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Ethernet linear protection switching with dual node interconnection

ITU-T G-series Recommendations – Supplement 60

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Supplement 60 to ITU-T G-series Recommendations

Ethernet linear protection switching with dual node interconnection

Summary

Supplement 60 to ITU-T G-series Recommendations describes potential solutions to support dual node interconnection (DNI) based on the ITU-T G.8031 Ethernet linear protection switching to support resilient interconnection with an adjacent recovery domain. Other viable means of supporting dual node interconnection for Ethernet are known to exist. This Supplement is intended to give examples based on Recommendation ITU-T G.8031 only.

History

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Supplement 60 to ITU-T G-series Recommendations

Ethernet linear protection switching with dual node interconnection

1 Scope

Supplement 60 to ITU-T G-series Recommendations describes potential solutions to support dual node interconnection (DNI) based on the ITU-T G.8031 Ethernet linear protection switching, inside a recovery domain. The dual node interconnection is between this recovery domain, which can be protected by one of the Ethernet linear protection-based mechanisms described in this Supplement, and an adjacent recovery domain via two nodes. This Supplement describes only solutions where the traffic between these two recovery domains passes through the same node in both directions. Description of the survivability mechanism within the adjacent recovery domain is outside the scope of this Supplement.

2 References

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

[ITU-T G.808.1] Recommendation ITU-T G.808.1 (2014), *Generic protection switching – Linear trail and subnetwork protection*.

[ITU-T G.7701] Recommendation ITU-T G.7701 (2016), *Common control aspects*.

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

[ITU-T G.8031] Recommendation ITU-T G.8031/Y.1342 (2015), *Ethernet linear protection switching.*

[ITU-T G.8081] Recommendation ITU-T G.8081/Y.1353 (2012), *Terms and definitions for automatically switched optical networks*.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following terms defined elsewhere:

3.1.1 transfer time, T_t: [ITU-T G.808.1]

3.1.2 shared risk group (SRG): [ITU-T G.8081]

3.1.3 recovery domain: [ITU-T G.7701]

3.2 Terms defined in this Supplement

This Supplement defines the following terms:

3.2.1 dual node interconnection: An architecture where two interconnected nodes provide node resiliency at the boundary between two recovery domains.

3.2.2 adjacent recovery domain: A recovery domain adjacent to the Ethernet linear protection DNI domain.

3.2.3 Ethernet linear protection DNI domain: A recovery domain where one of the solutions described in this Supplement is used to support reliable transfer of information.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

APS Automatic Protection Switching

CCM Continuity Check Message

DNI Dual Node Interconnection

EDNI Ethernet linear protection DNI

ETH Ethernet layer network

FS Forced Switch

LO Lockout of protection

LOC Loss of Continuity

MEP Maintenance Entity Group End Point

NR No Request

OAM Operation, Administration and Maintenance

SNC Subnetwork Connection

SNC/S Subnetwork Connection with Sublayer monitoring

SRG Shared Risk Group

SF-V Signal Fail on the vertical path

SF-W Signal Failure on the working path

TSF Trial Signal Fail

5 Conventions

The terms bridge, permanent bridge, selector bridge, selector and selective selector, are used in this Supplement as defined in [ITU-T G.808] without qualifying the input and output signals as normal signal or working/protection transport entities.

6 Introduction

Ethernet linear protection switching with dual node interconnection involves using three distinct points: node N1 is an end point behaving as defined in [ITU-T G.8031], and nodes N2 and N3 are interconnection points that provide node resiliency at the boundary between the two recovery domains. This is illustrated in Figure 6-1. The protection mechanism used within the Ethernet linear protection dual node interconnection (DNI) domain is based on 1:1 SNC/S linear protection mechanism, as defined in [ITU-T G.8031], with a selector bridge being used in node N1. The traffic in both directions passes through the same interconnection point.

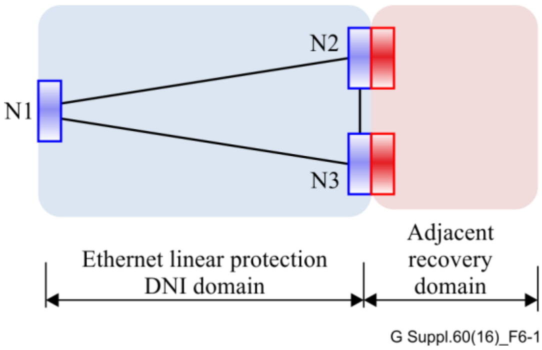

Figure 6-1 – Reference network for Ethernet linear protection switching with dual node interconnection

Regarding the adjacent recovery domain, it is assumed that:

1) Under normal conditions, it delivers traffic to/from node N2.

2) It is capable of indicating if N2 or N3 is isolated in it.

3) It is capable of ensuring no traffic loops are created in it as a result of switching actions in the Ethernet linear protection DNI domain.

4) When N2 is isolated in the Ethernet linear protection DNI domain, N2 isolation information can be transmitted to node N3 through the adjacent recovery domain.

5) It is capable of recovering traffic from N2 node isolation conditions in the Ethernet linear protection DNI domain when the Ethernet linear protection DNI domain informs the adjacent recovery domain of the N2 node isolation conditions via node N2, node N3, or both nodes.

Using Figure 6-1 as the reference network, subsequent clauses provide network objectives and example protection mechanisms for Ethernet linear protection DNI domain.

7 Network objectives

The following network protection objectives apply for the Ethernet linear protection DNI domain:

1) Transfer time (T_t) in response to a single failure should be less than 50 ms in the Ethernet linear protection DNI domain.

2) The Ethernet linear protection DNI domain shall inform the adjacent recovery domain of the isolation status of N2 and N3 in the Ethernet linear protection DNI domain, so that the adjacent recovery domain can decide which interconnection point to use for traffic delivery.

8 Failure scenarios

This Supplement describes how each solution addresses the following failure scenarios.

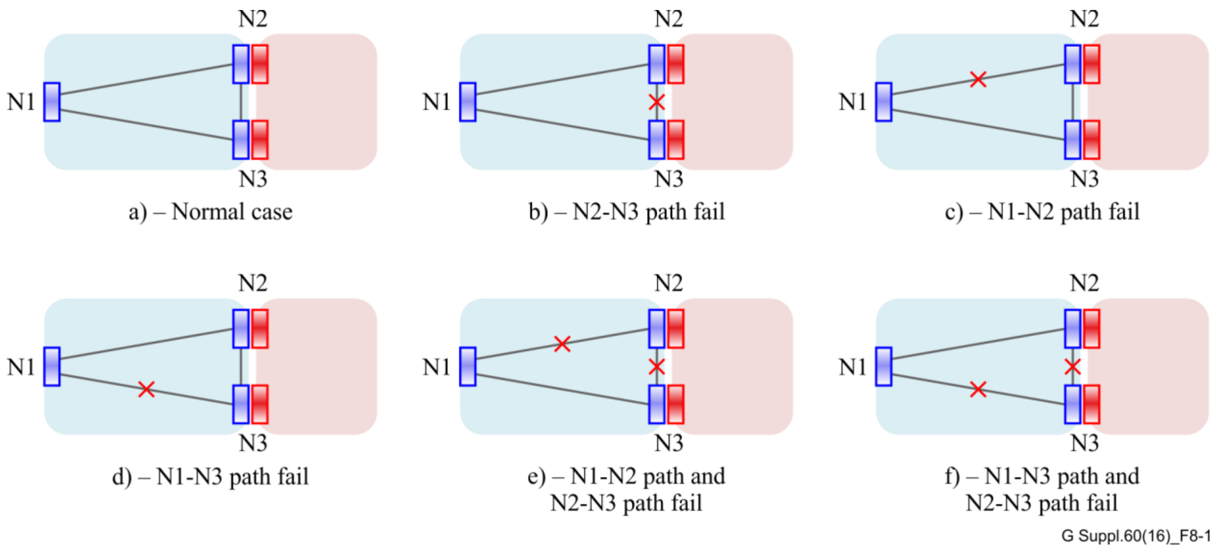

Figure 8-1 – Failure scenarios

These six cases are also considered when either N2 or N3 is isolated in the adjacent recovery domain.

9 Solutions for Ethernet linear protection switching with DNI

This clause provides descriptions of potential solutions to support DNI based on the Ethernet linear protection switching defined in [ITU-T G.8031]. Other viable means of supporting dual node interconnection for Ethernet are known to exist. This Supplement is intended to give examples based on [ITU-T G.8031] only.

9.1 Solution A

9.1.1 Assumptions

This solution has the following detailed assumptions regarding common assumption 2) listed in clause 6:

- Node N3 is informed from the adjacent recovery domain when N3 is isolated in that domain.
- Node N3 is informed from the adjacent recovery domain when N2 is isolated in that domain.

9.1.2 Architecture

Figure 9-1 shows the architecture of Ethernet linear protection DNI Solution A. The working path is defined between nodes N1 and N2 and the protection path is defined between nodes N1 and N3. There is a third path called vertical path defined between nodes N2 and N3. The status of the working path, the protection path and the vertical path are monitored by continuity check message (CCM) mechanisms, respectively.

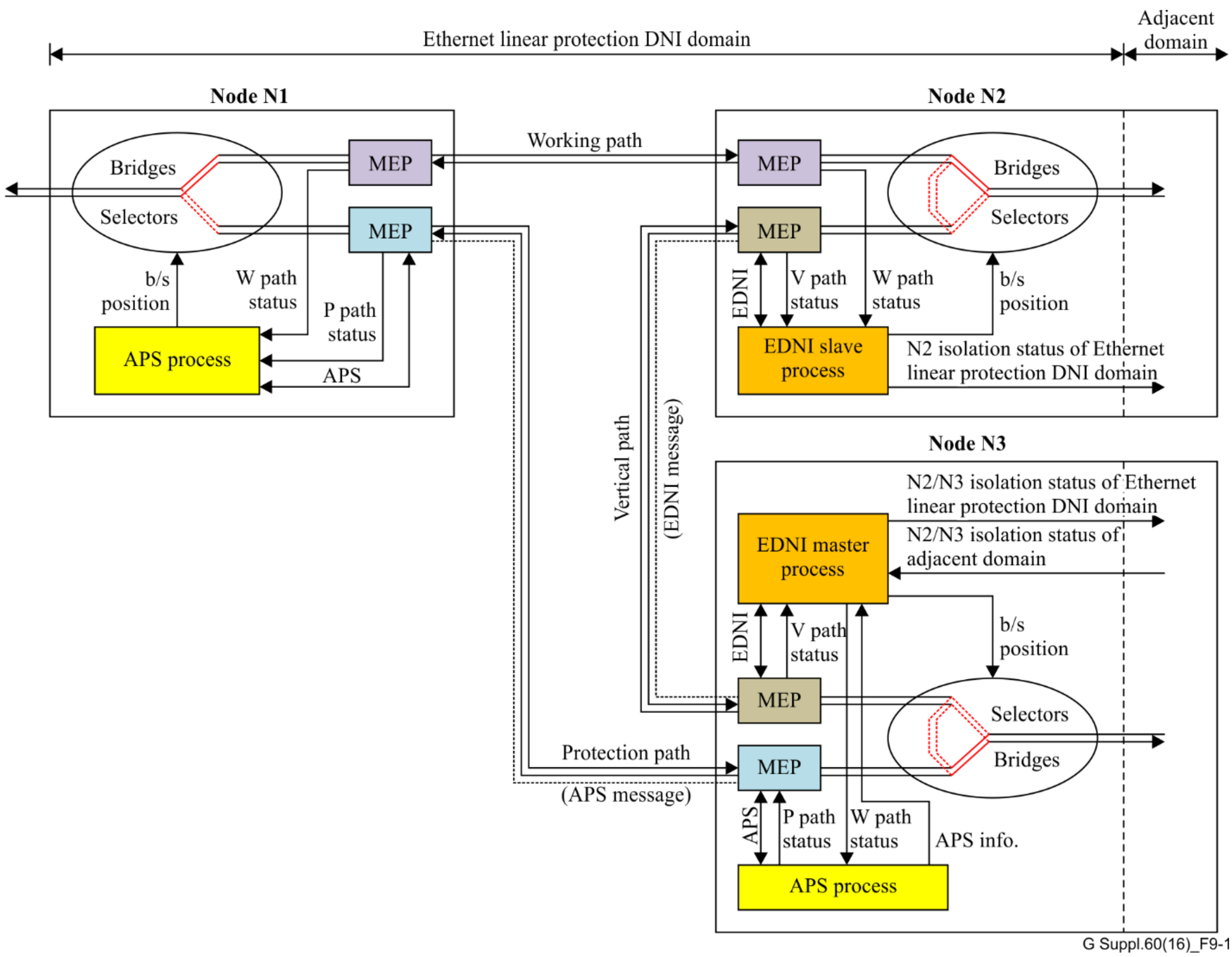

Figure 9-1 – Ethernet linear protection DNI architecture of solution A

N1 is the same as the end point of an ITU-T G.8031 protected domain. N3 also has the same automatic protection switching (APS) process as defined in [ITU-T G.8031] and exchanges APS messages with N1 through the protection path to perform protection switching between the working path and the protection path. All aspects of APS processes in N1 and N3, including APS messages and APS state machines, are exactly the same as those in the APS process defined in [ITU-T G.8031].

Ethernet linear protection DNI (EDNI) processes in N2 and N3 exchange EDNI messages through the vertical path to coordinate the Ethernet linear protection DNI operation. The EDNI process in N2 is defined as EDNI slave process and the EDNI process in N3 is defined as EDNI master process.

The EDNI master process determines the status of the working path based on the status of the working path received from N2, the status of the vertical path and the isolation status of N2 and N3 in the adjacent recovery domain, and sends the working path status to the APS process as a local request (ETH_CI_SSF(W)).

N2 and N3 have multiple selector bridges and selective selectors to provide connectivity among the working path (in case of N2), the protection path (in case of N3), the vertical path and the adjacent recovery domain as illustrated in Figure 9-2.

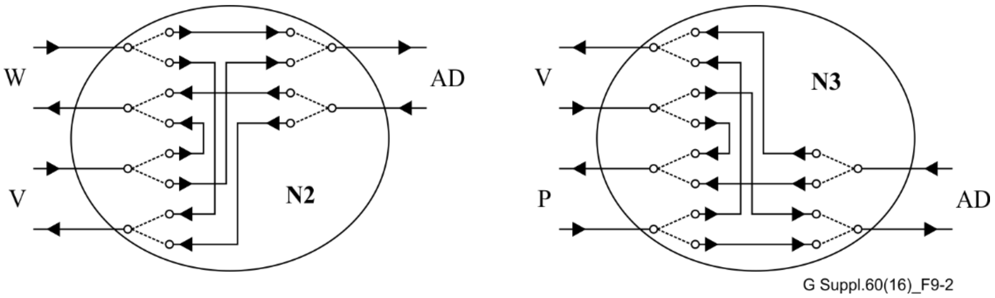

Figure 9-2 – Bridges and selectors in N2 and N3

The bridges and selectors in N2 and N3 are controlled by the EDNI master process based on the status of the APS process, the status of the vertical path and the isolation status of N2 and N3 in the adjacent recovery domain. Possible sets of the connectivity provided by the bridges and selectors are as follows:

[Bridges and selectors in N2]

– connect the working path to the adjacent recovery domain (W-AD) (default position)

– connect the working path to the vertical path (W-V)

– connect the vertical path to the adjacent recovery domain (V-AD)

[Bridges and selectors in N3]

– connect the protection path to the adjacent recovery domain (P-AD) (default position)

– connect the protection path to the vertical path (P-V)

– connect the vertical path to the adjacent recovery domain (V-AD)

9.1.3 Process

In addition to the ITU-T G.8031 processes in N1 and N3, this solution defines the EDNI master and slave processes in N3 and N2, respectively. The protocol message format and the operations of the EDNI processes are described in this subclause.

9.1.3.1 EDNI message

The format and the rule for transmission and acceptance of EDNI message are the same as those of APS message in [ITU-T G.8031]. Figure 9-3 shows the APS-specific information in the EDNI message.

1								2								3								4							
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
Request/ State				Prot. type				Requested signal								Bridged signal								T	Reserved (0)						
				A	B	D	R																								

Figure 9-3 – APS-specific information format in the EDNI message

The "Request/State" field is used to convey status of the vertical path or working path. Signal fail on the vertical path (SF-V) has a higher priority than the signal failure on the working path (SF-W). An EDNI message uses the values allocated by [ITU-T G.8031] for SF-P (1110), SF (1011) and NR (0000) to indicate SF-V, SF-W and no request (NR), respectively. All other values for the "Request/State" field allocated in [ITU-T G.8031] are not used, and therefore considered as invalid, in the context of EDNI message and should be ignored when received.

One of the four bits of the "Protection Type" field in the APS-specific information, the "R" bit (bit 1 of octet 1, as shown in Figure 9-3), is used as an "I" bit in the context of EDNI message. Bits 4 to 2 of octet 1 (bits "A", "B", "D") are not used in the EDNI processes in N2 and N3 and are fixed to the values 0, 0, 1, respectively. These three bits set to these values, together with bit 1, form one of the invalid protection type values in [ITU-T G.8031]. Together with the "Requested Signal" and the "Bridged Signal", the "I" bit is used to indicate the connectivity made by the bridges and selectors in N2 as described in Table 9-1.

Table 9-1 – Connectivity indication in the EDNI message

Requested signal	Bridged signal	"I" bit	Connectivity in N2
0	0	0	W-AD
0	0	1	W-V
1	1	0	V-AD

9.1.3.2 EDNI slave process in N2

N2 monitors the status of both working and vertical paths. The detected status (NR, SF-W or SF-V) is contained in the "Request/State" field in the EDNI message.

If the status of the vertical path is normal, the EDNI slave process sets its bridges and selectors to make connectivity as received in the EDNI message from N3. Otherwise, the EDNI slave process sets its bridges and selectors to the default position (W-AD).

The "Bridged Signal", "Requested Signal" and "I" bit in the sending EDNI messages reflect the current connectivity of N2, so that N3 can check consistency or protocol failure.

9.1.3.3 EDNI master process in N3

N3 monitors the status of the vertical path. The detected status (NR or SF-V) is contained in the "Request/State" field in the EDNI message.

If the status of the vertical path is normal, the EDNI master process passes the status of the working path to the APS process as received in the EDNI message (NR or SF-W). Otherwise, the EDNI master process determines the working path status based on the isolation status of N2 and N3 received from the adjacent recovery domain, for example, if the adjacent recovery domain is indicating that N2 is isolated while N3 is not isolated in the adjacent recovery domain, the EDNI master process sends SF-W to the APS process in order to trigger protection switching to switchover the traffic to the protection path if SF-W becomes the top priority global request in N1 or N3.

The EDNI master process determines the connectivity made by the bridges and selectors in N2 and N3 based on the status of the vertical path, the status of the APS process and the isolation status of N2 and N3 received from the adjacent recovery domain as described in Table 9-2. The determined connectivity for N2 is sent through the EDNI message.

Table 9-2 – Connectivity decision in the EDNI master process in N3

Vertical path status	OK						SF-V
APS process status	Working selected (r/b=0/0)			Protection selected (r/b=1/1)			–
N3 status from AD	OK		Isolated	OK		Isolated	–
N2 status from AD	OK	Isolated	–	OK	Isolated	–	–
Connectivity in N2	W-AD	W-V	W-AD	V-AD	W-AD	V-AD	W-AD
Connectivity in N3	P-AD	V-AD	P-AD	P-V	P-AD	P-V	P-AD

9.1.4 Operator's commands

All the operator's commands defined in [ITU-T G.8031] can be issued at either N1 or N3. Behaviour of each command is the same as that defined in [ITU-T G.8031] because selection between the working path and the protection path is determined by the [ITU-T G.8031] APS processes in N1 and N3. Depending on the isolation status of N2 and N3 in the adjacent recovery domain, the EDNI master process in N3 and the EDNI slave process in N2 decide whether the vertical path should be used or not for traffic delivery.

9.1.5 Detection and report of node isolation

If both the working and vertical failures are detected by N2, the EDNI slave process in N2 should inform the adjacent recovery domain that N2 has been isolated in the Ethernet linear protection DNI domain in order to trigger any action required in the adjacent recovery domain for the traffic delivery. When the working path failure is unidirectional in the direction from N2 to N1, N2 does not know that it has been isolated by itself even if the vertical path is failed. In this case, the EDNI master process in N3 can inform the adjacent recovery domain that N2 has been isolated in the Ethernet linear protection DNI domain since the APS process is selecting the protection path. Therefore, if the vertical path is failed and the APS process is selecting the protection path, the EDNI master process in N3 should inform the adjacent recovery domain that N2 has been isolated in the Ethernet linear protection DNI domain.

If N3 detects the vertical path failure and the APS process is selecting the working path, the EDNI master process in N3 should inform the adjacent recovery domain that N3 has been isolated in the Ethernet linear protection DNI domain in order to trigger any action required in the adjacent recovery domain for the traffic delivery.

Tables 9-3 and 9-4 summarize the isolation status report to the adjacent recovery domain in N2 and N3.

Table 9-3 – Isolation status report to the adjacent recovery domain in N2

V status	OK	SF	
W status	–	OK	SF
N2 status to AD	OK	OK	Isolated

Table 9-4 – Isolation status report to the adjacent recovery domain in N3

V status	OK	SF	
APS process status	–	Working selected (r/b=0/0)	Protection selected (r/b=1/1)
N2 status to AD	OK	OK	Isolated
N3 status to AD	OK	Isolated	OK

9.1.6 Supported failure cases

Table 9-5 describes failure cases supported by this solution.

Table 9-5 – Supported failure cases

Failure cases	Traffic path		
	when N2 and N3 are not isolated in AD	**when N2 is isolated in AD**	**when N3 is isolated in AD**
Normal	N1-N2-AD	N1-N2-N3-AD	N1-N2-AD
N2-N3 path fail	N1-N2-AD	N1-N3-AD	N1-N2-AD
N1-N2 path fail	N1-N3-N2-AD	N1-N3-AD	N1-N3-N2-AD
N1-N3 path fail	N1-N2-AD	N1-N2-N3-AD	N1-N2-AD
N1-N2 and N2-N3 paths fail	N1-N3-AD	N1-N3-AD	see Note
N1-N3 and N2-N3 paths fail	N1-N2-AD	see Note 1	N1-N2-AD
NOTE – No traffic path is available between N1 and adjacent recovery domain.			

9.2 Solution B

9.2.1 Assumptions

This solution has the following detailed assumptions regarding common assumption 2) listed in clause 6:

- Node N3 to detect when it is isolated within the adjacent recovery domain
- Either node N2 or node N3, or both, to detect when node N2 is isolated within the adjacent recovery domain

This solution has the following assumption in addition to the common assumptions listed in clause 6:

- In case the adjacent recovery domain has a vertical path between nodes N2 and N3, it is assumed that it is in a common shared risk group (SRG) with the vertical path within the Ethernet linear protection DNI domain so these two vertical paths usually fail together. Therefore, this mechanism does not define any additional rule for supporting recovery from failure scenarios where only one of the two vertical paths fail (e.g., the scenario where N1-N3 path fail and N2 is isolated in the adjacent recovery domain), since these failure scenarios are quite unlikely to happen.

9.2.2 Architecture

Figure 9-4 shows a high-level architecture of the Ethernet linear protection DNI used within the Ethernet linear protection DNI domain of solution B.

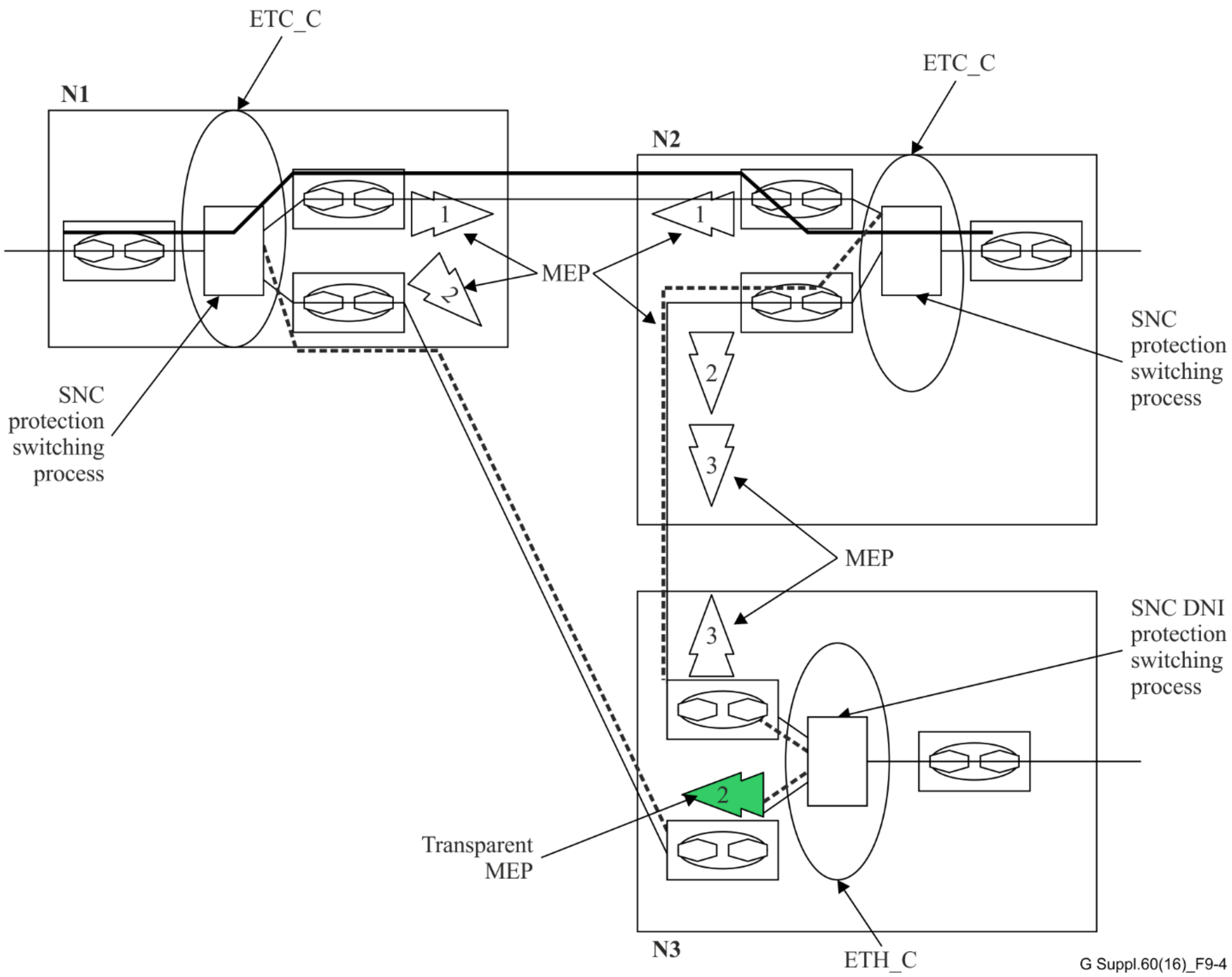

Figure 9-4 – ETH linear protection DNI architecture of solution B

A service is configured though the Ethernet linear protection DNI domain from N1 to N2.

In order to protect this service segment within the Ethernet linear protection DNI domain, a N1-N2 working path, and a N1-N3-N2 protection path are configured. The N1-N3-N2 protection path is composed by two sub paths N1-N3 and N3-N2.

It is required that maintenance entity group end points (MEPs) be activated for the purpose of monitoring failure of the working path, the protection path and the vertical path. All paths are monitored by individually exchanging CCM defined in [ITU-T G.8013]. MEG 1 is configured to monitor the working path, and MEG 2 is configured to monitor the protection path. MEG 3 is configured to monitor on the vertical link between N2 and N3 and it shall have a lower MEG level than MEG 2. A transparent MEP 2 in N3 should be configured with the same MEG ID and MEP ID of the MEP 2 in N2. APS messages are exchanged over MEG 2.

N1 is the same as the end point of an ITU-T G.8031 protected domain. N2 and N3 also have the same APS process as defined in [ITU-T G.8031] and exchanges APS messages with N1 through the protection path to perform protection switching between the working path and the protection path. All aspects of APS processes in N1, N2 and N3, including APS messages and APS state machines, are exactly the same as those in the APS process defined in [ITU-T G.8031].

The architecture of nodes N2 and N3 is designed such node N1 will operate exactly in the same way as if it were connected to a single node as in [ITU-T G.8031].

No new APS protocols or operation, administration and maintenance (OAM) messages are defined. Only the rules controlling the generation of existing OAM protocols or the consequent actions associated with existing OAM defects have been updated beyond current definitions in [ITU-T G.8021] to support DNI requirements in node N2 and N3.

The architecture of node N2 is very similar to the architecture of the end point in [ITU-T G.8031]: within the ETH connection function (ETH_C) in node N2, an ETH SNC protection switching process, as defined in [ITU-T G.8031], is responsible to bridge/select the traffic received/transmitted from/to the adjacent recovery domain as well as to control the bridge and selector functions by implementing the APS protocol defined in [ITU-T G.8031].

In addition, node N2 should support the following capabilities to allow proper operation of the DNI mechanism defined in this clause: dFOP alarm suppression (clause 9.2.2.2); fault propagation in case of node N2 isolation in the adjacent recovery domain (clause 9.2.3.2.1) as well as detection of node N2 isolation conditions in the Ethernet linear protection DNI domain (clause 9.2.5).

The architecture of node N3 is properly designed to allow proper operations of the DNI mechanism defined in this clause: within the ETH_C in Node N3, an ETH SNC DNI protection switching process is responsible to bridge/select the traffic received/transmitted from/to node N1 either to/from node N2 or the adjacent recovery domain and to control the status of the transparent MEP 2 as well as the bridge and selector functions depending on the status of the node resiliency; it is also responsible to implement the APS protocol defined in [ITU-T G.8031] for proper operation of node N1.

The DNI coordination rules for nodes N2 and N3 are designed to ensure proper operations of the SNC/S linear protection in different scenarios that depend on which node (N2 or N3) is actually peering, from an APS protocol perspective, with node N1. Two DNI states are defined to represent this condition:

- In the DNI normal state, node N2 is peering with node N1 from an APS protocol perspective. The protection path in Ethernet linear protection DNI domain is N1-N3-N2.
- In the DNI recovery state, node N3 is peering with node N1 from an APS protocol perspective. The protection path in Ethernet linear protection DNI domain is N1-N3.

Both nodes N2 and N3 should have a common view about this status condition.

9.2.2.1 DNI normal state

Figure 9-5 illustrates the status of the functional blocks on N3 during DNI normal state. In this condition, the selective bride and the selective selector, within the ETH SNC DNI protection switching process, are operated to forward the traffic between nodes N1 and N2.

The permanent bridge, within the transparent MEP 2 process, is used to copy the traffic received from N1 also to the MEP 2 sink function within N3: the OAM and APS state machines of MEP 2 on N3 receives all the CCM and APS messages generated by the MEP 2 in N1 and therefore operate as MEP 2 in N2.

The selective bridge and selectors, within the transparent MEP 2 process, are used to allow the OAM and APS messages on MEG 2 to be forwarded transparently between nodes N1 and N2 and to discard any OAM message generated by the MEP 2 within node N3.

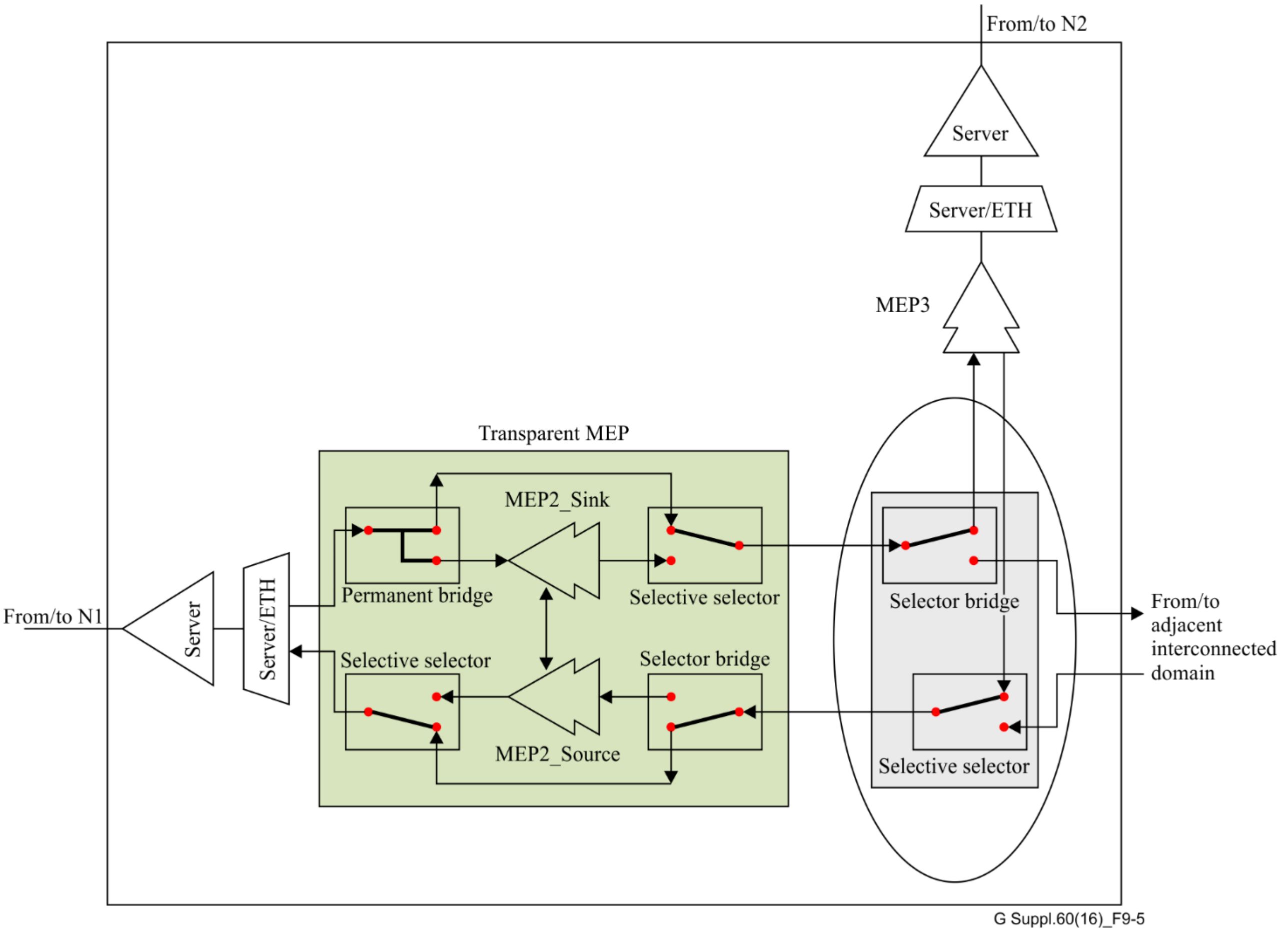

Figure 9-5 – Functional blocks on N3 in DNI normal state

The APS state machine within node N3 will receive the APS messages generated by N1 and generate APS messages accordingly: generated APS messages will however be dropped by the selective selector within the transparent MEP and not delivered to N1.

In DNI normal status, alarm reporting for any dFOP defect detected by the APS state machine in N3 will be suppressed.

In DNI normal state, node N2 operates exactly as the end point defined in [ITU-T G.8031].

The APS protocol running between nodes N1 and N2 is responsible to select the active path being either the working path (N1-N2) or the protection path (N1-N3-N2).

It is worth noting that this is the normal state for the DNI node resiliency: the APS protocol, running between nodes N1 and N2, may or may not be in its normal state.

9.2.2.2 DNI recovery state

Figure 9-6 illustrates the status of the functional blocks on N3 during DNI recovery state. In this condition, the selective bridge and the selective selector, within the ETH SCN DNI protection switching process, are operated to disconnect the protection path N1-N3-N2, connect the N1-N3 to the path of adjacent recovery domain, and forward the traffic between node N1 and the adjacent recovery domain.

The selective bridge and selectors within the transparent MEP 2 process of N3 are used to allow the OAM and APS messages on MEG 2 to be now sent to and received from nodes N1. MEP 2 in N3 is configured with the same MEG ID and MEP ID of the MEP 2 in N2.

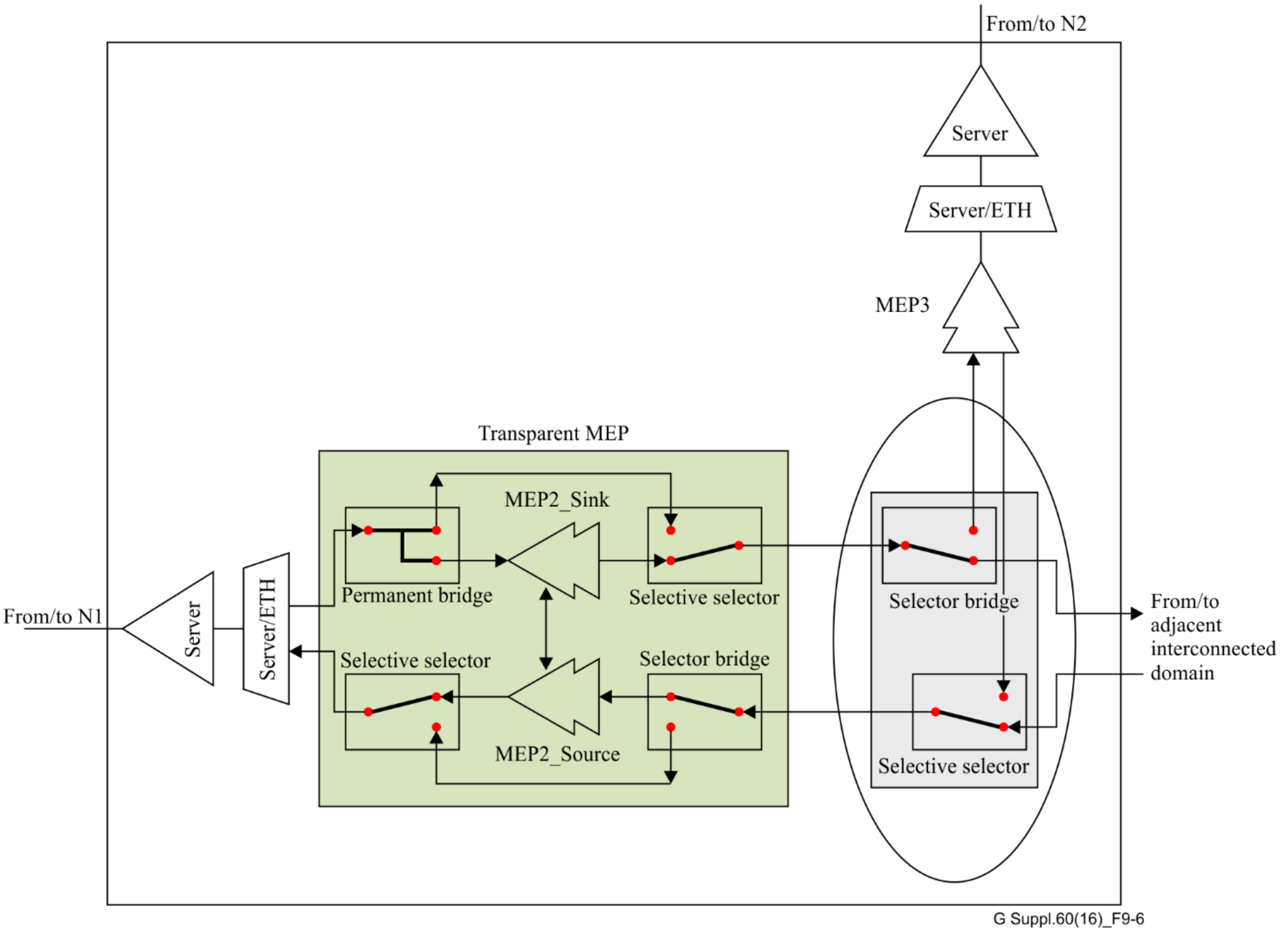

Figure 9-6 – Functional blocks on N3 in DNI recovery state

The APS state machine will receive the APS messages generated by N1 and generate APS messages accordingly: generated APS messages will now be forwarded by the selective selector, within the transparent MEP 2, toward N1.

In DNI recovery state, node N2 operates more or less as the end point defined in [ITU-T G.8031], with the following exceptions:

- Any operators' command in node N2 is cancelled (see clause 9.2.4)
- Alarm reporting for any dFOP defect detected by the APS state machine in N2 will be suppressed.

9.2.3 Process

9.2.3.1 Switching criteria for node resiliency

Node N2 gets into the DNI recovery state when it detects either a failure on the vertical path (see clause 9.2.3.1.1) or when it is isolated in the adjacent recovery domain (see clause 9.2.3.1.2). Node N3 gets into the DNI recovery state when it detects either a failure on the vertical path (see clause 9.2.3.1.1) or when it is notified by the adjacent recovery domain that node N2 is isolated (see clause 9.2.3.1.2).

It is worth noting that in case of N2 or N3 node failure, the other node (N3 or N2 respectively) will get into the DNI recovery state since it will detect at least the failure of the vertical path.

In all the other cases, both nodes N2 and N3 will be in the DNI normal state.

9.2.3.1.1 Failure of the vertical transport entity

The vertical path is assumed to be faulty when either a trial signal fail (TSF) condition or an RDI condition is detected by MEP 3.

The status for the vertical path is not a direct input to the APS state machine but only used to detect the DNI status and/or to trigger cascading actions.

Using the RDI would ensure that both N2 and N3 would get into the DNI recovery state also in case of unidirectional failures of the vertical path.

9.2.3.1.2 Node isolation conditions

When N3 is notified by the adjacent recovery domain that N2 is isolated, N3 will switch to DNI recovery state.

Since it may be possible that node N2 is not aware of being isolated, node N3 would also trigger generation of RDI on MEG 3 which is beyond current definitions in [ITU-T G.8021]: this will ensure that both N2 and N3 would get into the DNI recovery state.

9.2.3.2 Cascading logic

9.2.3.2.1 N2 behaviour

When N2 is notified by the adjacent recovery domain that it is isolated, since it may be possible that N3 is not aware of this condition, N2 will switch off CCM transmission, and start transmission of AIS on both the working path (MEP 1) and the vertical path (MEP 3) in the Ethernet linear protection DNI domain at the same time.

Switching off CCM transmission on MEP 1 in N2 will trigger protection switching in node N1.

Switching off CCM transmission on MEP 3 in N2 will trigger both node N2 and N3 to be in the DNI recovery state.

Insertion of AIS frames would suppress cLOC fault causes on MEP 1 in N1 and MEP 3 in N3, thus suppressing alarms reporting of loss of continuity (LOC) failure in the working path on nodes N1 and N3 to the operator in the Ethernet linear protection DNI domain.

The way of detection of N2’s isolation in the adjacent recovery domain is not limited. If the same mechanism described in this section is used within the adjacent recovery domain, monitoring information (CCM) will be received by N2 from the adjacent recovery domain. The detection of N2's isolation in the adjacent recovery domain is based on the monitoring information (CCM) as described in clause 9.2.5.1.

9.2.3.2.2 N3 behaviour

When N3 is notified by the adjacent recovery domain that N2 is isolated, SF-W (or FS) will be generated as a local request to the APS state machine in N3.

Since in this case, nodes N2 and N3 are in the DNI recovery state, the APS protocol running between nodes N1 and N3 would take care to trigger protection switching within the Ethernet linear protection DNI domain to recover traffic via node N3.

When N3 is notified by the adjacent recovery domain that it is isolated, SF-P (or LO) will be generated as a local request to the APS state machine in N3.

In case nodes N2 and N3 are in the DNI normal state, the APS messages generated by MEP 2 in N3 are dropped and this action will have no impact on the protection switching within the Ethernet linear protection DNI domain.

In case nodes N2 and N3 are in the DNI recovery state, the APS protocol running between nodes N1 and N3 would take care to avoid protection switching within the Ethernet linear protection DNI domain such that the traffic is forwarded between the two domains through node N2.

9.2.4 Operator's commands

Operator's commands can be issued only in nodes N1 and N2 and cannot be issued in node N3.

In DNI normal state, APS messages are exchanged between nodes N1 and N2. Operator's commands can be issued at either node N1 or N2, and will be processed following the rules defined in [ITU-T G.8031].

In DNI recovery state, APS messages are exchanged between nodes N1 and N3. Operator's commands can be issued only at node N1, and they will be processed by both nodes N1 and N3 following the rules defined in [ITU-T G.8031]. Node N2 will cancel any operator's commands (including LO) when in DNI recovery state.

9.2.5 Detection and report of node isolation

9.2.5.1 N2 behavior

Node N2 notifies the adjacent recovery domain that it is isolated if and only if a vertical path failure condition (as defined in clause 9.2.3.1.1) is detected and TSF is detected by MEP 1 on the working path. In all the other conditions, N2 does not notify the adjacent recovery domain that it is isolated.

It is worth noting that, in case of a unidirectional failure of the working path between node N2 and N1, node N2 will not notify the adjacent recovery domain that it is isolated.

9.2.5.2 N3 behavior

Node N3 notifies the adjacent recovery domain that it is isolated if and only if a vertical path failure condition (as defined in clause 9.2.3.1.1) is detected and the APS state machine in N3 is in a local or remote SF-P state or in a remote lockout of protection (LO) state.

It is worth noting that, since SF-P and LO are the highest priority APS requests, node N3 can detect all its isolation conditions and properly inform the adjacent recovery domain.

Node N3 notifies the adjacent recovery domain that node N2 is isolated if and only if a vertical path failure condition (as defined in clause 9.2.3.1.1) is detected and the APS state machine in N3 is in a remote SF-W state or in a remote forced switched (FS) or in a remote MS-P state.

It is worth noting that in case of a unidirectional failure of the working path between node N1 and N2, node N3 will not notify the adjacent recovery domain that node N2 is isolated. In case of a unidirectional failure of the working path between node N2 and N1, node N3 will notify the adjacent recovery domain of node N2 being isolated unless an APS request, having higher priority of SF-W and causing protection switching within the Ethernet linear protection DNI domain, exists on the APS state machine in N3: in this case also node N3 is isolated in the Ethernet linear protection DNI domain and the node N3 isolation is notified to the adjacent recovery domain.

9.2.6 Supported failure cases

Table 9-6 describes failure cases supported by this solution.

Table 9-6 – Supported failure cases

Failure cases	Traffic path		
	when N2 and N3 are not isolated in AD	**when N2 is isolated in AD**	**when N3 is isolated in AD**
Normal	N1-N2-AD	N1-N3-AD	N1-N2-AD
N2-N3 path fail	N1-N2-AD	N1-N3-AD	N1-N2-AD
N1-N2 path fail	N1-N3-N2-AD	N1-N3-AD	N1-N3-N2-AD
N1-N3 path fail	N1-N2-AD	see Note 2	N1-N2-AD
N1-N2 and N2-N3 paths fail	N1-N3-AD	N1-N3-AD	see Note 1
N1-N3 and N2-N3 paths fail	N1-N2-AD	see Note 1	N1-N2-AD

NOTE 1 – No traffic path is available between N1 and adjacent recovery domain.

NOTE 2 – The traffic will be disrupted in such case: the two vertical paths usually fail together, so this failure scenario is quite unlikely to happen (see clause 9.2.1).

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