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Metro transport network linear protection

Recommendation ITU-T G.8331

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Recommendation ITU-T G.8331

Metro transport network linear protection

Summary

Recommendation ITU-T G.8331 defines the operation of linear protection switching schemes for the metro transport network path layer, including the automatic protection switching (APS) protocol.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.8331	2022-02-13	15	11.1002/1000/14916

Keywords

APS, linear protection, MTN.

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Metro transport network linear protection

1 Scope

This Recommendation defines the operation of 1+1 end-to-end uni/bidirectional linear protection switching schemes for the metro transport network (MTN) path layer, including the automatic protection switching (APS) protocol. The mechanism is based on the generic linear protection specifications in [ITU-T G.808.1].

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.800] Recommendation ITU-T G.800 (2016), *Unified functional architecture of transport networks*.

[ITU-T G.808] Recommendation ITU-T G.808 (2016), *Terms and definitions for network 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.8312] Recommendation ITU-T G.8312 (2020), *Interfaces for the metro transport network*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

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

3.1.2 active transport entity [ITU-T G.808]

3.1.3 APS protocol: 1-phase [ITU-T G.808]

3.1.4 bridge [ITU-T G.808]

3.1.5 forwarding end point [ITU-T G.800]

3.1.6 head-end [ITU-T G.808]

3.1.7 hold-off timer [ITU-T G.808.1]

3.1.8 non-revertive (protection) operation [ITU-T G.808]

3.1.9 normal traffic signal [ITU-T G.808]

3.1.10 null signal [ITU-T G.808]

3.1.11 permanent bridge [ITU-T G.808]

3.1.12 protected domain [ITU-T G.808]

3.1.13 protection class: individual [ITU-T G.808]

3.1.14 protection class: trail-protection [ITU-T G.808]

3.1.15 protection group [ITU-T G.808]

3.1.16 protection transport entity [ITU-T G.808]

3.1.17 revertive (protection) operation [ITU-T G.808]

3.1.18 selector [ITU-T G.808]

3.1.19 tail-end [ITU-T G.808]

3.1.20 working transport entity [ITU-T G.808]

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

APS Automatic Protection Switching

CRC Cyclic Redundancy Check

DNR Do Not Revert

EXER Exercise

FS Forced Switch

FwEP Forwarding End Point

LO LOckout of protection

MS Manual Switch

MTN Metro Transport Network

MTNP Metro Transport Network Path

NR No Request

SD Signal Degrade

SF Signal Fail

WTR Wait-To-Restore

5 Conventions

None.

6 Protection architecture and characteristics

6.1 Architecture class

In the metro transport network (MTN) path (MTNP), protection is end-to-end and individual trail protection is supported. For a description of individual trail protection, refer to clause 11.1.1 of [ITU-T G.808.1].

6.2 Architecture types

MTNP provides 1+1 protection architecture as described in clause 7.1 of [ITU-T G.808.1].

6.3 Switching types

MTNP provides both unidirectional and bidirectional switching as described in clause 8 of [ITU-T G.808.1].

6.4 Operation types

MTNP linear protection supports both non-revertive and revertive operation types. For descriptions of non-revertive and revertive operation types, refer to clause 9 of [ITU-T G.808.1].

6.5 Protection switching trigger

Protection switching action shall be invoked when any of the following conditions apply:

- Operator control (e.g., Manual Switch (MS), Forced Switch (FS) and Lockout of protection (LO)) is initiated without a higher priority switch request being in effect;
- Signal Fail (SF) or Signal Degrade (SD) is declared on the active transport entity and the hold-off timer has expired, and any higher priority switch request is not in effect;
- A Wait-to-Restore (WTR) timer expires (in revertive operation) without a higher priority switch request being in effect;
- The received APS signal requests to switch and has a higher priority than any other local request.

6.5.1 Signal fail declaration conditions

SF is declared when the MTNP signal fail condition is detected.

6.5.2 Signal degrade declaration conditions

SD is declared when the MTNP signal degrade condition is detected.

7 Protection group commands

Protection group commands, such as LO, FS, MS, Exercise (EXER), Clear, Freeze, and Clear freeze, are provided as described in clause 19 of [ITU-T G.808.1].

8 Automatic protection switching protocol

8.1 Automatic protection switching – specific information format

The APS-specific information is carried over two APS bytes in an APS message. The format of the APS message is defined in [ITU-T G.8312]. The APS-specific information received from the far end is accepted only when the received APS message contains a correct cyclic redundancy check (CRC).

The format of the APS-specific information within each APS message is defined in Figure 8-1.

<table>
<tr><td colspan="8">APS1</td><td colspan="8">APS2</td></tr>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td colspan="4" rowspan="2">Request/
state</td><td colspan="4">Prot. Type</td><td colspan="4" rowspan="2">Requested
signal</td><td colspan="4" rowspan="2">Bridged
signal</td></tr>
<tr><td>A</td><td>B</td><td>D</td><td>R</td></tr>
</table>

Figure 8-1 – APS-specific information format

Table 8-1 describes code points and values for the APS-specific information.

Table 8-1 – Code points and field values

Request/State		1111	Lockout of protection (LO)	Highest priority
		1110	Signal Fail on Protection (SF-P)	↑
		1101	Forced Switch (FS)	|
		1011	Signal Fail on Working (SF-W)	|
		1001	Signal Degrade (SD)	|
		0111	Manual Switch (MS)	|
		0101	Wait-to-Restore (WTR)	|
		0100	Exercise (EXER)	|
		0010	Reverse Request (RR)	|
		0001	Do Not Revert (DNR)	|
		0000	No Request (NR)	Lowest priority
		Others	Reserved	
Protection type	A	0	No APS channel	
		1	APS channel	
	B	0	1+1 (permanent bridge)	
		1	Reserved	
	D	0	Unidirectional switching	
		1	Bidirectional switching	
	R	0	Non-revertive operation	
		1	Revertive operation	
Requested signal		0	Null signal	
		1	Normal traffic signal	
		2-15	Reserved	
Bridged signal		0	Reserved	
		1	Normal traffic signal	
		2-15	Reserved	

For the protection architectures defined in this Recommendation, a 1-phase APS is used.

8.2 Principle of 1-phase APS operation

1-phase APS Protocol is defined in [ITU-T G.808]. The 1+1 linear protection switching algorithm is performed in network elements at both ends of a protected domain. Bidirectional switching is achieved by transmitting local switching requests to the far end via the "Request/State" in the first octet (APS1) of the APS-specific information (see Figure 8-1). The transmitted "Requested Signal" and "Bridged Signal" in the second octet (APS2) of the APS-specific information contain the local bridge/selector status information; a persistent mismatch between both ends may thus be detected and leads to an alarm.

8.3 Revertive mode

In the revertive mode of unidirectional protection switching operation, in conditions where normal traffic signal is being received via the protection transport entity, if local protection switching requests have been previously active and now become inactive, a local WTR state is entered. Since this state now represents the highest priority local request, it is indicated on the transmitted "Request/State" information and maintains the switch.

In the case of bidirectional protection switching, a local WTR state is entered only when there is no higher priority of request received from the far end than that of the WTR state.

This state normally times out and becomes a No Request (NR) state after the WTR timer has expired. The WTR timer is deactivated earlier if any local request of higher priority pre-empts this state.

A switch to the protection transport entity may be maintained by a local WTR state or by a remote request (WTR or other) received via the "Request/State" information. Therefore, in a case where a bidirectional failure for the working transport entity has occurred and subsequent repair has taken place, the bidirectional reversion back to the working transport entity does not take place until WTR timers at both ends have expired.

8.4 Non-revertive mode

In non-revertive mode of unidirectional protection switching operation, in conditions where normal traffic signal is being transmitted via the protection transport entity, if local protection switching requests have been previously active and now become inactive, a local Do Not Revert (DNR) state is entered. This state is indicated on the transmitted "Request/State" information and maintains the switch, thus preventing reversion back to the released selector position in non-revertive mode under NR conditions.

In the case of bidirectional protection switching operation, a local DNR state is entered when there is no higher priority of request received from the far end than that of the DNR state, or when both the local state and far-end state are NR with the requested signal number 1.

8.5 Transmission and acceptance of APS protocol

The APS messages are transported via the protection transport entity only, being inserted by the head-end of the protected domain and extracted by the tail-end of the protected domain. Although it may also be transmitted identically on the working transport entity, receivers should not assume so and should have the capability to ignore this information on the working transport entity.

The APS messages are transmitted in every "A" opportunity within the BABL block insertion pattern defined in [ITU-T G.8312]. Note that the APS message consists of two 66B blocks, and complete messages are always transmitted; if the APS status changes during the transmission of a message, the status is updated in the next message.

If no valid APS-specific information is received, the last valid received information remains applicable except in case of SF condition on the protection transport entity.

8.6 Request type

The request types reflect the highest priority condition, command or state. In the case of unidirectional switching, this is the highest priority value determined from the near end only. In bidirectional switching, the sent "Request/State" shall indicate:

a) A reverse request (RR) if one of the following applies:
   I. the remote request is of higher priority;
   II. the requests are of the same level (and are higher priority than a NR/DNR) and the sent "Request/State" already indicates RR;
   III. the requests are of the same level (and are higher priority than a NR/DNR) and the sent "Request/State2 information does not indicate RR and the remote request indicates a lower requested signal number.

b) The local request in all other cases.

8.7 Protection types

The valid configurations of the protection type are as specified below:

000x: 1+1 unidirectional, no APS

100x: 1+1 unidirectional w/APS

101x: 1+1 bidirectional w/APS

The default value for the protection type is all zeros, i.e., ABDR = 0b0000. Note that when the protection type has the default value, no APS messages are sent.

If the "B" bit mismatches, the selector is released. This will result in a defect.

Provided the "B" bit matches:

a) If the "A" bit mismatches, the side expecting APS will fall back to 1+1 unidirectional switching without APS communication;

b) If the "D" bit mismatches, the bidirectional side will fall back to unidirectional switching;

c) If the "R" bit mismatches, one side will clear switches to "WTR" and the other will clear to "DNR". The two sides will interwork and the traffic is protected;

8.8 Requested signal

This indicates the signal that the near-end requests be carried over the protection transport entity.

For NR and LO, this can only be the null signal (0). For Exercise, this can be the null signal (0) when Exercise replaces NR, or the normal traffic signal (1) in the case where Exercise replaces DNR. For SF or SD, this will be the normal traffic signal, or the null signal to indicate that protection is failed or degraded. For all other requests, this will be the normal traffic signal requested to be carried over the protection transport entity.

8.9 Bridged signal

This indicates the signal that is bridged onto the protection transport entity. For 1+1 protection, the value of this field is always "1" to indicate the normal traffic signal.

8.10 Control of bridge

In 1+1 architectures, the normal traffic signal is permanently bridged to the protection transport entity.

8.11 Control of selector

In 1+1 unidirectional architectures (with or without APS communication), the selector is set entirely according to the highest priority local request.

In 1+1 bidirectional architectures, the normal traffic signal will be selected from the protection transport entity when the outgoing "Requested Signal" indicates the normal traffic signal.

8.12 Signal Fail of the protection transport entity

Signal fail on the protection transport entity (SF-P) is higher priority than any defect that would cause the normal traffic signal to be selected from the protection transport entity. For a case when an APS signal is in use, a SF on the protection transport entity (over which the APS signal is routed) has priority over the FS. LO command has higher priority than SF-P; during failure conditions, lockout status is kept active.

8.13 Equal priority requests

In general, once a switch has been completed due to a request, it will not be overridden by another request of the same priority (first come, first served behaviour). When equal priority requests occur simultaneously, the conflict is resolved in favour of the request with the lower requested signal number. For a 1+1 protection architecture, this is relevant only when APS messages are enabled and for bidirectional switching. For example, SD for the null signal is considered to have higher priority than SD for the normal traffic signal, resulting in both tail-ends selecting the working transport entity. In 1+1 bidirectional switching, a request received over the APS channel with the null signal will always override an identical priority local request with the normal traffic signal. Equal priority requests for the same requested signal number from both sides of a bidirectional protection group are both considered valid, and equivalent to a received "RR" from a near-end processing standpoint.

8.14 Command acceptance and retention

The commands Clear, LO, FS, MS and EXER are accepted or rejected in the context of previous commands, the condition of the working and protection transport entities in a protection group, and (in bidirectional switching only) the received APS information.

The Clear command is only valid if a near-end LO, FS, MS, or EXER command is in effect, or if a WTR state is present at the near end and rejected otherwise. This command will remove the near-end command or WTR state, allowing the next lower priority condition or (in bidirectional switching) APS request to be asserted.

Other commands are rejected unless they are higher priority than the previously existing command, condition or (in bidirectional switching) APS request. If a new command is accepted, any previous, lower priority command that is overridden is forgotten. If a higher priority command overrides a lower priority condition or (in bidirectional switching) APS request, that other request will be reasserted if it still exists at the time the command is cleared.

If a command is overridden by a condition or (in bidirectional switching) APS request, that command is forgotten.

8.15 Hold-off timer

A hold-off timer as defined in [ITU-T G.808.1] is supported. The value is configurable with a suggested range of 0 to 10 seconds in steps of 100 ms (accuracy of ±5 ms).[1]

8.16 Wait-to-restore timer

A WTR timer as defined in [ITU-T G.808.1] is supported. The value is configurable with a suggested range of 5 to 12 minutes in steps of 1 minute. The default is 5 minutes.

8.17 Exercise operation

An Exercise command as defined in [ITU-T G.808.1] is supported. In 1-phase APS protocol, the valid response will be an RR with the corresponding requested and bridged signal numbers. When Exercise commands are input at both ends, an EXER, instead of RR, is transmitted from both ends. The standard response to DNR should be DNR rather than NR. When the exercise command is cleared, it will be replaced with NR or RR if the requested signal number is 0, and DNR or RR if the requested signal number is 1.

8.18 Failure of protocol defects

"Failure of protocol" situations for protection types requiring APS are as follows:

a) Fully incompatible provisioning (the "B" bit mismatch, described in clause 8.7);

b) No match in sent "Requested Signal" and received "Requested Signal" in case of bidirectional switching for > 50 ms;

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[1] There is no lower layer protection in MTN (i.e., no MTNS protection) and MTNP protection is end-to-end (i.e., no upstream path layer protection), so a hold-off timer value greater than 0 may not be needed.

c) Three consecutive APS messages are not received when there are no defects on the protection transport entity.

Fully incompatible provisioning is detected by receiving only one APS message.

If an unknown request or a request for an invalid signal number is received, it will be ignored.

Appendix I

Network objectives

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

The MTN linear protection mechanism protects path layer channels end-to-end. The protection mechanism should meet the following network objectives:

1) MTN linear protection switching should be applicable to a MTNP, which provides connectivity between two forwarding end points (FwEP). Additional detail on the MTNP layer and related atomic functions can be obtained from [b-ITU-T G.8310]. Other entities to be protected are for further study.

2) The protection transport entity should be configured such that 100 per cent of the impaired normal traffic signal should be protected for a failure on a single working channel.

3) The transfer time T_t, as defined in [ITU-T G.808], shall not exceed 50 ms.

4) The path layer working transport entity and protection transport entity should be periodically monitored.

5) Subsequent to a protection switching event, 66B blocks should be delivered in order.

   NOTE – Subsequent to a protection switching event, 66B blocks may temporarily be lost or duplicated due to differential path delay.

6) Revertive and non-revertive switching should be provided as network operator options.

7) A mismatch between the bridge/selector positions of the near end and the far end should be detected.

   – The bridge/selector mismatch for the local network element should be detected and reported.

   – The bridge/selector mismatch should be cleared by a network operator action.

8) Operator requests such as LO, FS and MS commands should be supported.

9) Prioritized protection between SF and operator requests should be supported.

10) A provisionable "generic hold-off function" should be provided so as to delay the beginning of the protection switching action.

11) The path layer linear protection should not affect the switching action in other layers.

Appendix II

Operation example of MTN linear protection protocol

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

Operation examples of 1+1 unidirectional switching (Figure I.1) and 1+1 bidirectional switching (Figure I.2) shown in Appendix I of [ITU-T G.873.1] are applied to MTN linear protection.

Bibliography

[b-ITU-T G.8310] Recommendation ITU-T G.8310 (2020), *Architecture of the metro transport network*.

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