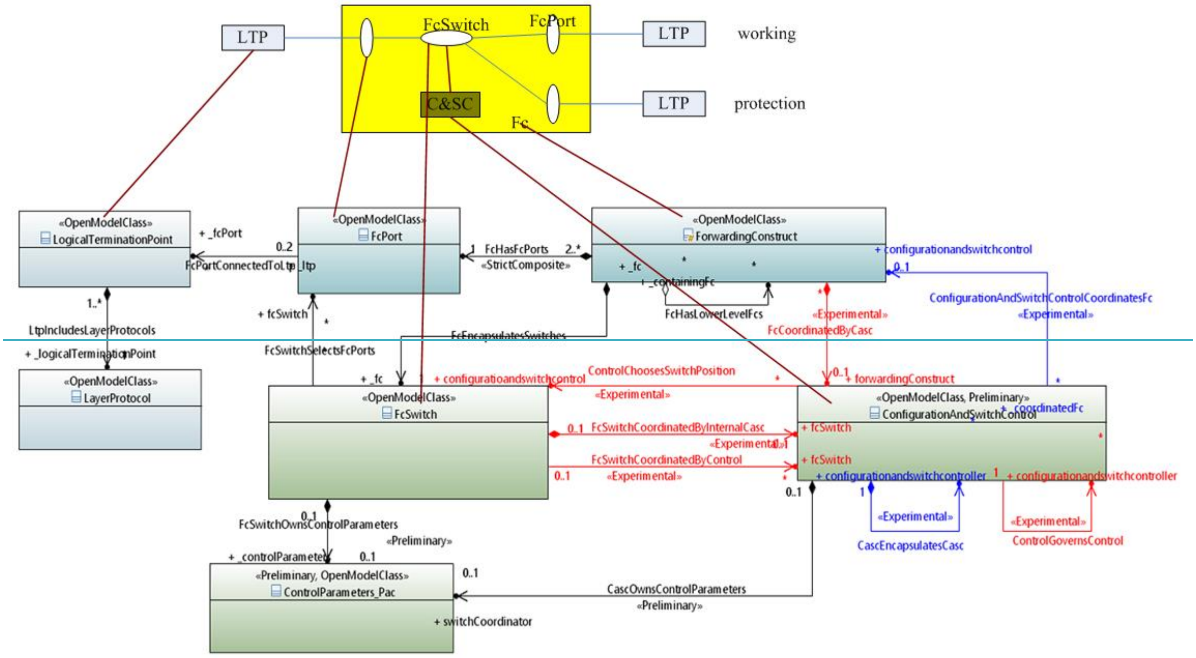
Figure E.1-1 of G.7711 shows the basic resilience pattern, the simplified resilience model for MPLS-TP linear protection can be expressed as the Figure 7.1.1-2.

Classes FcSwitch, ConfigurationAndSwitchControl (CASC), ControlParameters_Pac are present 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 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. [1]

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 CASC independence: 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.



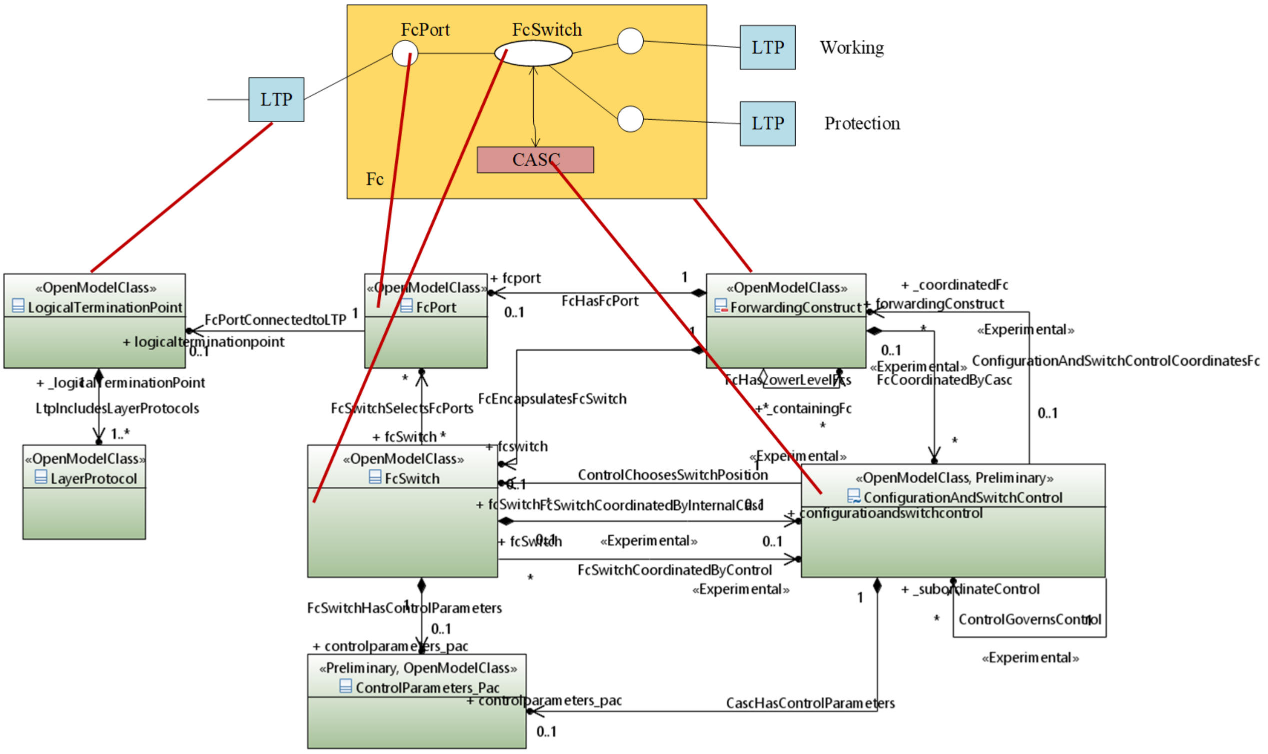



Figure 7.1.1-2 resilience model for MPLS-TP Linear protection

Following text will give the model for MPLS-TP linear protection spec model.

Figure 7.1.1-3 shows the LTP (Logical Termination Point) spec model. Two spec object classes named MtLinearProtectionTtpSoSpec and MtLinearProtectionTtpSiSpec are associated with LTP. The attributes of these two Spec classes are imported from G.8152.

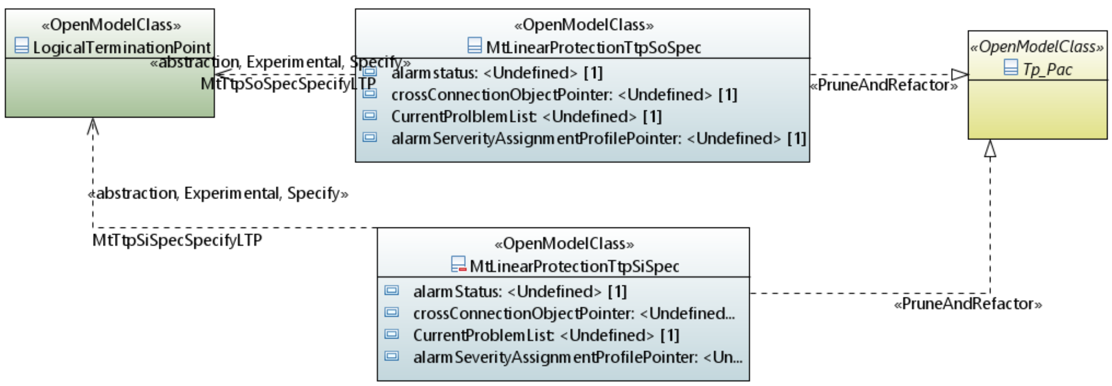



**Figure 7.1.1-3 Linear protection LTP Spec model**

Figure 7.1.1-4 shows the MPLS-TP linear Protection model. There are two spec object class named Mt_LinearProtectionSwitchSpec and Mt_LinearProtectionCascSpec. Mt_LinearProtectionSwitchSpec is used to specify the core model FcSwitch. The attributes of it are imported from G.8152. And Mt_LinearProtectionCascSpec is used to specify the core model CASC. The operations of it are imported from G.8152 too.

PortRoletypeSpec is a datatype, it is used to specify the datatype of PortRole, PortRole is an attribute of FcPort.

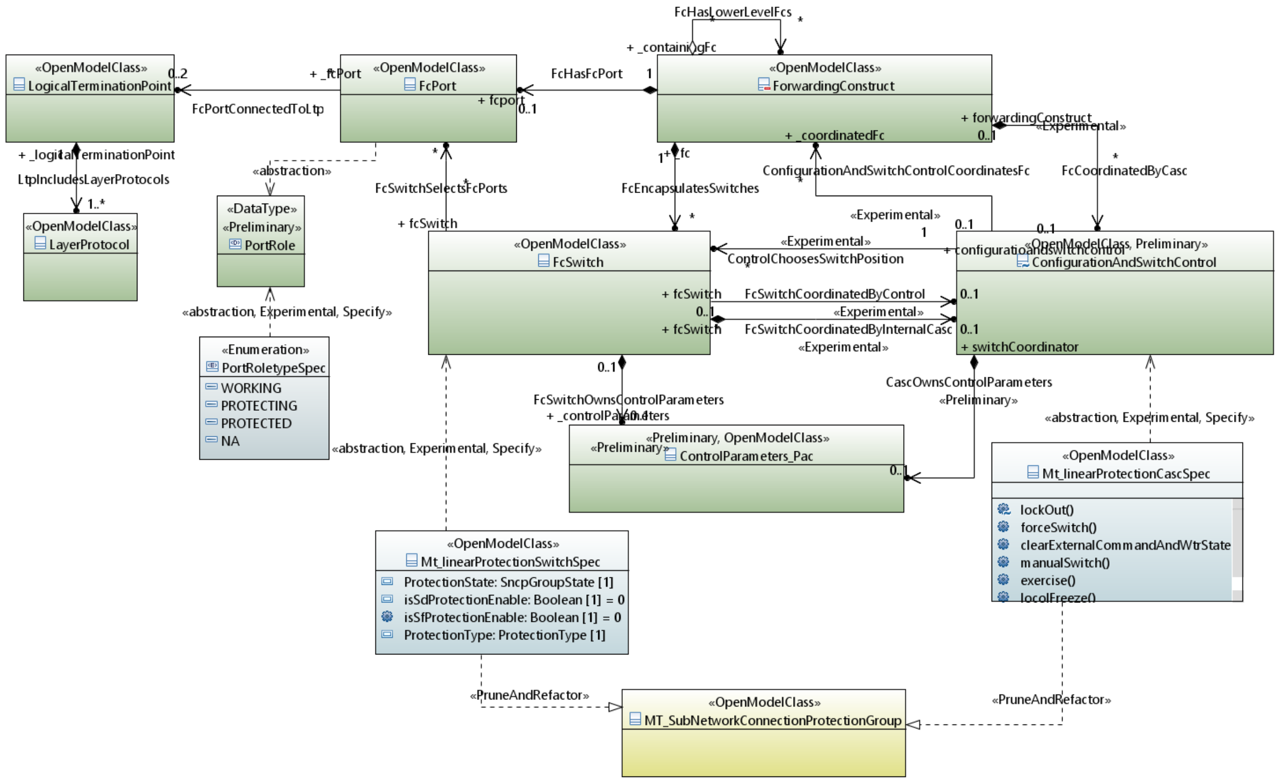



Figure 7.1.1-4 MPLS-TP linear protection spec model

### 7.1.2 Shared ring protection

<Editor Note: : need to update the second column of table 7.1.2-1 (G.8152) , after G.8152 defines the MSRP model. >

In G.8132 Figure 8-1, it gives a function model of MSRP (see the upper part of Figure 7.1.2-1). And in G.7711 annex E, it has the generic resilience model. The following Figure 7.1.2-1 shows the mapping between G.8132 Figure 8-1 and G.7711 for the MPLS-TP shared ring protection.

Note that Figure 8-1 in G.8132 is the same as Figure 9-11 (which shows the atomic functions for MSRP_C) in G.8121.

An MSRP ring tunnel is modelled as a server sub-layer for the MPLS-TP LSP sub-layer. Figure 8-1 in 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.

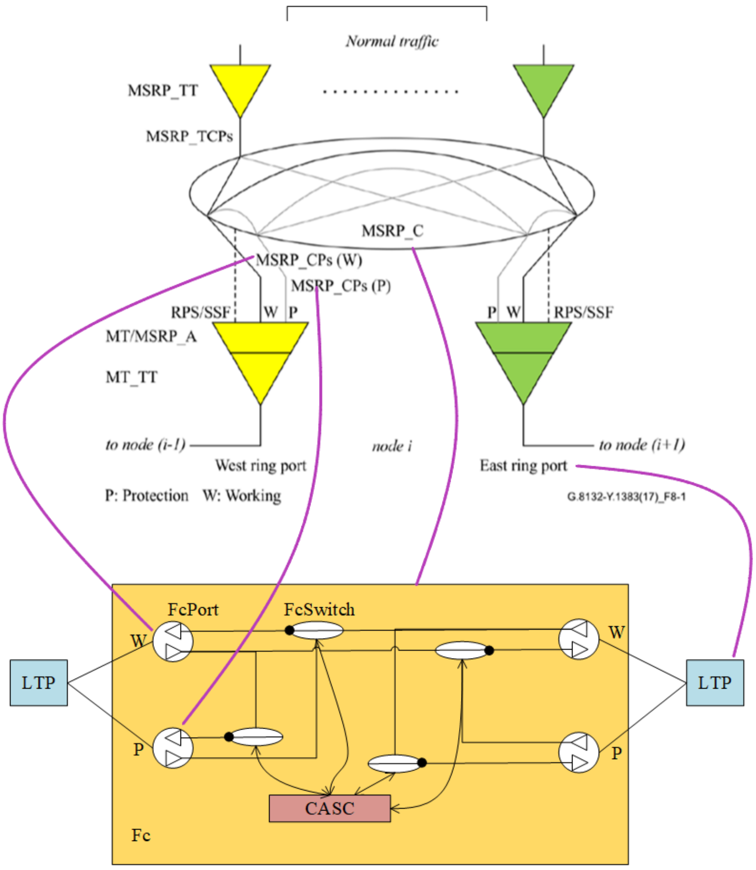



Figure 7.1.2-1 mapping between G.8132 Figure 8-1 and G.7711 for MSRP

Table 7.1.2-1 mapping between **G.8132, G.8152 and G.7711** for MSRP

| **G.8132** | **G.8152** | **G.7711** |
|---|---|---|
| MSRP switching process | Not defined yet, need for further study | FcSwitch+CASC+ Spec |
| MSRP_C | Not defined yet, need for further study | FC+ Spec |
| MSRP_CP | Not defined yet, need for further study | FcPort +Spec |
| West ring port/East ring port | MT_TrailTerminationPoint | LTP +Spec |

Figure E.1-1 of G.7711 shows the basic resilience pattern, the simplified resilience model for MSRP can be expressed as the Figure 7.1.2-2.

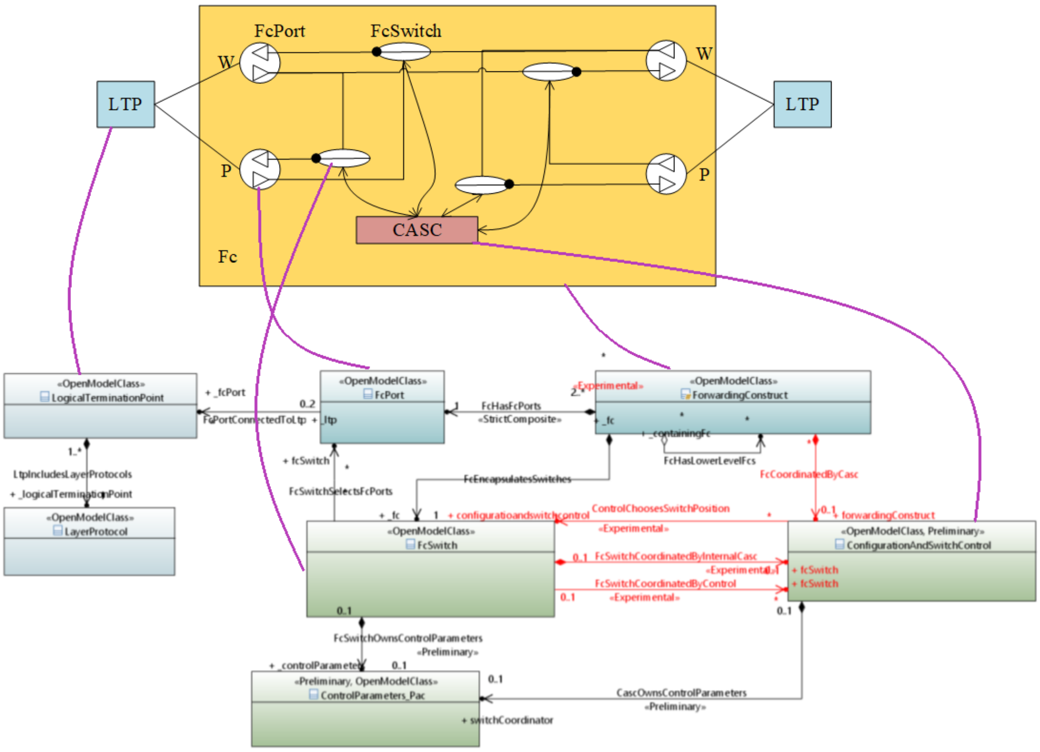



Figure 7.1.2-2 resilience model for MSRP

The FcSwitch class models the switched forwarding of traffic (traffic flow) between FcPorts and is present where there is protection functionality in the FC. 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.

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 CASC independence: CASC encapsulated in an FcSwitch, CASC encapsulated in an FC and CASC encapsulated in a CASC. In clause 2.1 will give some use cases for this.

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

Following text will give the spec models for MSRP.

Figure 7.1.2-3 shows the LTP (Logical Termination Point) spec model. One spec object class named MtRpsCtpSec is associated with LTP. The attributes of this Spec class are imported from G.8152.

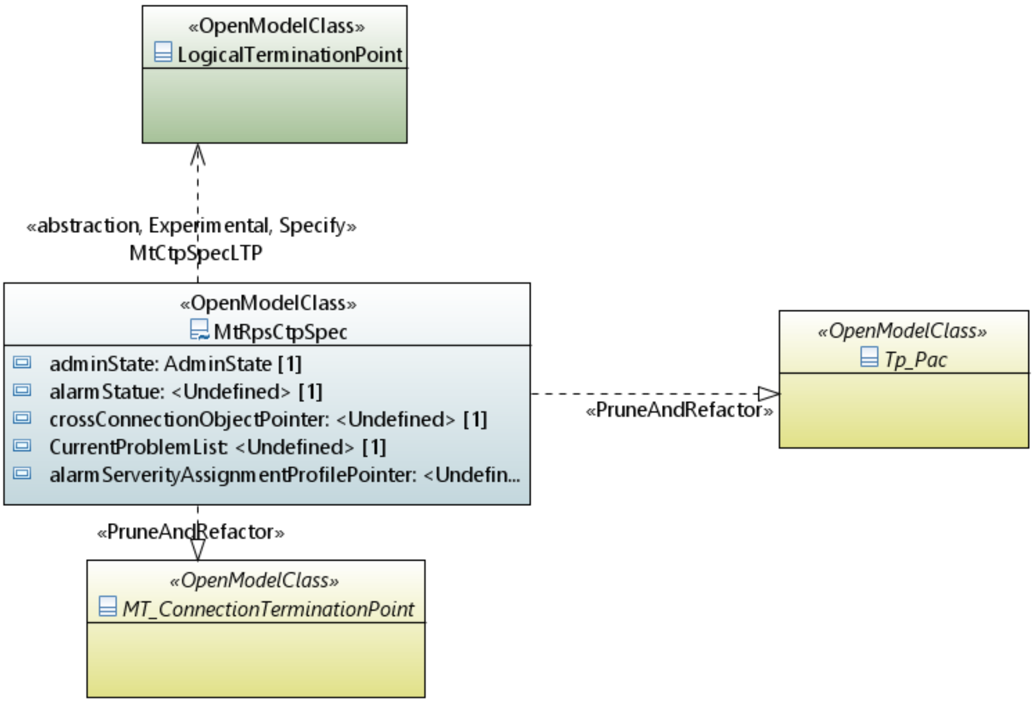



**Figure 7.1.2-3 MSRP LTP Spec model**

Figure 7.1.2-4 shows the MSRP spec model. There are two spec object class named Mt_SRPswitchSpec and Mt_SRPCascSpec. Mt_SRPswitchSpec is used to specify the core model FcSwitch. The attributes of it are all from G.8132 (because G.8152 doesn't have the MSRP model). And Mt_SRPCascSpec is used to specify the core model CASC. The operations of it are also from G.8132 too.

PortRoletypeSpec is a datatype, it is used to specify the datatype of PortRole, PortRole is the howsattribute of FcPort.

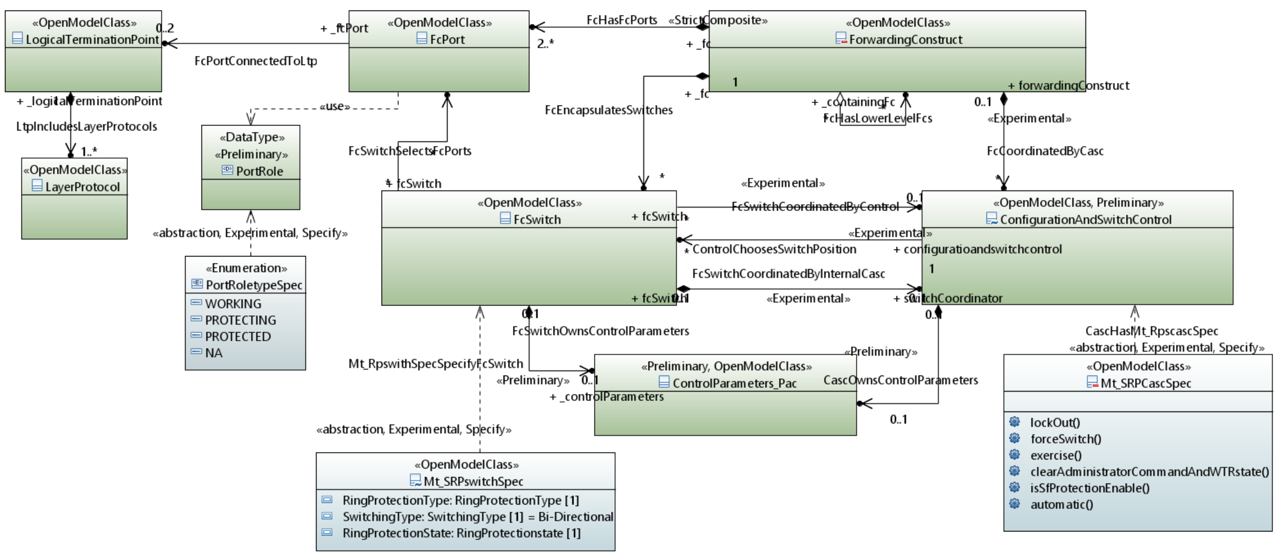



**Figure 7.1.2-4 MSRP spec model**

Figure 7.1.2-5 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.

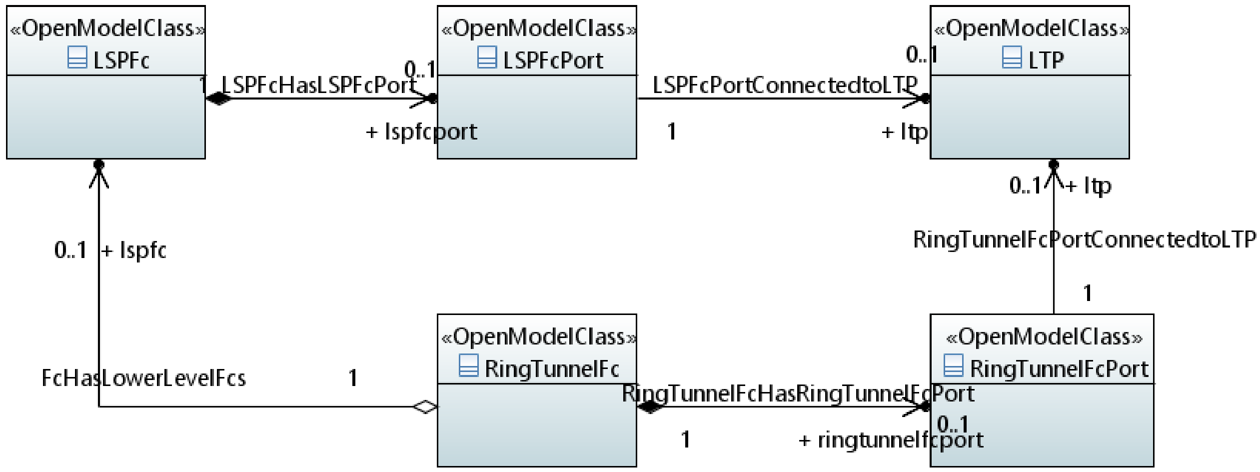



**Figure 7.1.2-5 Fc instance**

Annex A describe the principles of the 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

This clause shows how the required object classes are pruned/refactored and augment to the MPLS-TP protection UML.

#### 7.2.1 Linear protection

This clause shows how the required object classes are pruned/refactored and augment to the G.7711 MPLS-TP Protection UML.

~~<Editor Note: : This is just a sample. Details are to be provided.>~~

In G.8152, the MPLS-TP linear protection is modelled by the MT_SNCP_Group object class. The following tables will verify the compatibility in attributes and operations level between G.8152 and 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.<br>Since this attribute indicates the protection type of the SNCP Group. | ControlParameters_Pac::prottype.<br>As CIM doesn't describe the data type values for prottype, the values are specified from G8152 ProtectionType. |
| 2. | MT_SubNetworkConnectionProtectionGroup::holdOffTime | This attribute already exists in the ControlParameters_Pac. | ControlParameters_Pac::holdOffTime |

| | | | |
|---|---|---|---|
| 3. | MT_SubNetworkConnectionProtectionGroup::sncpGroupState | It could be modelled as ~~ControlParameters_Pac~~ FcSwitch specified attribute ProtectionState. Since this attribute indicates the protection state of the SNCP Group. | FcSwitch specified attribute ProtectionState, which is specified from G.8152 sncpGroupState |
| 4. | MT_SubNetworkConnectionProtectionGroup::isSdProtectionEnabled | It could be modelled as ~~ControlParameters_Pac specified attribute.~~FcSwitch specified attribute isSdProtectionEnabled. | FcSwitch specified attribute isSdProtectionEnabled, this attribute is specified from G.8152 |

**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. ~~May need to add "lockout" to FcSwitch::Switchcontrol.~~ So it may use CASC specified operations to describe.<br><br>**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. | CASC specified operations:: lockout() |
| 2. | MT_SubNetworkConnectionProtectionGroup::forceSwitch() | ~~It could be considered by setting FcSwitch::_SelectedFcPort to the designated switching port. And FcSwitch::Switchcontrol may need to add a value of "forced switch".~~ It could be considered by setting FcSwitch as forceSwitch. CASC is the control component for FcSwitch. So it may use CASC | CASC specified operations::forceSwitch() |

| | | | |
|---|---|---|---|
| | | specified operations to describe. | |
| 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. ~~Considering add an attribute WaitToRestoreTime to the ControlParameters_Pac.~~ ControlParameters_Pac already has WaitToRestoreTime attributes | CASC specified operations::clearExternalCommandAndWTRstate() |
| 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.<br><br>~~And FcSwitch::Switchcontrol may need to add a value of "manual switch".~~ Switchcontrol already has the value MANUAL | CASC specified operations::manualSwitch() |
| 5. | MT_SubNetworkConnectionProtectionGroup::exercise() | Need more discussion in G.7711 | CASC specified operations::exercise() |
| 6. | MT_SubNetworkConnectionProtectionGroup::localFreeze() | It could be considered by setting ConfigurationAndSwitchControl::isFroze as true. | CASC specified operations::localFreeze() |
| 7. | MT_SubNetworkConnectionProtectionGroup::clearLocalFreeze() | It could be considered by setting ConfigurationAndSwitchControl::isFroze as false. | CASC specified operations::clearLocalFreeze() |

In G.8152, it only describes these and operations in table 7-2 and table 7-3. But according to G.8131, it may also include the following attributes. See table 7-4.

**Table 7.2.1-3 Linear protection attributes verification -suggest to add in G.8152**

| | Attributes in G.8152 --suggest to add | Corresponding attributes in G.7711 | Attributes for G.8152.2 |
|---|---|---|---|
| 1 | MT_SubNetworkConnectionProtectionGroup::_workingTP | 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 |
| 2 | MT_SubNetworkConnectionProtectionGroup::_protectingTP | 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 |
| 3 | MT_SubNetworkConnectionProtectionGroup::_protectedTP | 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 |
| 4 | MT_SubNetworkConnectionProtectionGroup::_reversionMode | This attribute already exists in the ControlParameters_Pac. | ControlParameters_Pac::reversionMode |

### 7.2.2 shared ring protection

<Editor Note: Details are to be provided. >

This clause shows how the required object classes are pruned/refactored and augment to the G.7711 MPLS-TP Protection UML.

In G.8152, there is no object class for MSRP. The following tables will give the MSRP required object classes based on G.8132 and G.7711.   And according to the MSRP model in clause 7.1.2.

**Table 7.2.2-1 MSRP attributes mapping**

| | Attributes in G.8132 | Corresponding attributes in G.7711 | Attributes for G.8152.2 |
|---|---|---|---|
| 5. | Three types of ring protection mechanisms are specified: | This attribute already exists in the | ControlParameters_Pac::prottype. |

| | | | |
|---|---|---|---|
| | wrapping, short wrapping and steering | ControlParameters_Pac::prottype. But the values of prottype are not defined. So it should specify the it's values. | As CIM doesn't describe the data type values for prottype, the values are specified from 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 G.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 attribute RingProtectionState. | FcSwitch::RingProtectionState, this attribute is specified from 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 G.8132 | Corresponding attributes in G.7711 | Operations for 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 | CASC specified operations::exercise() |

| | | | |
|---|---|---|---|
| | | operations to describe. | |
| 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

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

<Editor Note: Details are to be provided. >

## 8 MPLS-TP Resilience Data Models

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

<Editor Note: Details are to be provided. >

### 8.1 MPLS-TP Resilience YANG Data Model

This clause contains the YANG data model of the MPLS-TP Protection functions identified in Clause 6.

<Editor Note: Details are to be provided. >

### 8.2 others Data Models

Need to 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

## A.1 Shared ring Protection

### A.1.1 Shared ring Architecture overview

The MSRP architecture is specified in ITU-T Recommendation 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.1.1-1 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.

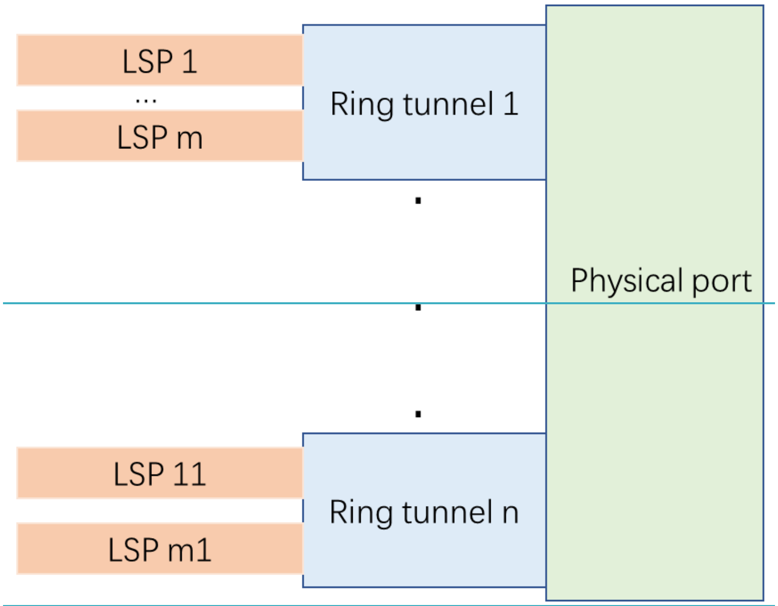



Figure A.1.1-1 The Logic Layers of The Ring

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.1.1-2, 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.1.1-2 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.1.1-2, 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

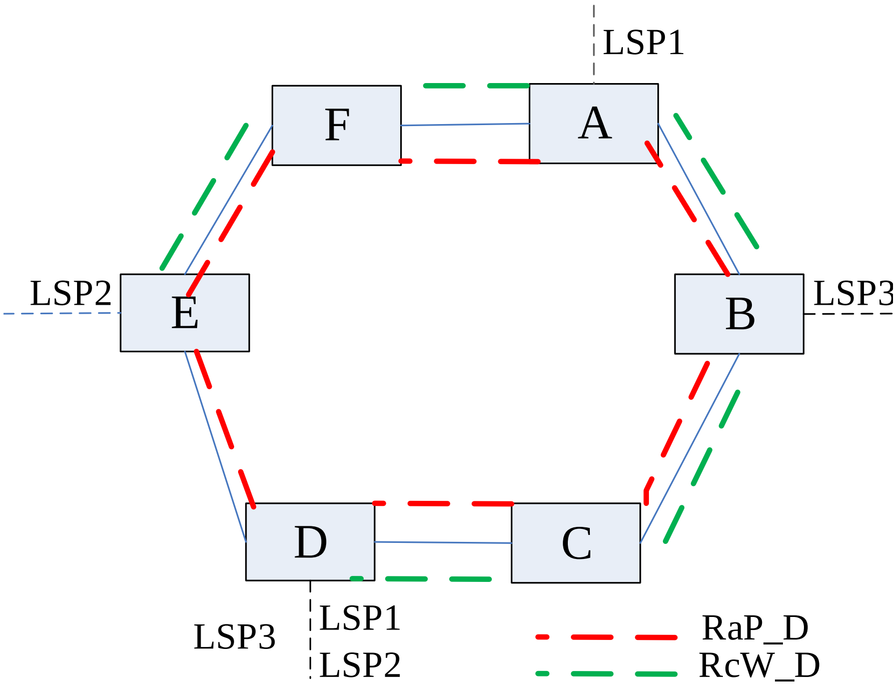



Figure A.1.1-2 Ring tunnels in MSRP

Following sections specifies the ring protection mechanisms in detail. Ingeneral, 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.1.2 wrapping

Figure A.1.2 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.

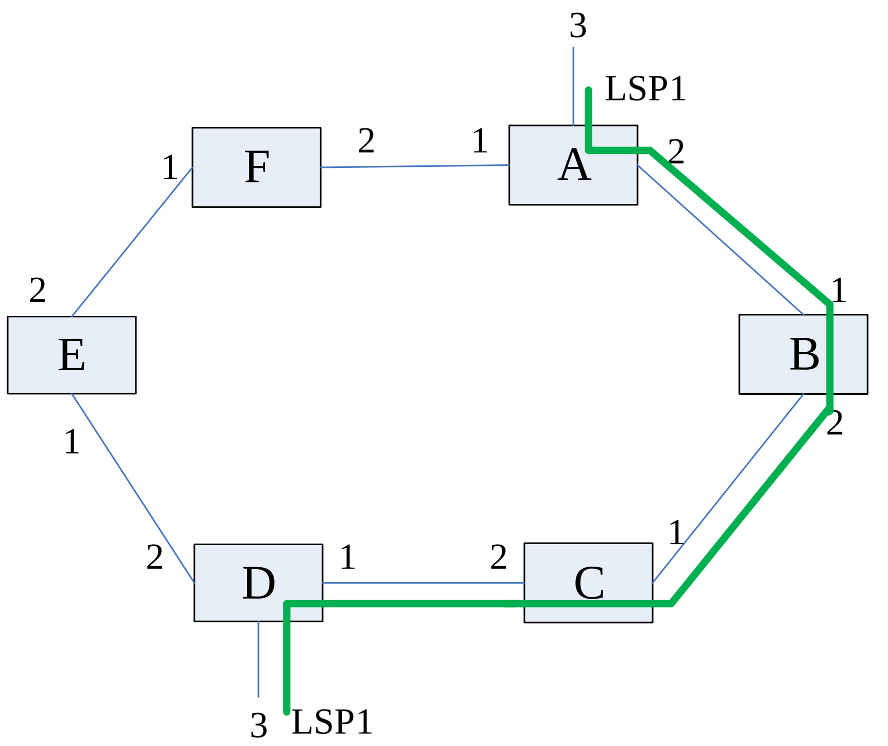



Figure A.1.2-1 basic network

When a link failure between node B and node C occurs, see the following Figure A.1.2-2. 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 ~~node C switches the anticlockwise protection ring tunnel back to the clockwise working ring tunnel~~. Then signal then will follow the path A-B-A-F-E-D-C-D.

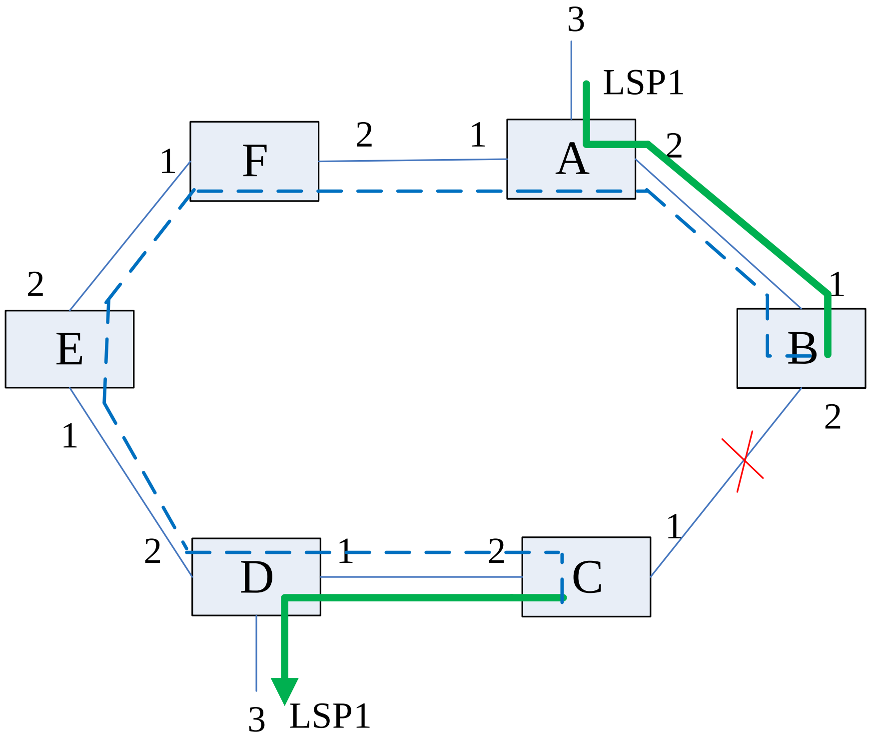



Figure A.1.2-2 Wrapping for link failure

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

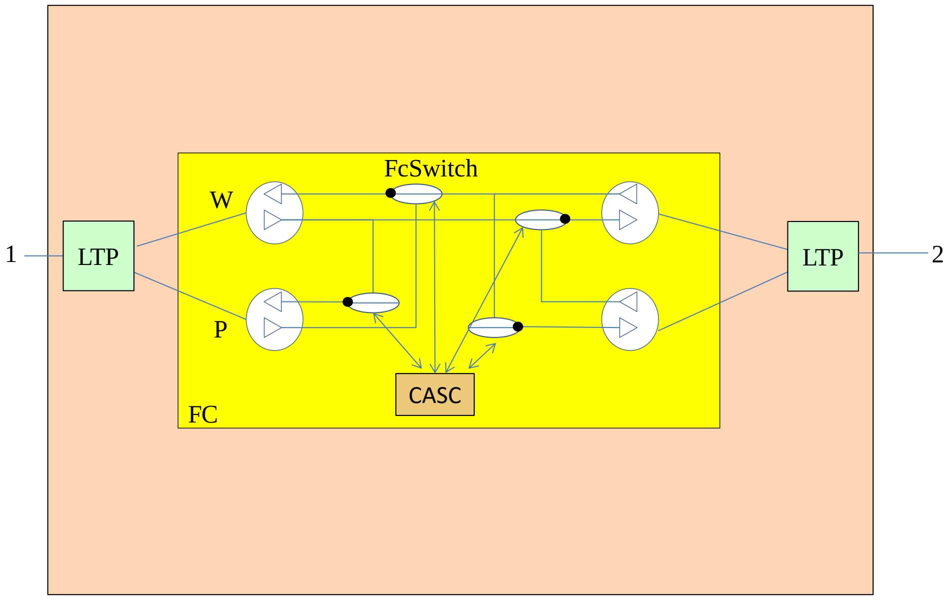



Figure A.1.2-3 Wrapping: node B and node C (no failure in ring)

Figure A.1.2-3 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 ~~path~~ ring tunnel.

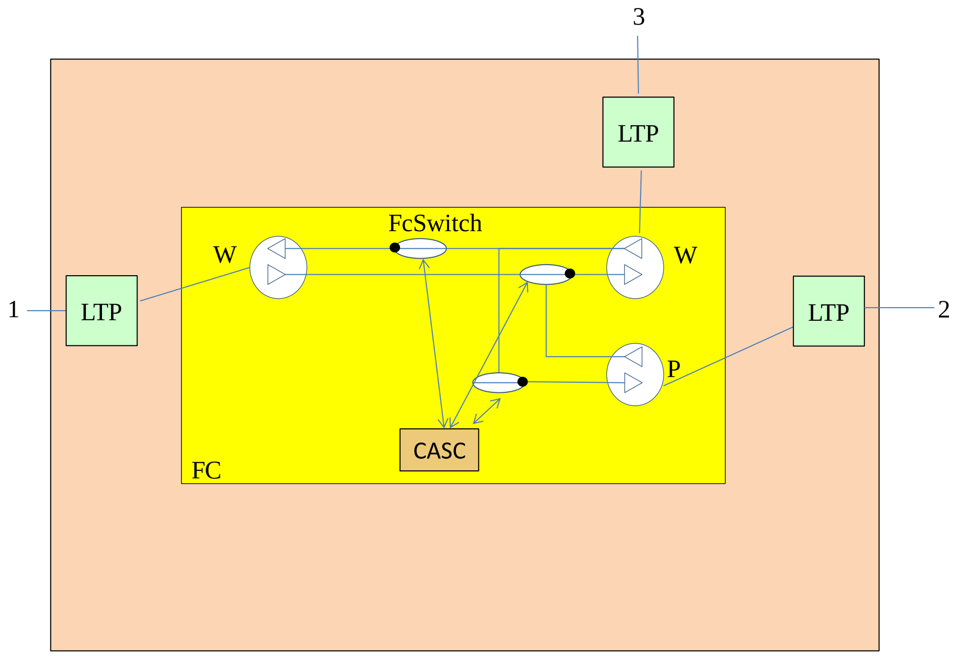



Figure A.1.2-4 Wrapping: node D (no failure in ring)

Figure A.1.2-4 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 ~~path~~ 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.

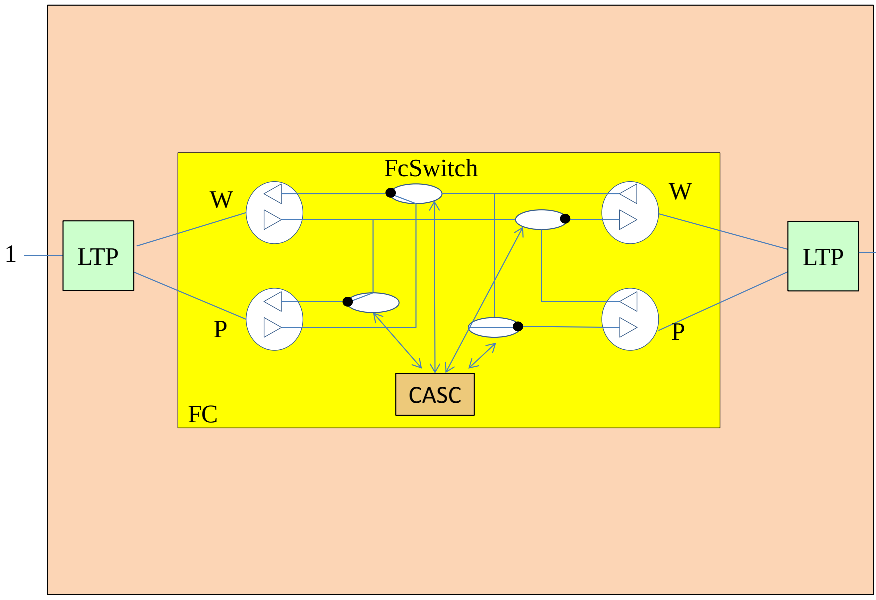



Figure A.1.2-5 Wrapping: node B with failure on link between node B and node C

Figure A.2.1-5 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 ~~path~~ ring tunnel. The FC allows signal to flow between the working and protection on port1, such that the signal is wrapped back to port1.

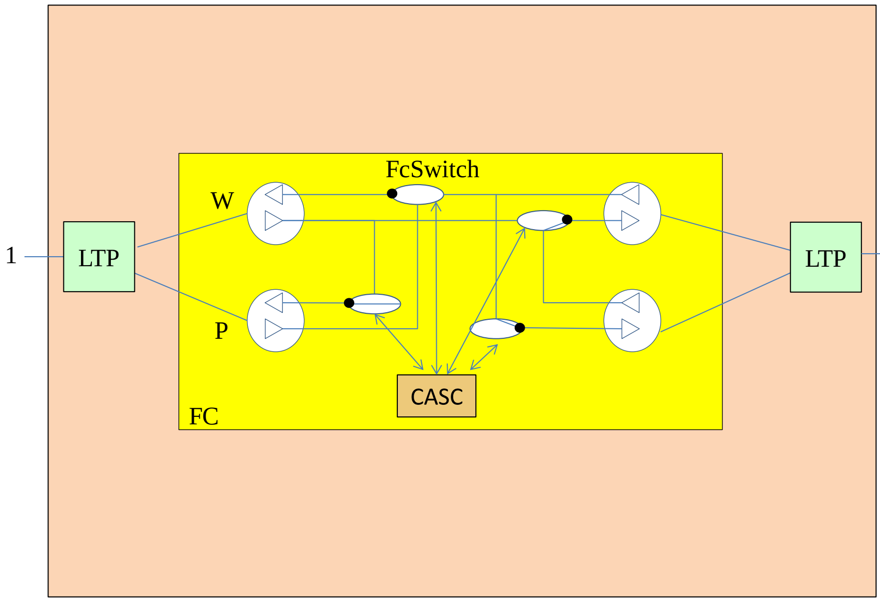



Figure A.1.2-6 Wrapping: node C with failure on link between node B and node C

Figure A.1.2-6 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.

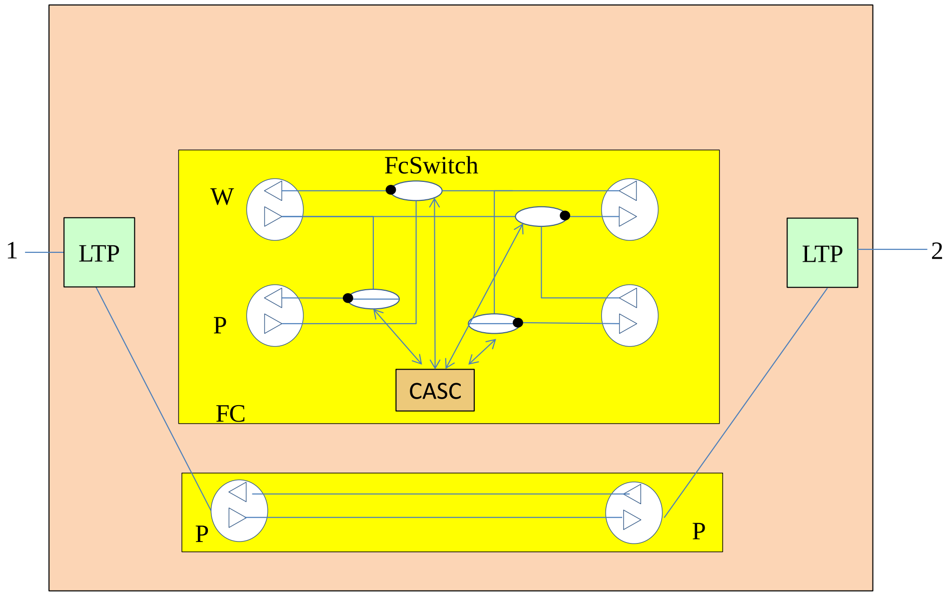



Figure A.1.2-7 Wrapping: node E and node F with failure on link between node B and node C

Figure A.1.2-7 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 ~~path~~ 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 ~~the signal~~ 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.1.3 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.1.3-1 shows a view of a basic network. This figure is the same to A.1.2-1. A signal is passing from port3 node A to port 3 node D. LSP1 is through the path A-B-C-D.

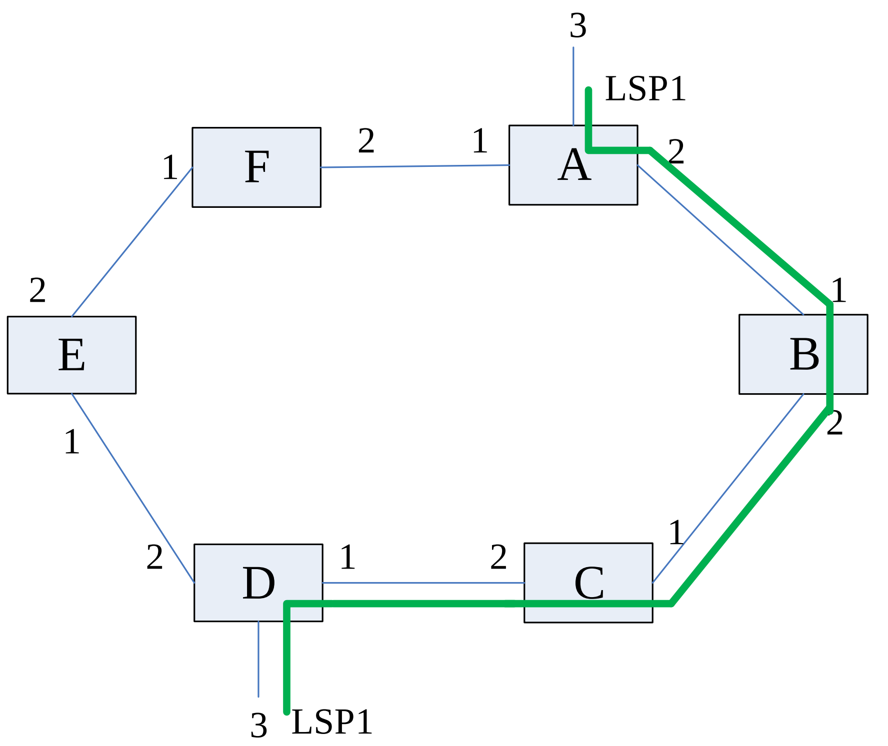



Figure A.1.3-1 basic network

When a link failure between node B and node C occurs, see the following Figure A.1.3-2. 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.

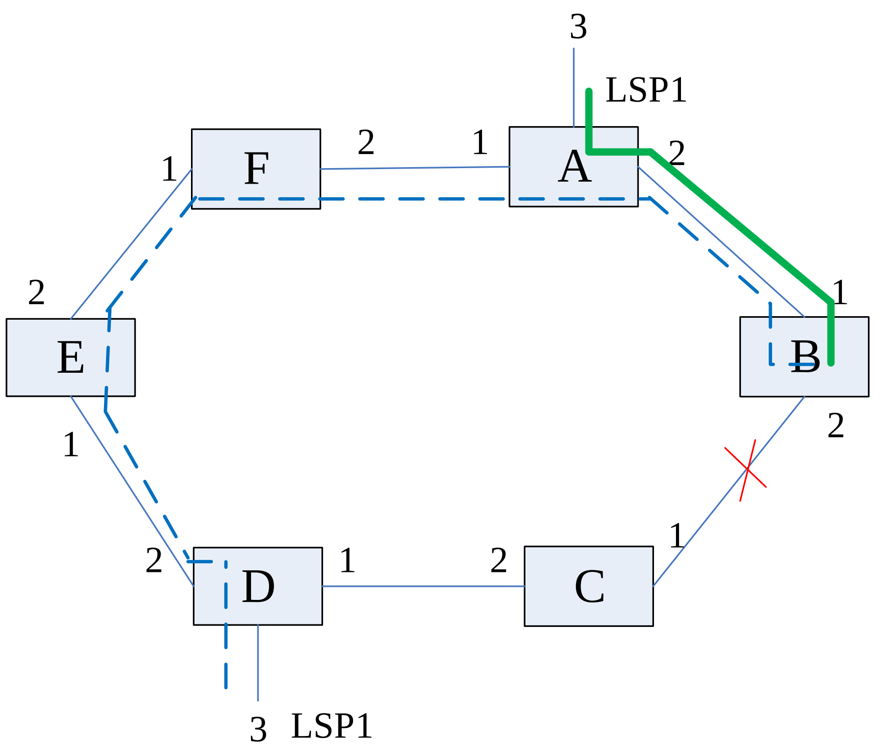



Figure A.1.3-2 short-wrapping for link failure

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 Figures A.1.2-3 and Figure A.1.2-4.

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

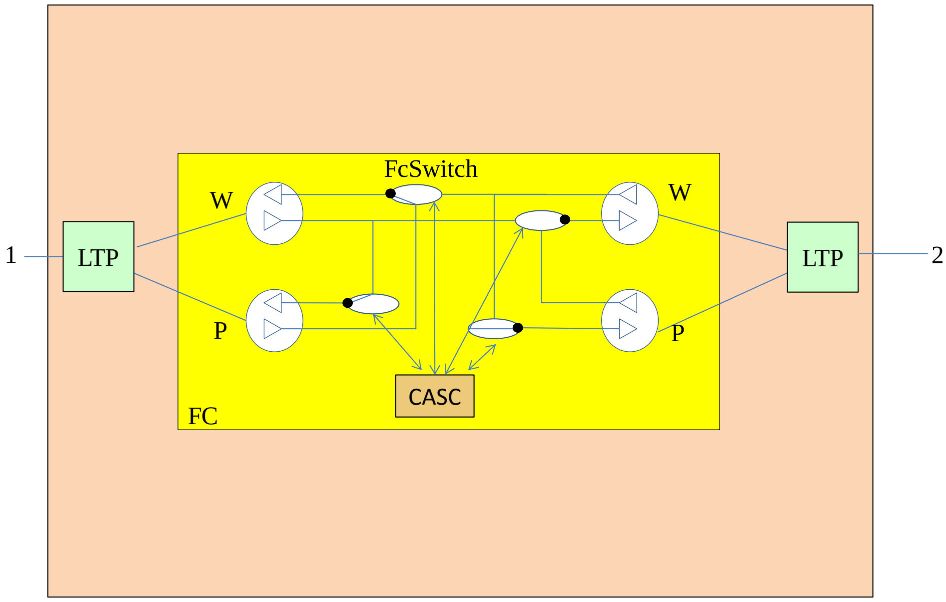



Figure A.1.3-3 Wrapping: node B with failure on link between node B and node C

Figure A.1.3-3 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.1.2-5 wrapping scheme.

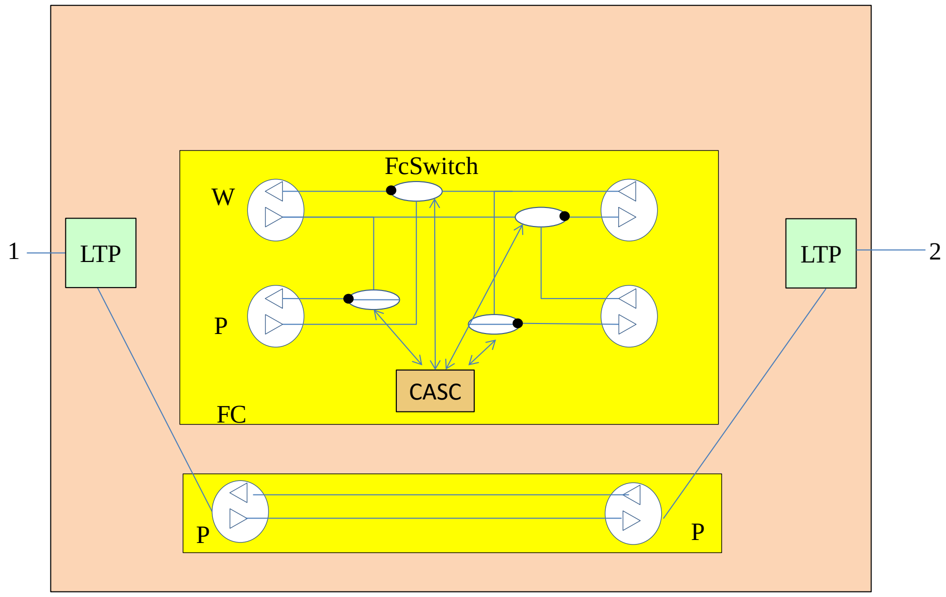



Figure A.1.3-4 short-wrapping: node E and node F with failure on link between node B and node C

Figure A.1.3-4 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.

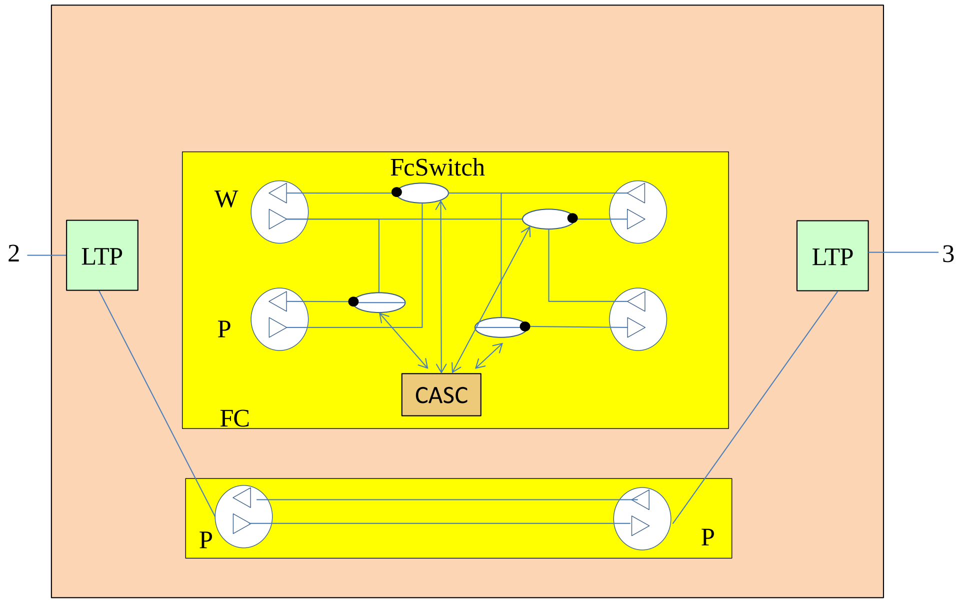



Figure A.1.3-5 short-wrapping: node D with failure on the link between node B and node C

Figure A.1.3-5 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.

### A.1.4 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.1.4-1 shows a view of the basic network. This figure is the same to A.1.2-1. A signal is passing from port3 node A to port 3 node D. LSP1 is through the path A-B-C-D.

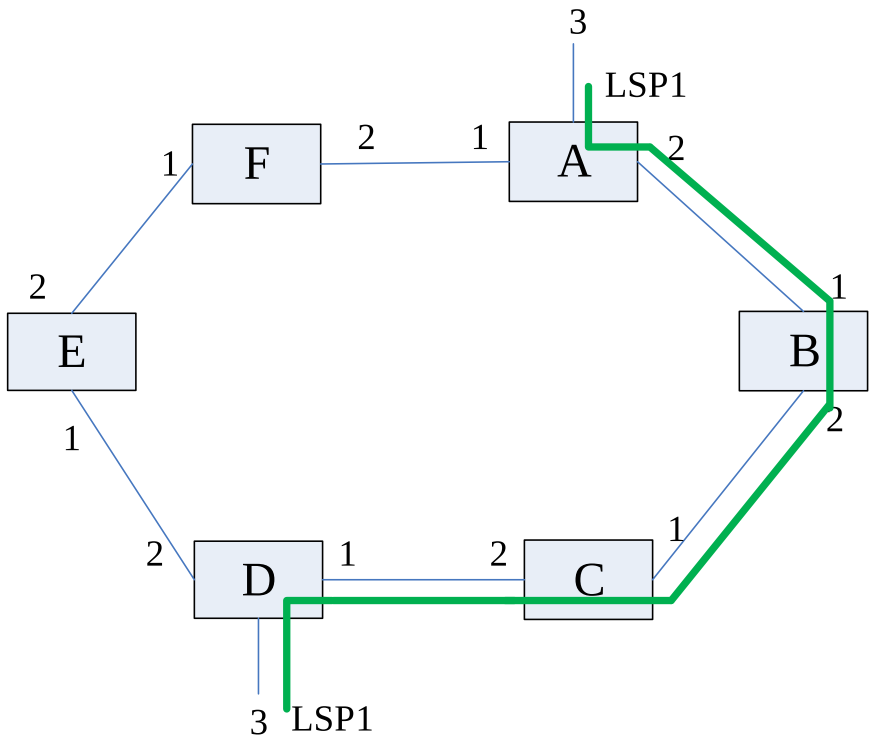



Figure A.1.4-1 basic network

When a link failure between node B and node C occurs, as shown in the following Figure A.1.4-2, 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.

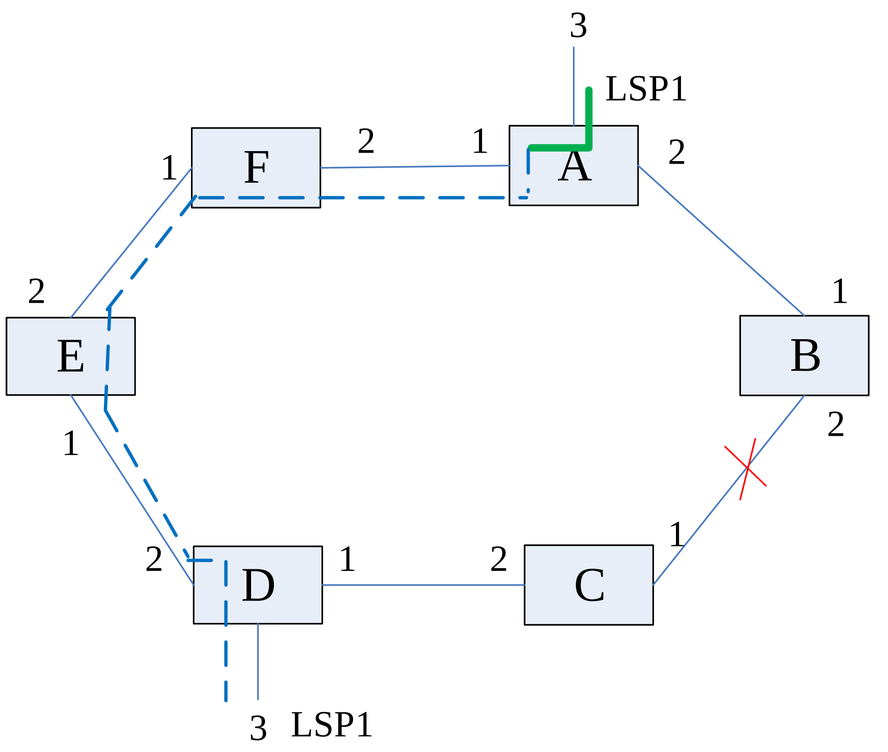



Figure A.1.4-2 Steering for link failure

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.1.2-3, Figure A.1.2-4.

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

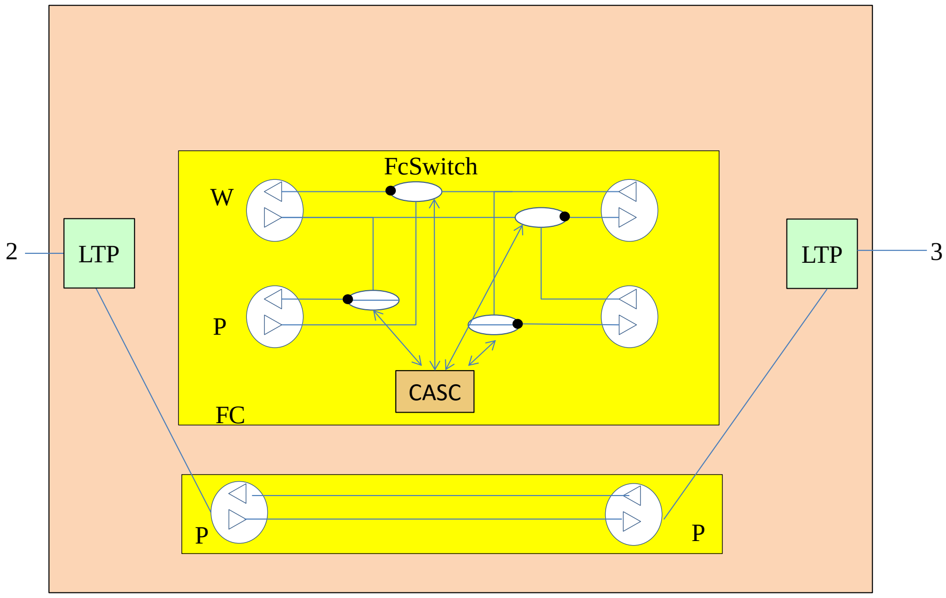



Figure A.1.4-3 Steering: node D with failure on link between node B and node C

Figure A.1.4-3 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.

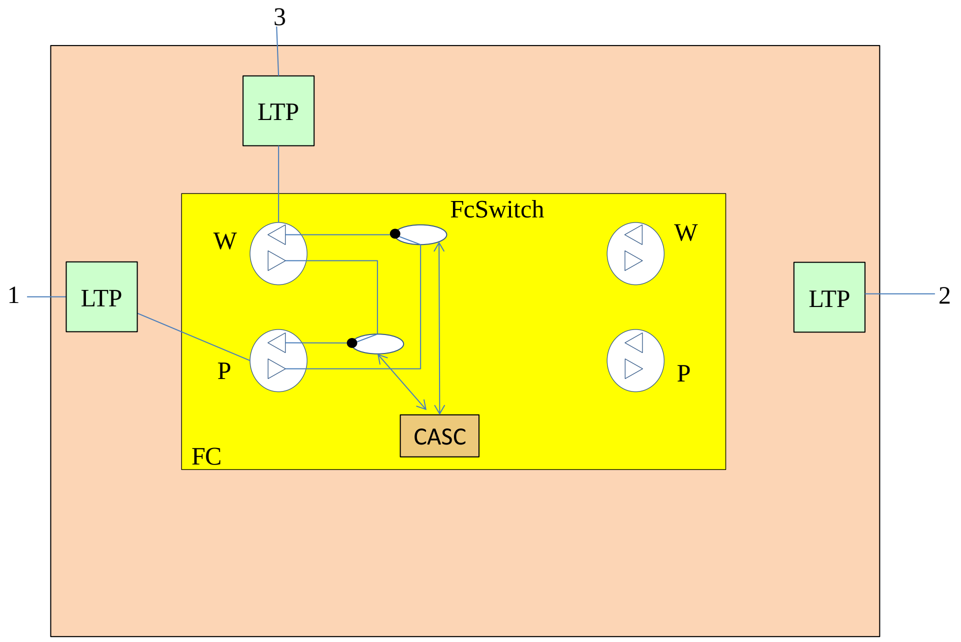



Figure A.1.4-4 Steering: node A with failure on link between node B and node C

Figure A.1.4-4 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.

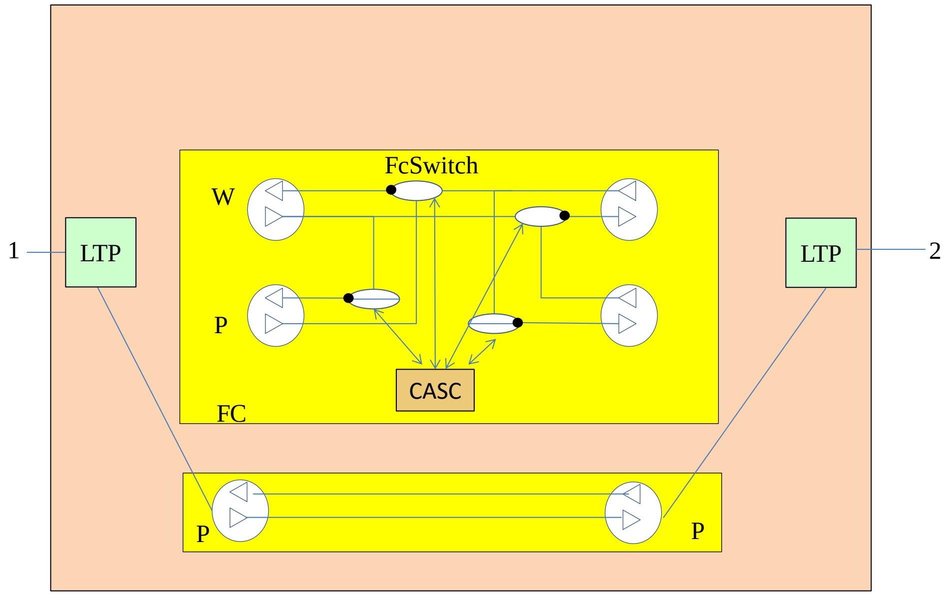



Figure A.1.4-5 Steering: node E and node F with failure on link between node B and node C

Figure A.1.4-5 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 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.

# Appendix I

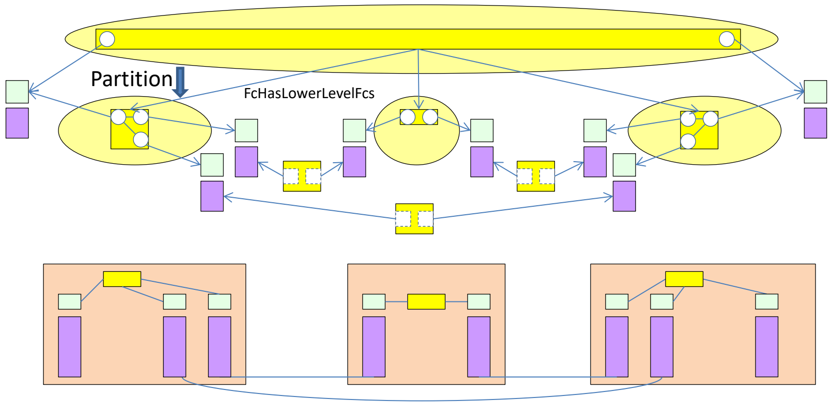
## Resilience examples

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

## I.1 Linear Protection

### I.1.1 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.1.1-1 simple example of Linear 1+1/1:1**

Figure I.1.1-1 [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-end FC is partitioned into subordinate (via FcHasLowerLevelFcs). MPLS-TP SNC/S protection and trail protection all can be represented by this common example.

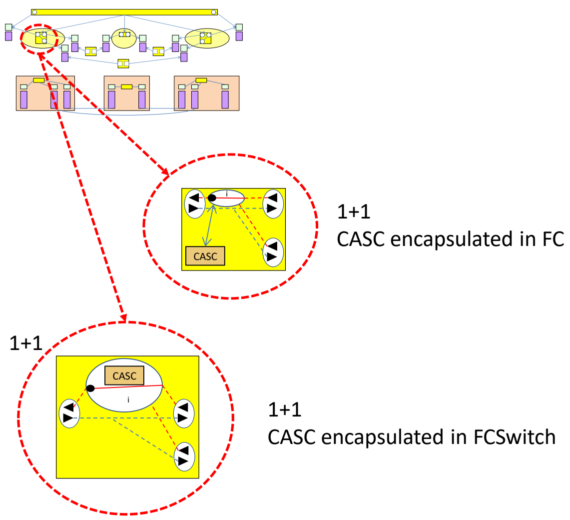



**Figure I.1.1-2 detail of a nodal view of 1+1 switches**

Figure I.1.1-2 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.

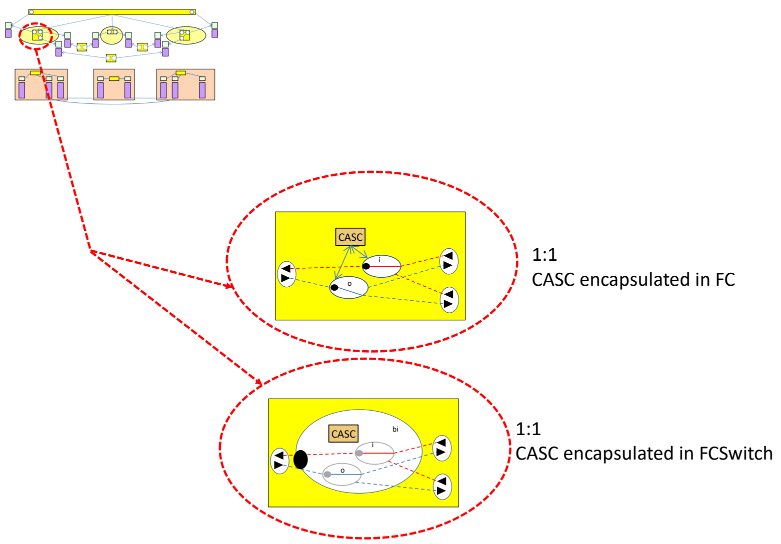
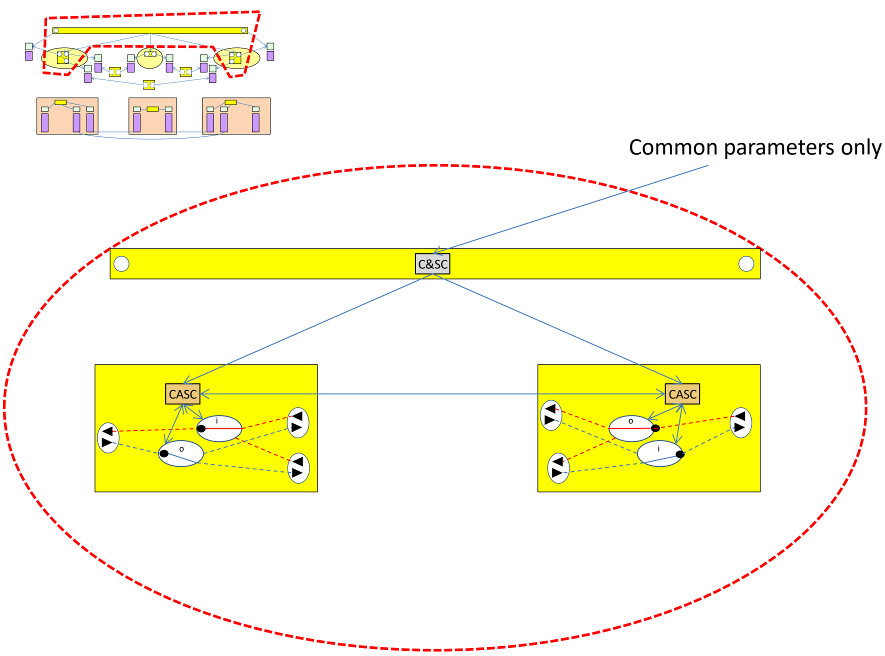



**Figure I.1.1-3 detail of a nodal view of 1:1 switches**

Figure I.1.1-3 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). The same to Figure 2.



**FigureI.1.1-4 Showing an high-level abstract controller in a 1:1 case**

Figure I.1.1-4 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.

## I.2 Shared ring Protection

<Editor Note: suggest to add short wrapping and steering cases. >

### I.2.1 wrapping

Figure I.2.1-1 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.

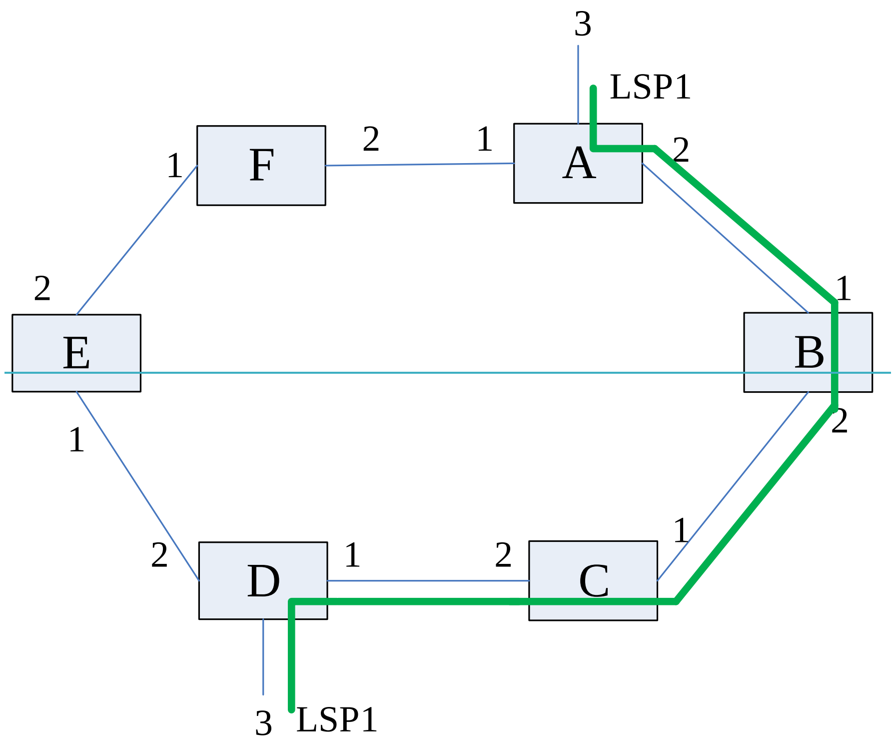
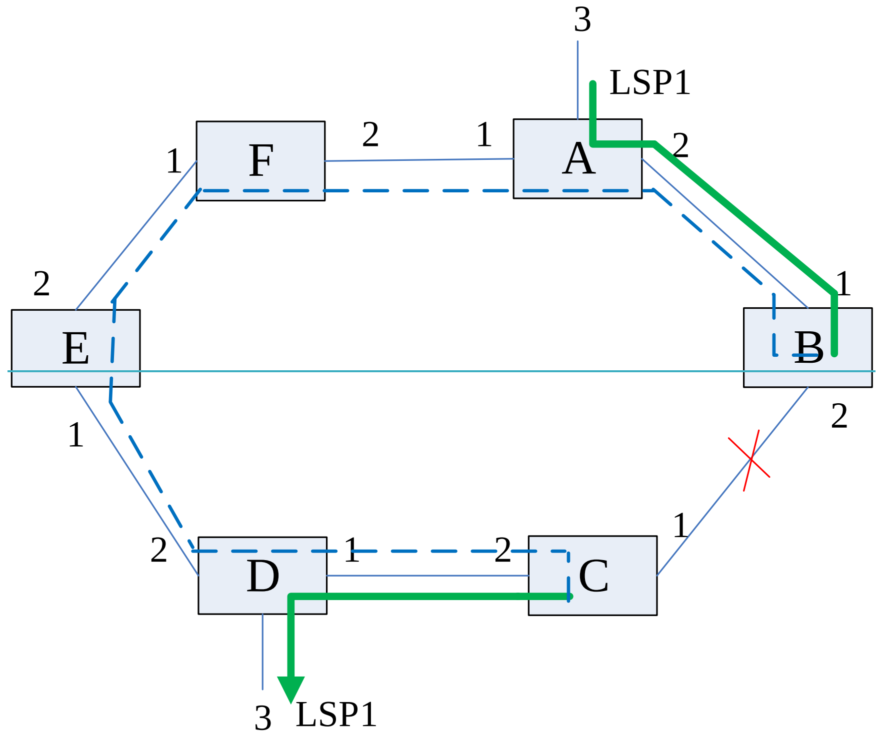



Figure I.2.1-1 basic network

When a link failure between node B and node C occurs, see the following Figure I.2.1-2. The node B switches the clockwise working ring tunnel to the anticlockwise protection ring tunnel, and node C switches the anticlockwise protection ring tunnel back to the clockwise working ring tunnel. The signal then will follow the path A-B-A-F-E-D-C-D.




s

Figure I.2.1-2 Wrapping for link failure

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

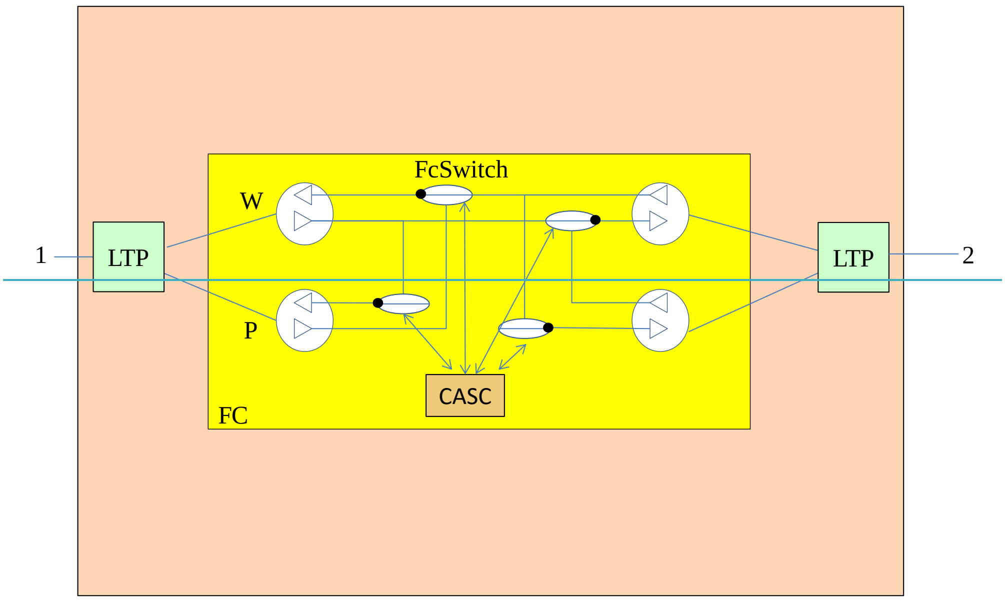



Figure I.2.1-3 Wrapping: node B and node C (no failure in ring)

Figure I.2.1-3 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 path.

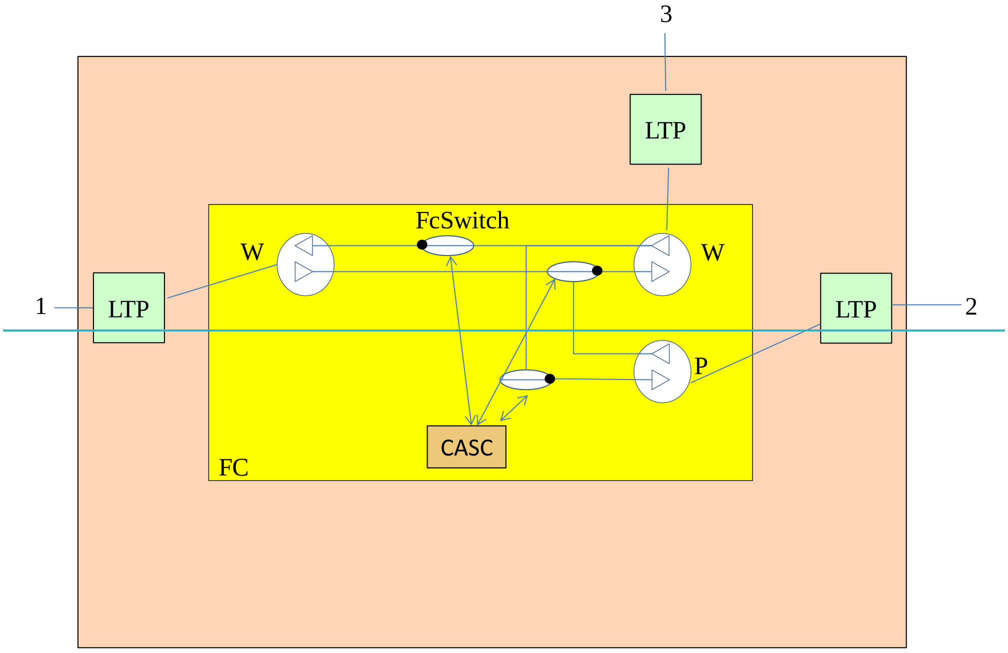



Figure I.2.1-4 Wrapping: node D (no failure in ring)

Figure I.2.1-4 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 path.

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.

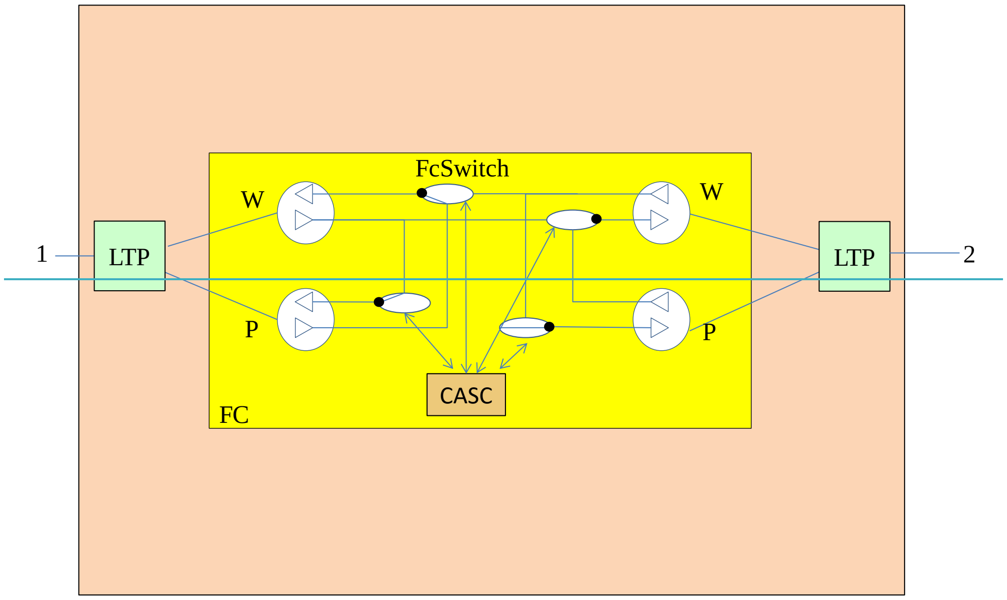
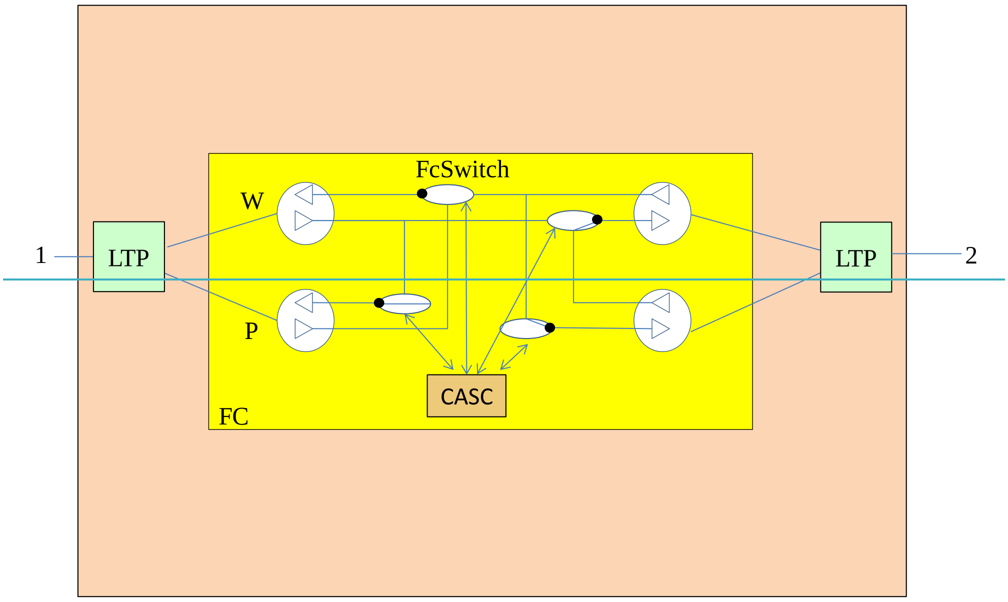


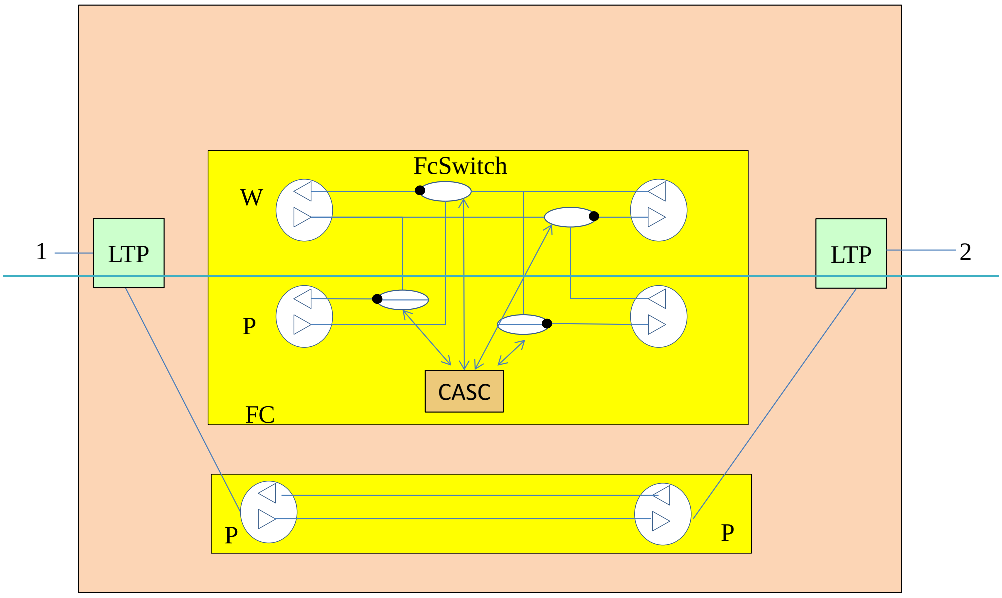

Figure I.2.1-5 Wrapping: node B with failure on link between node B and node C

~~Figure A.2.1-5 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 path. The FC allows signal to flow between the working and protection on port1, such that the signal is wrapped back to port1.~~




~~Figure I.2.1-6 Wrapping: node C with failure on link between node B and node C~~

~~Figure I.2.1-6 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 I.2.1-7 Wrapping: node E and node F with failure on link between node B and node C~~

Figure I.2.1-7 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 path 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 protect the signal 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.

### I.2.2 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 I.2.2-1 shows a view of a basic network. This figure is the same to I.2.1-1. A signal is passing from port3 node A to port 3 node D. LSP1 is through the path A-B-C-D.

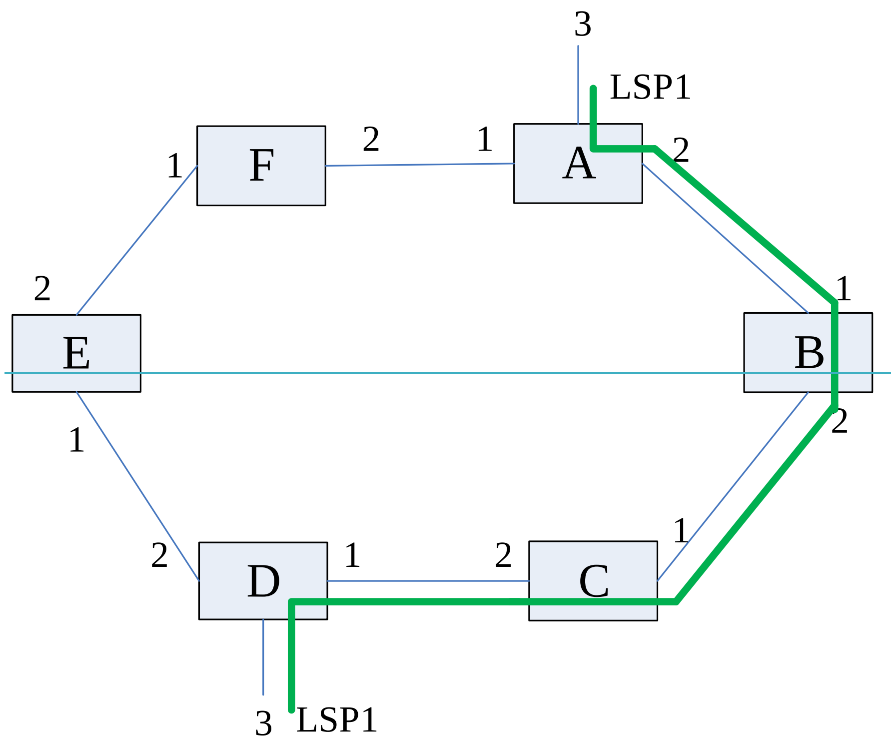



Figure I.2.2-1 basic network

When a link failure between node B and node C occurs, see the following Figure I.2.2-2. The 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.

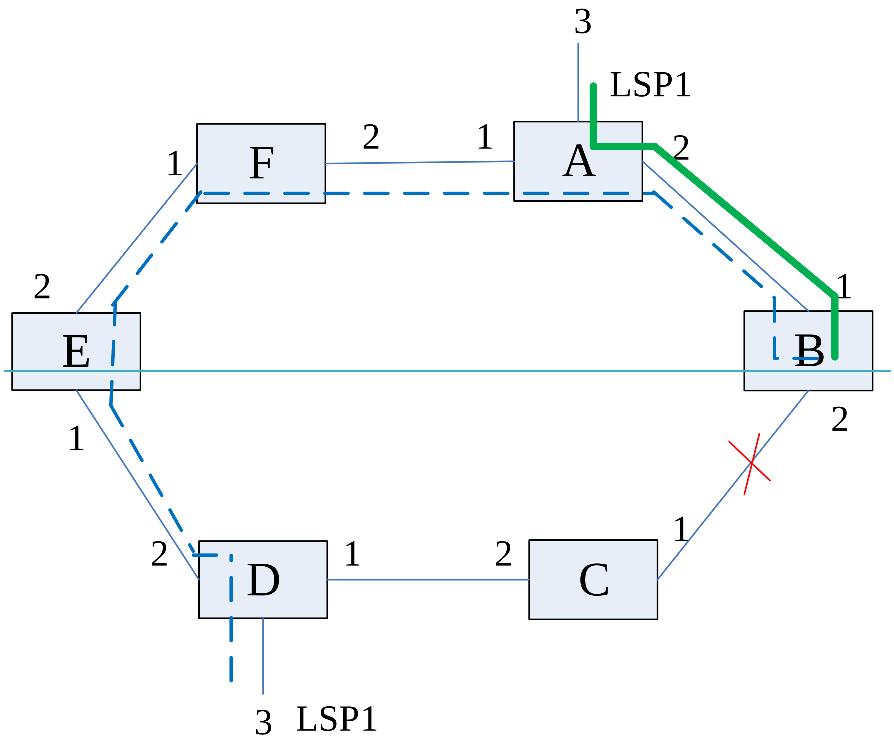



Figure I.2.2-2 short-wrapping for link failure

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 Figures I.2.1-3 and Figure I.2.1-4.

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

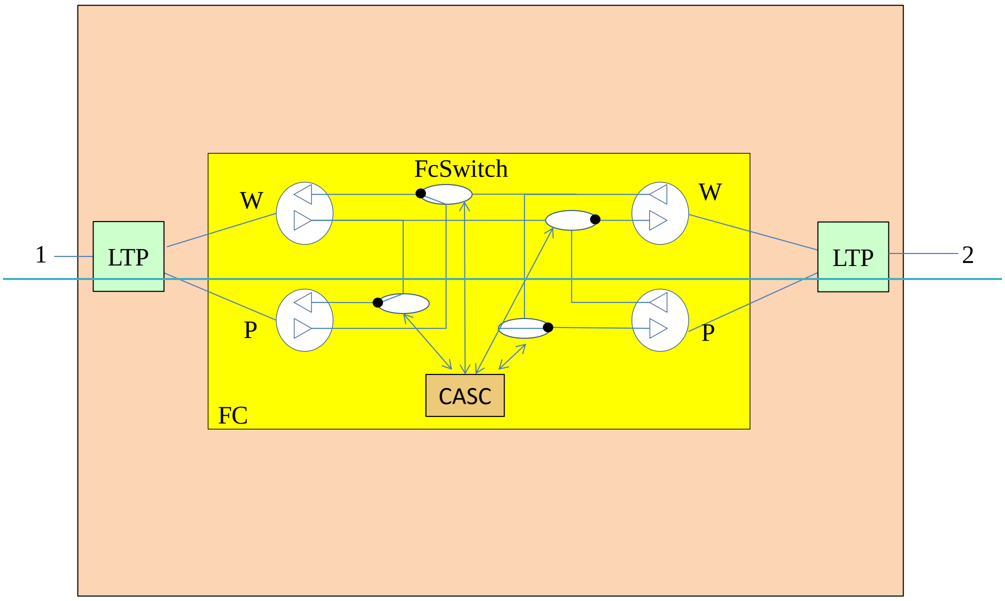



Figure I.2.2-3 Wrapping: node B with failure on link between node B and node C

Figure I.2.2-3 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 I.2.1-5 wrapping scheme.

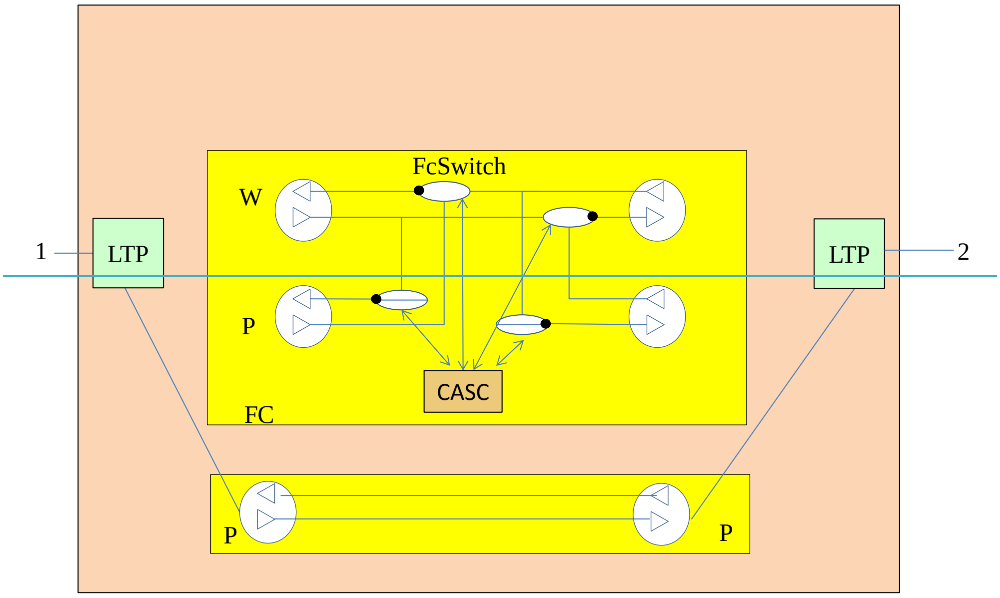



Figure I.2.2-4 short-wrapping: node E and node F with failure on link between node B and node C

Figure I.2.2-4 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.

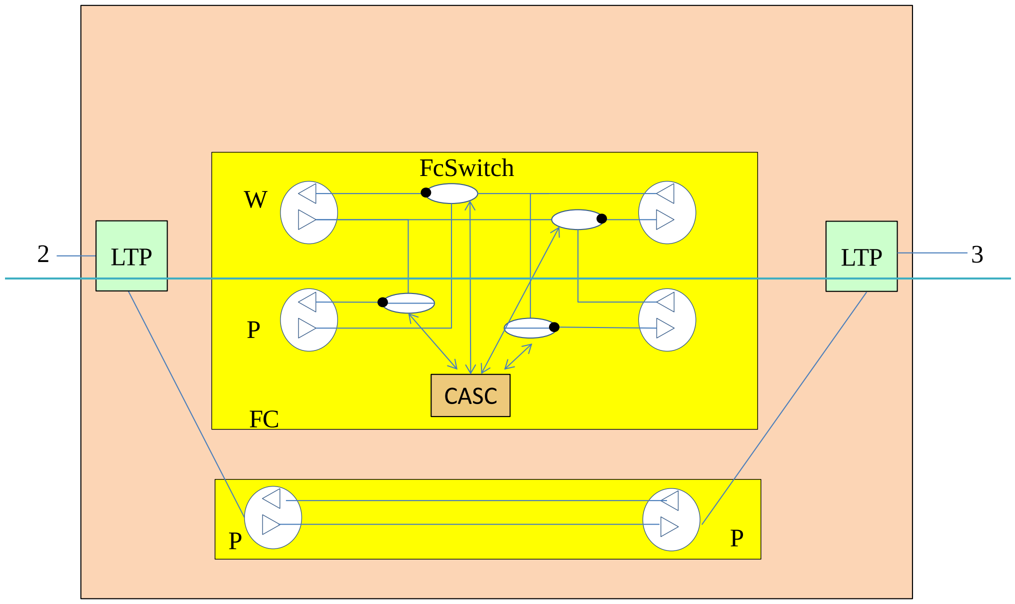



Figure I.2.2-5 short-wrapping: node D with failure on the link between node B and node C

Figure I.2.2-5 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.

### I.2.3 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 I.2.3-1 shows a view of the basic network. This figure is the same to I.2.2-1. A signal is passing from port3 node A to port 3 node D. LSP1 is through the path A-B-C-D.

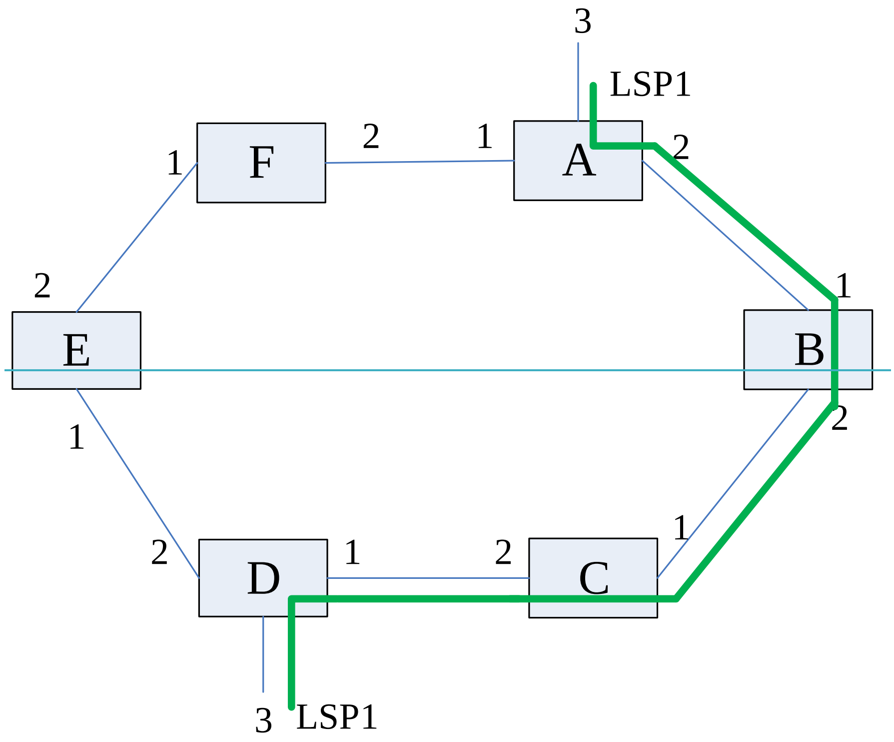



Figure I.2.3-1 basic network

When a link failure between node B and node C occurs, as shown in the following Figure I.2.3-2, 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.

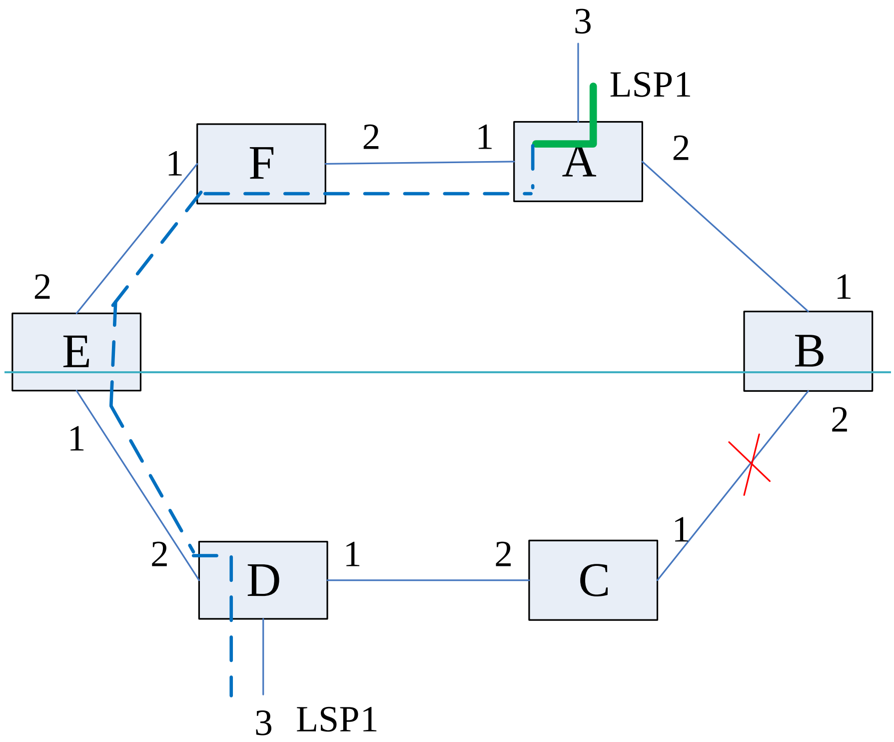



Figure I.2.3-2 Steering for link failure

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 I.2.1-3, Figure I.2.1-4.

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

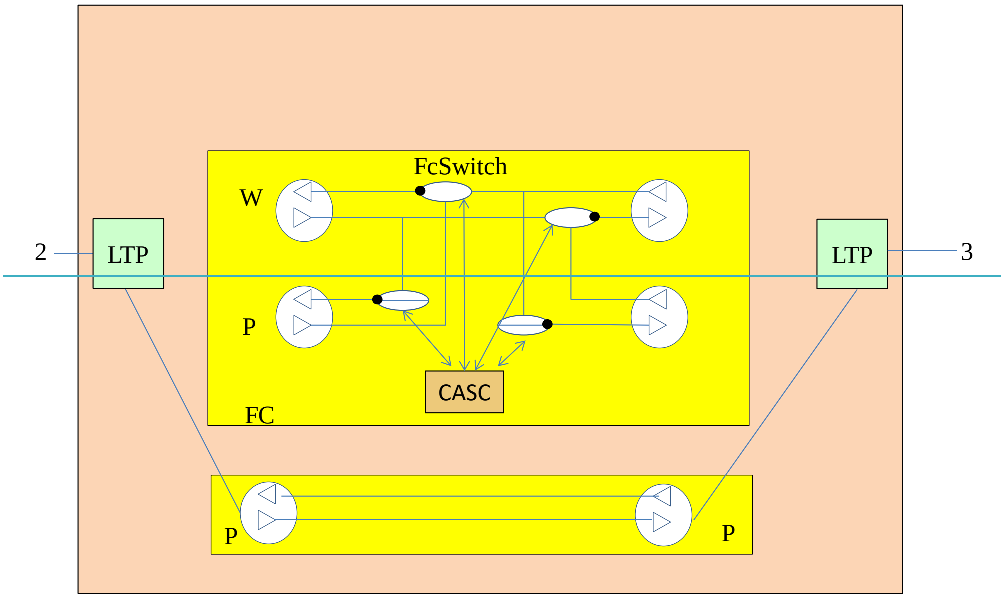



Figure I.2.3-3 Steering: node D with failure on link between node B and node C

Figure I.2.3-3 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.

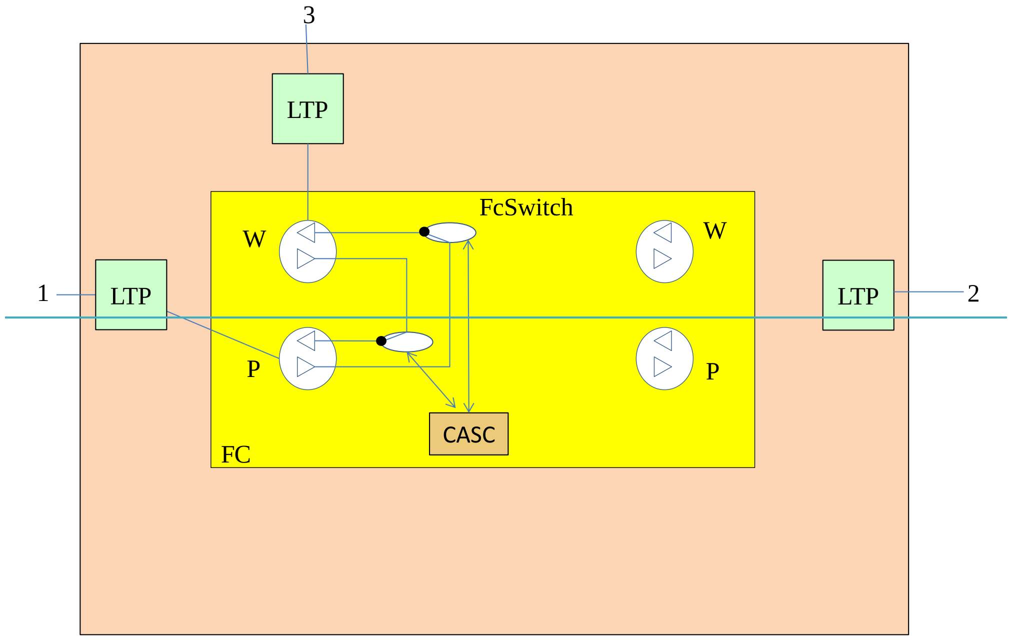



Figure I.2.3-4 Steering: node A with failure on link between node B and node C

Figure I.2.3-4 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.

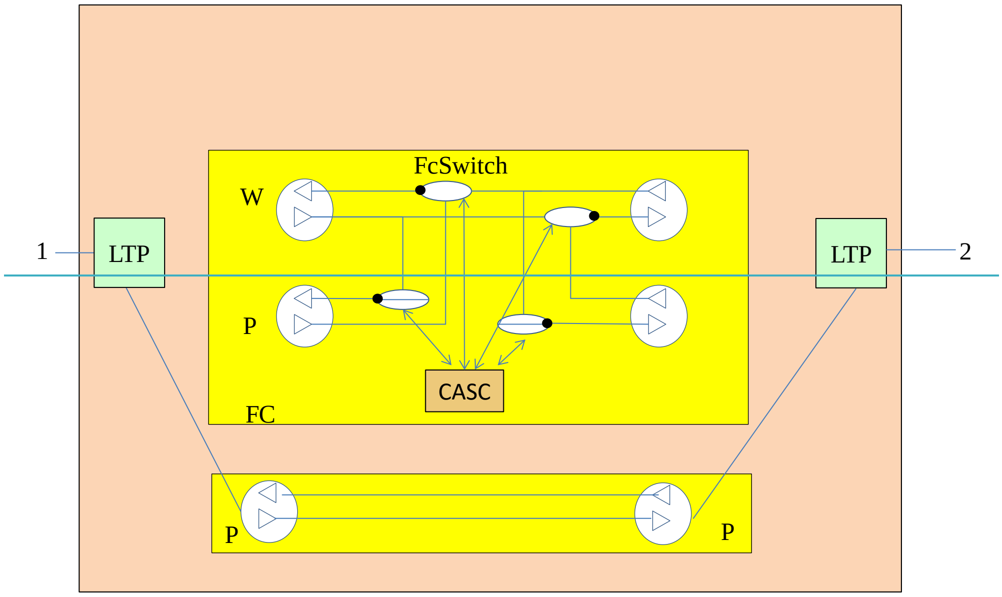



Figure I.2.3-5 Steering: node E and node F with failure on link between node B and node C

Figure I.2.3-5 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 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.~~

# Bibliography

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[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)

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