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Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements —

Part 1Q: Bridges and bridged networks

AMENDMENT 1: Path control and reservation

Technologies de l'information — Télécommunications et échange d'information entre systèmes — Réseaux locaux et métropolitains — Exigences spécifiques —

Partie 1Q: Ponts et réseaux pontés

AMENDEMENT 1: Contrôle d'acheminement et réservation

Reference number
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IEEE Std 802.1Qca™-2015
(Amendment to
IEEE Std 802.1Q™-2014
as amended by
IEEE Std 802.1Qcd™-2015 and
IEEE Std 802.1Q-2014/Cor 1-2015)

IEEE Standard for
Local and metropolitan area networks—

Bridges and Bridged Networks

Amendment 24: Path Control and Reservation

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Approved 3 September 2015

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Abstract: Explicit path control, bandwidth reservation, and redundancy (protection, restoration) for data flows are specified in this amendment to IEEE Std 802.1Q-2014.

Keywords: Bridge, Bridged Local Area Network, IEEE 802®, IEEE 802.1Q™, IEEE 802.1Qac™, LAN, local area network, metropolitan area network, Shortest Path Bridging, SPB, Virtual Bridged Local Area Network, virtual LAN

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Introduction

This introduction is not part of IEEE Std 802.1Qca™-2015, IEEE Standard for Local and metropolitan area networks—Bridges and Bridged Networks—Amendment 24: Path Control and Reservation.

This amendment to IEEE Std 802.1Q-2014 specifies protocol extensions, procedures and managed objects for explicit path control, bandwidth reservation, and redundancy (protection, restoration) for data flows.

This standard contains state-of-the-art material. The area covered by this standard is undergoing evolution. Revisions are anticipated within the next few years to clarify existing material, to correct possible errors, and to incorporate new related material. Information on the current revision state of this and other IEEE 802® standards may be obtained from

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1. Overview

1.3 Introduction

Insert the following paragraph and list items at the end of 1.3:

This standard also specifies further protocol extensions, procedures, and managed objects to IS-IS for providing capabilities beyond Shortest Path Bridging (SPB) for Bridged Networks. These extensions involve explicit path control, bandwidth reservation, and redundancy (protection, restoration) for data flows. Thus, this standard specifies bridging on explicit paths for unicast and multicast frames, specifying protocols to determine multiple active topologies. To this end it

ca) Describes the use of explicit trees, e.g., to improve resiliency and decrease the probability of congestion.
cb) Requires that active topologies calculated by one or multiple entities external to the routing protocol are such that the characteristics of the MAC Service are provided.
cc) Supports management selection of explicit trees for support of any given VLAN within an SPT Region.
cd) Specifies Intermediate System to Intermediate System Path Control and Reservation (ISIS-PCR): the use of and extensions to the Intermediate System to Intermediate System (IS-IS) protocol to establish explicit trees.
ce) Specifies the use of ISIS-PCR for recording bandwidth assignments.
cf) Specifies redundancy for ISIS-SPB and ISIS-PCR.

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2. Normative references

Insert the following references into Clause 2 in alphanumeric order:

IETF RFC 5303, Three-way Handshake for IS-IS Point-to-Point Adjacencies, October 2008.[2]

IETF RFC 5305, IS-IS Extensions for Traffic Engineering, October 2008.

IETF RFC 5307, IS-IS Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS), October 2008.

IETF RFC 7810, IS-IS Traffic Engineering (TE) Metric Extensions, 2016.

IETF RFC 7811, An Algorithm for Computing Maximally Redundant Trees for IP/LDP Fast-Reroute, 2016.

[2]IETF documents (i.e., RFCs) are available for download at http://www.rfc-archive.org/.

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3. Definitions

Insert the following terms into Clause 3 in alphabetic order, number them appropriately, and renumber the subsequent terms in the clause accordingly:

3.x Almost Directed Acyclic Graph (ADAG): A directed graph that can be transformed into a Directed Acyclic Graph (DAG) by removing all arcs incoming to the ADAG Root.

3.x Bridge Local Computation Engine (BLCE): A computation engine in a Bridge that performs path and routing computations. The BLCE implements, e.g., Shortest Path First (SPF), Constrained Shortest Path First (CSPF), or the Maximally Redundant Trees Algorithm (IETF RFC 7811).

3.x constrained tree: A tree meeting a certain constraint, e.g., providing a minimal available bandwidth.

3.x constrained routing (CR): Shortest path routing on a topology pruned to only contain the links meeting a given constraint.

3.x Constrained Shortest Path First (CSPF): The phrase for the Dijkstra Shortest Path First Algorithm when it is run after pruning the links not meeting a given constraint.

3.x cut-bridge: A Bridge whose removal partitions the network.

3.x cut-link: A link whose removal partitions the network.

3.x Directed Acyclic Graph (DAG): A directed graph containing no directed cycle.

3.x Explicit Tree (ET): An explicitly defined tree, which is specified by its Edge Bridges and the paths among the Edge Bridges. If only the Edge Bridges are specified but the paths are not, then it is a loose explicit tree. If the paths are also specified, then it is a strict explicit tree.

3.x Explicit Tree Database (ETDB): A database storing explicit trees.

3.x Generalized Almost Directed Acyclic Graph (GADAG): A directed graph that has only Almost Directed Acyclic Graphs (ADAGs) as all of its topology blocks.

3.x Intermediate System to Intermediate System (IS-IS) Path Control and Reservation (ISIS-PCR): IS-IS with the Path Control and Reservation extensions specified by Clause 45 of IEEE Std 802.1Qac-2015.

3.x Loop-Free Alternate (LFA): A loop-free backup path for local repair after a failure event.

3.x Maximally Redundant Trees (MRTs): A pair of trees with a common MRT Root where the path from any leaf Bridge to the MRT Root along the first tree (MRT-Blue) and the path from the same leaf Bridge along the second tree (MRT-Red) share the minimum number of Bridges and the minimum number of links. Each such shared Bridge is a cut-bridge. Any shared links are cut-links. If more than two maximally redundant trees are needed, then they are handled as individual static explicit trees as explained in 45.3.2 of IEEE Std 802.1Qac-2015.

3.x MRT-Blue: One of the two Maximally Redundant Trees (MRTs), specifically, the increasing MRT where links in the Generalized Almost Directed Acyclic Graph (GADAG) are taken in the direction from a lower topologically ordered Bridge to a higher one.

3.x MRT-Red: One of the two Maximally Redundant Trees (MRTs), specifically, the decreasing MRT where links in the Generalized Almost Directed Acyclic Graph (GADAG) are taken in the direction from a higher topologically ordered Bridge to a lower one.

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3.x MRT Root: The common root of the two Maximally Redundant Trees (MRTs), i.e., of MRT-Blue and MRT-Red.

3.x Path Control Agent (PCA): The agent that is part of the Intermediate System to Intermediate System (IS-IS) Domain and thus can perform IS-IS operations on behalf of a Path Computation Element (PCE), e.g., maintain Link State Database (LSDB) and send Link State protocol data units (PDUs) (LSPs).

3.x Path Computation Element (PCE): An entity that is capable of computing a path through a network based on a representation of the network's topology (obtained by undefined means external to the PCE). A PCE is a higher layer entity in a Bridge or an end station.

3.x Point of Local Repair (PLR): A Bridge that locally redirects the data traffic to a backup path, e.g., to a loop-free alternate path after a failure event.

3.x redundant trees: A pair of trees with a common root where the paths from any leaf Bridge to the root along the first tree and the second tree are disjoint.

3.x Shared Risk Link Group (SRLG): A set of links that share a resource whose failure affects each link.

3.x topology block: A maximally two-connected (induced) subgraph, a cut-link with the two Bridges at either end, or an isolated Bridge.

3.x Traffic Engineering Database (TED): A database storing the traffic engineering information propagated by a link state protocol, e.g., Intermediate System to Intermediate System (IS-IS).

3.x Two-connected: A topology that has no cut-bridges. This is a topology that requires at least two Bridges to be removed before it is partitioned.

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4. Abbreviations

Insert the following abbreviations into Clause 4 in alphabetic order:

ADAG	Almost DAG
BLCE	Bridge Local Computation Engine
CR	constrained routing
CSPF	Constrained Shortest Path First
DAG	Directed Acyclic Graph
ET	Explicit Tree
ETDB	Explicit Tree Database
GADAG	Generalized ADAG
ISIS-PCR	IS-IS with Path Control and Reservation extensions
LFA	Loop-Free Alternate
LSDB	Link State Database
LT	Loose Tree
LTS	Loose Tree Set
MO	Managed Object
MRTs	Maximally Redundant Trees
PCE	Path Computation Element
PCA	Path Control Agent
PCR	Path Control and Reservation
PLR	Point of Local Repair
PTP	IEEE 1588™ precision time protocol
SRLG	Shared Risk Link Group
ST	Strict Tree
TAI	Temps Atomic International—International Atomic Time
TED	Traffic Engineering Database

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5. Conformance

Insert the following subclause, 5.4.6, after 5.4.5.2:

5.4.6 Path Control and Reservation (PCR) (optional)

A VLAN Bridge implementation that conforms to the provisions of this standard for PCR in Clause 45 shall

a) Support the IS-IS link state protocol with the extensions for explicit path control (ISIS-PCR) as specified in 45.1;
b) Support the SPB Link Metric sub-TLV as specified in 28.12.7;
c) Support the SPB Base VLAN-Identifiers sub TLV as specified in 28.12.4;
d) Support the SPB Instance sub-TLV as specified in 28.12.5;
e) Support the SPBV MAC address sub-TLV as specified in 28.12.9;
f) Support the SPBM Service Identifier and Unicast Address sub-TLV as specified in 28.12.20;
g) Support the ST ECT Algorithm as specified in 45.1.2 and the use of the ST ECT Algorithm as specified in 45.3.2;
h) Support the Topology sub-TLV, the Hop sub-TLV, and the corresponding ISIS-PCR operations for explicit trees as specified in 45.1;
i) Support the management functionality specified in 12.28.

A VLAN Bridge implementation that conforms to the provisions of this standard for PCR in Clause 45 may

j) Support the LT ECT Algorithm as specified in 45.1.2;
k) Support the LTS ECT Algorithm as specified in 45.1.2
l) Support the MRT ECT Algorithm as specified in 45.3.3;
m) Support the MRTG ECT Algorithm as specified in 45.3.4
n) Support the Administrative Group sub-TLV and the corresponding ISIS-PCR operations as specified in 45.1.11;
o) Support the Bandwidth Constraint sub-TLV and the corresponding ISIS-PCR operations as specified in 45.1.12;
p) Support the Bandwidth Assignment sub-TLV and the corresponding ISIS-PCR operations as specified in 45.2.1;
q) Support the Timestamp sub-TLV as specified in 45.2.2;
r) Support LFA for unicast data flows as specified in 45.3.1;
s) Support the PCR Management Information Base (MIB) objects defined in 17.7.19.

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7. Principles of Virtual Bridged Network operation

Change the introductory text of Clause 7 as shown:

This clause establishes the principles and a model of Virtual Bridged Network operation. It defines the context necessary for

a) The operation of individual VLAN Bridges (Clause 8);
b) Their participation in the Spanning Tree Algorithm and Protocol (STP) (Clause 8 of IEEE Std 802.1D, 1998 Edition [B9]), Rapid Spanning Tree Algorithm and Protocol (RSTP) (Clause 13), Multiple Spanning Tree Algorithm and Protocol (MSTP) (Clause 13), ~~and~~ Shortest Path Bridging (SPB) ~~protocols~~ (Clause 27), and Path Control and Reservation (PCR) (Clause 45) protocols;
c) The management of individual Bridges (Clause 12); and
d) The management of VLAN Topology (Clause 11)

to support, preserve, and maintain the quality of the MAC Service as discussed in Clause 6.

7.1 Network overview

Replace Figure 7-1 with the following figure:

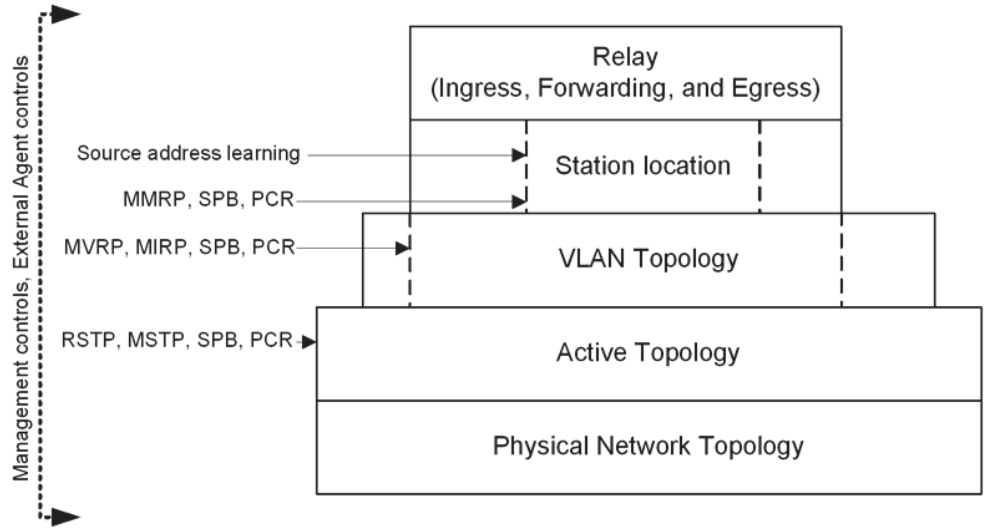

Figure 7-1—VLAN Bridging overview

7.3 Active topology

Change 7.3 as shown:

Bridges cooperate to calculate one or more loop-free and fully connected active topologies, i.e., spanning trees. The algorithms and protocols—RSTP (13.4), MSTP (13.5), SPB (Clause 27), PCR (Clause 45)—that support that calculation provide rapid recovery from network component failure (6.5.1) by using alternate physical connectivity, without requiring management intervention.

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The Bridge's forwarding processes constrain the potential path for each user data frame to a single spanning tree. A Bridge that uses RSTP or STP allocates all frames to a single CST. An MST or SPT Region (13.8, 27.4.1) comprises the transitive closure of Bridges that use MSTP or SPB and that agree on the allocation of frames with a given VID to a given subtree within the region. That subtree can be an MSTI, a SPT, an Explicit Tree (ET), or the IST that is the logical continuation of the CST through the region. Interoperability between MST and SPT Bridges and SST Bridges, and between differently configured MST/SPT Bridges, is achieved by allocating all frames to the CST at region boundaries. Thus the spanning tree for a given frame can comprise subtrees of the CST together with an MSTI or SPT within each region. Frames with different VIDs can be assigned to the same or to different trees and subtrees within a region.

NOTE—In a stable network, the MSTP and SPB algorithms verify that each MST/SPT Region is fully connected internally. However, if the CST Root lies outside the region, the region can be partitioned temporarily as necessary to prevent external connectivity between Bridge Ports at the region boundary from creating a loop. A given region of the network can be an MST Region, an SPT Region, or both, but the protocol mechanisms that verify connectivity internal to the region require that regions do not overlap or subset other regions.

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8. Principles of Bridge operation

8.4 Active topologies, learning, and forwarding

Change the 12th paragraph of 8.4 as follows:

If a B-VLAN is supported by SPBM (Clause 27), the frame is assigned a B-VID value that identifies the frame as subject to SPBM and identifies the B-VLAN and the SPT Set (Clause 3). The SPT is identified (from among those in that set) by the source address of the frame (B-SA) which identifies the SPT root. When ISIS-SPB sets forwarding True for that SPT, a Dynamic Filtering Entry for that B-VID, source address tuple is included in the Filtering Database so that it passes the active topology enforcement check (8.6.1). An individual destination address identifies the SPT that is rooted at that destination and belongs to the SPT Set identified by the VID. If relaxed ingress checking (45.3.1) is supported, then a MAC Address Registration Entry is included in the Filtering Database for that VID, individual destination address tuple if there is any source whose path to the destination in that SPT is via the given Bridge. The Port Map of those MAC Address Registration entries comprises only the ports that are upstream for a given individual destination address (45.3.1). If a B-VLAN is supported by SPBM, learning is disabled for all frames for that B-VID.

8.6.1 Active topology enforcement

Change the 11th paragraph of the introductory text of 8.6.1 as follows:

If the Bridge uses ISIS-SPB and the VID identifies a VLAN supported by SPBM, then for that VID

- Learning is False for all Bridge Ports;
- Forwarding is True for the reception Port if and only if a Dynamic Filtering Entry for the frame's source address exists and specifies Forward for that Port or a MAC Address Registration Entry for the frame's individual destination address exists and specifies Forward for that Port; and
- Forwarding is True for all other Bridge Ports.

Change the 12th paragraph in the introductory text of 8.6.1 as follows:

All Bridges other than SST Bridges implement the MST Configuration Table (8.9.1). The use of VIDs to determine learning and forwarding, as required by this clause shall be consistent with that table as follows. VIDs allocated by the MST Configuration Table (8.9.1) of value

- CIST-MSTID (0x000) are CIST VIDs.
- SPBM-MSTID (0xFFC) are Base VIDs supported by SPBM.
- SPBV-MSTID (0xFFD) are Base VIDs supported by SPBV.
- TE-MSTID (0xFFE) are ESP-VIDs supported by PBB-TE.
- SPVID-Pool-MSTID (0xFFF) are VIDs reserved for use by ISIS-SPB as SPVIDs.
- All VIDs allocated to other values of MSTID are assigned to the MSTI identified by that MSTID.

8.8.9 Querying the FDB

Insert the following paragraph before the first paragraph in 8.8.9:

If a frame is assigned to a VLAN supported by SPBM, then the Filtering Database is queried upon reception of the frame by the ingress port for ingress checking and the frame is forwarded or filtered. If single port admittance ingress checking (6.5.4.2) is applied, then the frame is forwarded only if a Dynamic Filtering Entry for that VID, source address tuple specifies forward for the ingress port; otherwise, the frame is filtered. If relaxed ingress checking (45.3.1) is applied, then the frame is forwarded only if the ingress port is

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in the Port Map of the MAC Address Registration Entry for that VID, individual destination address tuple; otherwise, the frame is filtered.

8.9.3 ID to MSTI Allocation Table

Change 8.9.3 as follows:

The FID to MSTI Allocation Table defines, for all FIDs that the Bridge supports, the MSTID to which the FID is allocated.

a) The IST is identified by the reserved MSTID value 0.
b) The use of PBB-TE is identified by the reserved MSTID value TE-MSTID (0xFFE).
c) Each MSTID in the MSTI List identifies an MSTI.
   The reserved MSTID values 0 and TE-MSTID, SPBV-MSTID, SPBM-MSTID and ~~0xFFF~~SPVID-Pool-MSTID are never used in the MSTI List.
d) The following MSTID values identify the method used to support the VLANs identified by the Base VIDs allocated to those MSTIDs:
   1) 0xFFC—SPBM-MSTID
   2) 0xFFD—SPBV-MSTID
   3) 0xFFF—SPVID-Pool-MSTID: Allocated to FIDs that are not used to filter frames including SPVIDs for SPBV

NOTE—MSTIDs that are present in the MSTI List (12.12) identify spanning tree instances supported by MSTP. MSTIDs identify (indirectly) VLANs that are supported by SPB.

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12. Bridge management

12.25 Shortest Path Bridging managed objects

Replace Figure 12-3 with the following figure:

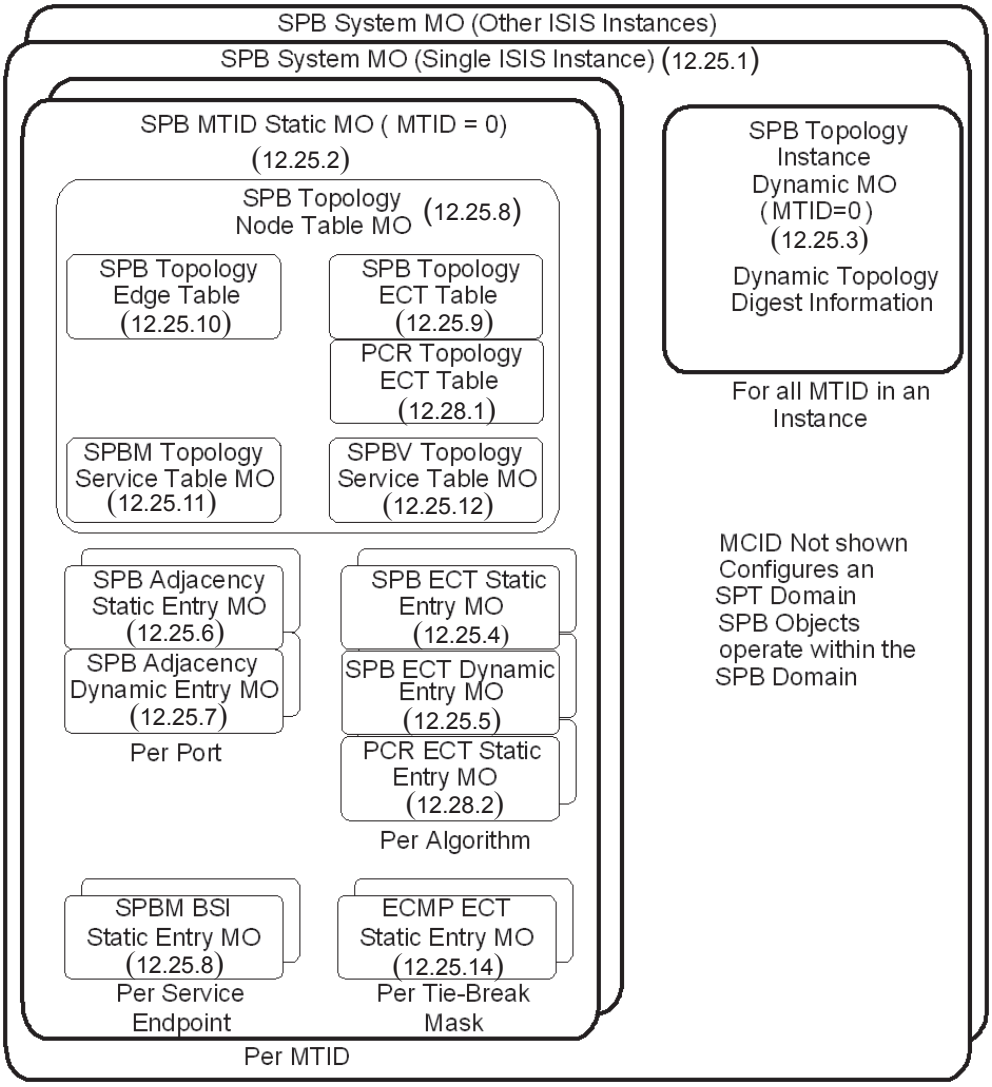

Figure 12-3—SPB managed objects (MOs)

Insert the following items at the end of the lettered list in 12.25:

o) The PCR ECT Static Entry managed object (12.28.1).
p) The PCR Topology ECT Table managed object (12.28.2).

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12.25.4 The SPB ECT Static Entry managed object

12.25.4.1 Create SPB ECT Static Entry managed object

12.25.4.1.2 Inputs

Change items c) and d) of 12.25.4.1.2 as shown:

c) The identifier of the ECT Algorithm (ECT-ALGORITHM) to be used for this Base VID (Table 28-1, Table 44-1, Table 45-1). The Default is the LowPATHID 00-80-C2-01 (28.8).
d) The pre-configured value of the SPVID assigned to this Bridge if operating in SPBV mode. This input is ignored if auto-allocated is selected [12.25.1.2.2, item c)]. This VID value must have been assigned to the ~~reserved MSTID value 0xFFF~~SPVID-Pool-MSTID (27.4) in the FID to MSTI Allocation Managed Object (12.12.2.2).

Insert the following subclause, 12.28, after 12.27.1:

12.28 Path Control and Reservation (PCR) management

The VLAN Bridges that support IS-IS implement the following SPB managed objects because they are required for IS-IS operations in a Bridged Network. Therefore, these SPB managed objects are required for explicit path control via IS-IS, i.e., for PCR operations:

— SPB System managed object (12.25.1),
— SPB MTID Static managed object (12.25.2),
— SPB Topology Instance Dynamic managed object (12.25.3),
— SPB ECT Static Entry managed object (12.25.4),
— SPB ECT Dynamic Entry managed object (12.25.5),
— SPB Adjacency Static Entry managed object (12.25.6),
— SPB Adjacency Dynamic Entry managed object (12.25.7),
— SPBM BSI Static Entry managed object (12.25.8),
— SPB Topology Node Table managed object (12.25.9),
— SPB Topology ECT Table managed object (12.25.10),
— SPB Topology Edge Table managed object (12.25.11),
— SPBM Topology Service Table managed object (12.25.12),
— SPBV Topology Service Table managed object (12.25.13).

The above listed SPB managed objects shall be used to configure PCR operations in SPT Bridges as specified in Clause 45. For instance, if a VLAN is under explicit path control via IS-IS, then the corresponding explicit ECT Algorithm value of Table 45-1 has to be used for the VLAN's Base VID when the SPB ECT Static Entry managed object (12.25.4) is created.

NOTE—The SPBM BSI Static Entry managed object (12.25.8) and the SPBM Topology Service Table managed object (12.25.12) are not required if no backbone Service Instance is present in the SPT Region.

Managed objects dedicated to PCR are needed only for Maximally Redundant Trees (MRTs). Due to the dependence on SPB managed objects, the PCR managed objects are specified as part of the SPB managed object hierarchy as illustrated in Figure 12-3. The following are the PCR managed objects in an SPT Bridge:

a) The PCR ECT Static Entry managed object (12.28.1)
b) The PCR Topology ECT Table managed object (12.28.2)

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The SPVID parameter of an ISIS-SPB sub-TLV and an SPB managed object does not convey Shortest Path VID if it refers to an explicit tree (Clause 45), but the SPVID parameter is used to carry another type of VID as specified by 45.1.3, e.g., an MRT VID. These VIDs are always configured and never auto-allocated.

If the ECT Algorithm takes the value of the LTS ECT Algorithm (Table 45-1) and it is a learning VLAN (45.1.3), i.e., the VLAN's Base VID is allocated to the SPBV-MSTID (0xFFD), then the Bridge's VID [also allocated to the SPBV-MSTID, and not to the SPVID pool (SPVID-Pool-MSTID: 0xFFF) as is done for Shortest Path Bridging operation] has to be configured in place of the SPVID parameter of the SPB ECT Static Entry managed object [12.25.4.1.2, item d)].

If the ECT Algorithm is one of the MRT algorithms (Table 45-1), then MRT VID values are domain-wide for a non-learning VLAN, whereas they are Bridge-local for a learning VLAN. If it is a learning VLAN (45.1.3), i.e., the VLAN's Base VID is allocated to the SPBV-MSTID, then the Bridge's MRT VIDs (also allocated to the SPBV-MSTID) have to be configured as the MRT-Blue VID and MRT-Red VID parameters of the PCR ECT Static Entry managed object (12.28.1). MRT VIDs are configured; they cannot be auto-allocated. The Base VID's SPVID entry in the SPB ECT Static managed object (12.25.2) is ignored for learning VLANs if the MRTs protect each other. If the MRTs protect an SPT for a learning VLAN, then a Shortest Path VID (a real SPVID allocated to the SPVID-Pool-MSTID) has to be associated with the SPT Bridge, in addition to its MRT VIDs, which is provided as specified by 12.25. The Shortest Path VID is configured via the SPB ECT Static Entry managed object (see 12.25.4.1.2, item d)] and its allocation method (automatic or manual) is configured via the SPB System managed object (see 12.25.1.2.2, item c)].

12.28.1 The PCR ECT Static Entry managed object

Each Bridge has one PCR ECT Static Entry managed object per Base VID assigned with MRT operation (45.3.3, 45.3.4). The static Entry contains the MRT VID configuration parameters for the Base VID. It is persistent over reboot. The management operations that can be performed on the ECT Static Entry managed object are as follows:

a) Create a PCR ECT Static Entry managed object (12.28.1.1).
b) Read a PCR ECT Static Entry managed object (12.28.1.2).
c) Write a PCR ECT Static Entry managed object (12.28.1.3).
d) Delete a PCR ECT Static Entry managed object (12.28.1.4).

12.28.1.1 Create PCR ECT Static Entry managed object

12.28.1.1.1 Purpose

To create, configure, and interrogate a PCR ECT Static Entry managed object on a Bridge.

12.28.1.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID. This VID has been allocated either to the SPBM-MSTID (0xFFC) for non-learning VLANs or to the SPBV-MSTID (0xFFD) for learning VLANs in the FID to MSTI Allocation table (12.12.2.2). An SPB ECT Static Entry managed object (12.25.4) has to be created for the Base VID and Topology Index prior to the creation of the PCR ECT Static Entry managed object.
c) The MRT-Blue VID assigned with the Base VID of the corresponding SPB ECT Static Entry managed object. The MRT-Blue VID has to be allocated to the same MSTID as the Base VID. If it is a non-learning VLAN, i.e., the Base VID is allocated to the SPBM-MSTID (0xFFC), and the MRTs are used to protect each other, then the value of the MRT-Blue VID has to take the value of the Base VID. An MRT-Blue VID is always assigned by configuration. In the case of a learning VLAN or if the MRTs protect SPTs of a non-learning VLAN, the values of Base VID, MRT-Blue VID, and MRT-Red VID are all different.

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d) The MRT-Red VID assigned with the Base VID of the corresponding SPB ECT Static Entry managed object. The MRT-Red VID has to be allocated to the same MSTID as the Base VID. An MRT-Red VID is always assigned by configuration.

12.28.1.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because the Topology Index value is not defined.
   2) Operation rejected because the SPB ECT Static Entry managed object does not exist for the Base VID and Topology Index.
   3) Operation rejected because the requested Base VID was not assigned with MRT operation.
   4) Operation rejected due to MRT-Blue VID not allocated to the same MSTID as the Base VID.
   5) Operation rejected due to MRT-Red VID not allocated to the same MSTID as the Base VID.
   6) Operation accepted.

12.28.1.2 Read PCR ECT Static Entry managed object

12.28.1.2.1 Purpose

To obtain information about the PCR ECT Static Entry managed object for a Base VID.

12.28.1.2.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID. The value 4095 is a wildcard indicating that information on any Base VID assigned with MRT operation is requested.

12.28.1.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected.
   2) Operation accepted.
b) A Topology Index value that uniquely identifies this topology instance.
c) A list of <Base VID, MRT-Blue VID, MRT-Red VID> 3-tuples assigned with MRT operation. The list is null if no VLAN is assigned with MRT operation. The list comprises a single 3-tuple if the Base VID parameter is not the wildcard (12.28.1.2.2).

12.28.1.3 Write PCR ECT Static Entry managed object

12.28.1.3.1 Purpose

To configure a PCR ECT Static Entry managed object for a Base VID.

12.28.1.3.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID. This VID has been allocated either to the SPBM-MSTID (0xFFC) for non-learning VLANs, or to the SPBV-MSTID (0xFFD) for learning VLANs in the FID to MSTI Allocation table (12.12.2.2). An SPB ECT Static Entry managed object (12.25.4) has to be created for the Base VID and Topology Index prior to the creation of the PCR ECT Static Entry managed object.
c) The MRT-Blue VID assigned with the Base VID of the corresponding SPB ECT Static Entry managed object. The MRT-Blue VID has to be allocated to the same MSTID as the Base VID. If it is a non-learning VLAN, i.e., the Base VID is allocated to the SPBM-MSTID (0xFFC), and the MRTs are used to protect each other, then the value of the MRT-Blue VID has to take the value of the Base

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VID. An MRT-Blue VID is always assigned by configuration. In the case of a learning VLAN or if the MRTs protect SPTs of a non-learning VLAN, the values of Base VID, MRT-Blue VID, and MRT-Red VID are all different.

d) The MRT-Red VID assigned with the Base VID of the corresponding SPB ECT Static Entry managed object. The MRT-Red VID has to be allocated to the same MSTID as the Base VID. An MRT-Red VID is always assigned by configuration.

12.28.1.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because the Topology Index value is not defined.
   2) Operation rejected because the SPB ECT Static Entry managed object does not exist for the Base VID and Topology Index.
   3) Operation rejected because the requested Base VID was not assigned with MRT operation.
   4) Operation rejected due to MRT-Blue VID not allocated to the same MSTID as the Base VID.
   5) Operation rejected due to MRT-Red VID not allocated to the same MSTID as the Base VID.
   6) Operation accepted.

12.28.1.4 Delete PCR ECT Static Entry managed object

12.28.1.4.1 Purpose

To delete the PCR ECT Static Entry managed object for a Base VID.

12.28.1.4.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID.

12.28.1.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because the Bridge has services currently assigned with this Base VID.
   2) Operation rejected because the SPT Region has services currently using this Base VID.
   3) Operation rejected because PCR ECT Static Entry managed object does not exist for the Base VID.
   4) Operation accepted.

12.28.2 The PCR Topology ECT Table managed object

There is one PCR Topology ECT Table managed object per Bridge per IS-IS topology. It is populated by IS-IS with the nodal ECT parameters discovered for all SPT Bridges participating in that topology within the SPT Region. This object is automatically created as a consequence of the creation of a PCR ECT Static Entry managed object for the given IS-IS topology. It is automatically deleted with the deletion of the last PCR ECT Static Entry managed object for the given IS-IS topology. The management operations that can be performed on the PCR Topology ECT Table managed object are as follows:

a) Read PCR Topology ECT Table managed object.

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12.28.2.1 Read PCR Topology ECT Table managed object

12.28.2.1.1 Purpose

To obtain nodal information from all SPT Bridges of an SPT Region on the binding of Base VIDs to the MRT algorithms in an IS-IS topology.

12.28.2.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The System Identifier of a remote Bridge. The value zero is a wildcard indicating the information on all System identifiers is requested.
c) The Base VID. The value 4095 is a wildcard indicating that information on any Base VID assigned with MRT operation is requested.

12.28.2.1.3 Outputs

A list comprising one entry for each Base VID assigned to MRT operation at a Bridge within the SPT Region that the local IS-IS instance is aware. The list can be empty. Each entry contains the following information about a remote Bridge:

a) The Topology Index value that uniquely identifies this topology instance.
b) The System Identifier of the remote Bridge.
c) The Base VID.
d) The VLAN's operational mode (learning or non-learning).
e) MRT-Blue VID.
f) MRT-Red VID.

If item b) identifies a specific remote Bridge, then the above list comprises one entry per Base VID as specified in item c), containing only information about the specific remote Bridge.

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17. Management Information Base (MIB)

17.2 Structure of the MIB

Change the following row in Table 17-1 as shown:

Table 17-1—Structure of the MIB modules

Module	Subclause	Defining IEEE standard	Reference	Notes
IEEE8021-SPB-MIB	17.2.19, 17.7.19	802.1aq, 802.1Qca	Clause 27, Clause 28, Clause 45	Initial version in IEEE Std 802.1aq; PCR MIB is specified as an extension to IEEE8021-SPB-MIB, initial version in IEEE Std 802.1Qca

17.2.19 Structure of the IEEE8021-SPB-MIB

Insert the following rows at the end of Table 17-25:

Table 17-25—IEEE8021-SPB-MIB structure and relationship to this standard

Clause 17 MIB table/object	Reference
ieee8021PcrEctStaticTable	12.28.1
ieee8021PcrEctStaticTableEntry	12.28.1
ieee8021PcrEctStaticEntryTopIx	12.28.1.1.2
ieee8021PcrEctStaticEntryBaseVid	12.28.1.1.2
ieee8021PcrEctStaticEntryMrtBlueVid	12.28.1.1.2, 45.3.3, 45.3.4
ieee8021PcrEctStaticEntryMrtRedVid	12.28.1.1.2, 45.3.3, 45.3.4
ieee8021PcrEctStaticEntryRowStatus	12.28.2.1.3
ieee8021PcrTopEctTable	12.28.2
ieee8021PcrTopEctTableEntry	12.28.2
ieee8021PcrTopEctEntryTopIx	12.28.2.1.2, 12.28.2.1.3
ieee8021PcrTopEctEntrySysId	12.28.2.1.2, 12.28.2.1.3
ieee8021PcrTopEctEntryBaseVid	12.28.2.1.2, 12.28.2.1.3
ieee8021PcrTopEctEntryMode	12.28.2.1.2, 12.28.2.1.3
ieee8021PcrTopEctEntryMrtBlueVid	12.28.2.1.3, 45.3.3, 45.3.4
ieee8021PcrTopEctEntryMrtRedVid	12.28.2.1.3, 45.3.3, 45.3.4

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17.3 Relationship to other MIBs

Insert the following subclause, 17.3.22, after 17.3.21:

17.3.22 Relationship of the PCR MIB to other MIB modules

PCR configurations are based on the IEEE8021-SPB-MIB because PCR operations are largely based on ISIS-SPB sub-TLVs. The IEEE8021-SPB-MIB provides all that is needed for explicit path control; only MRT operations require extensions. Therefore, the PCR MIB objects and compliance are specified as part of the IEEE8021-SPB-MIB.

17.4 Security considerations

Insert the following subclause, 17.4.22, after 17.4.21:

17.4.22 Security considerations of the PCR MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects can be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described next.

The security considerations described for the EEE8021-SPB-MIB apply to the PCR MIB.

The following PCR MIB objects could be manipulated to interfere with the operation of SPT Bridges. This could, for example, be used to misconfigure the network to cause loss of connectivity or to misdirect traffic. The read-write and/or read-create objects in following table are vulnerable:

ieee8021PcrEctStaticTable

Some of the readable MIB objects (i.e., objects with a MAX-ACCESS other than not accessible) can be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. The following read-only tables with their respective objects in this MIB could be used by an attacker to understand the logical topology of the network:

ieee8021PcrTopEctTable

17.7 MIB modules

17.7.19 Definitions for the IEEE8021-SPB-MIB module

Replace 17.7.19 with the following text:

```
-- ================================================================
--  IEEE 802.1 Shortest Path Bridging (SPB) MIB                   --
-- ================================================================

IEEE8021-SPB-MIB DEFINITIONS ::= BEGIN

IMPORTS
   MODULE-IDENTITY, OBJECT-TYPE, Integer32, Unsigned32
```


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```
        FROM SNMPv2-SMI
    RowStatus, MacAddress, TruthValue, TEXTUAL-CONVENTION
        FROM SNMPv2-TC
    ieee802dot1mibs, IEEE8021PbbIngressEgress,
    IEEE8021BridgePortNumber, IEEE8021PbbServiceIdentifier,
         IEEE8021PbbTeEsp
        FROM IEEE8021-TC-MIB
    ieee8021BridgeBasePort
        FROM IEEE8021-BRIDGE-MIB
    VlanId, VlanIdOrNone, VlanIdOrAny
        FROM Q-BRIDGE-MIB
    dot1agCfmMepEntry, dot1agCfmMdIndex, dot1agCfmMaIndex
        FROM IEEE8021-CFM-MIB
    InterfaceIndexOrZero
        FROM IF-MIB
    SnmpAdminString
        FROM SNMP-FRAMEWORK-MIB
    MODULE-COMPLIANCE, OBJECT-GROUP
        FROM SNMPv2-CONF;

ieee8021SpbMib MODULE-IDENTITY
    LAST-UPDATED "201506230000Z"  -- June 23, 2015
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
         "  WG-URL: http://grouper.ieee.org/groups/802/1/index.html
          WG-EMail: stds-802-1@ieee.org

            Contact: IEEE 802.1 Working Group Chair
             Postal: C/O IEEE 802.1 Working Group
                     IEEE Standards Association
                     445 Hoes Lane
                     Piscataway
                     NJ 08855
                     USA
              E-mail: STDS-802-1-L@LISTSERV.IEEE.ORG"
    DESCRIPTION  "802.1 SPB MIB"

    REVISION  "201506230000Z"  -- June 23, 2015
    DESCRIPTION  "802.1Qca additions"

    REVISION  "201305130000Z"  -- May 13, 2013
    DESCRIPTION  "802.1Qbp additions and corrections"

    REVISION  "201202030000Z"  -- February 3, 2012
    DESCRIPTION  "802.1 Shortest Path Bridging MIB Initial Version"

         ::= { ieee802dot1mibs 26 }

-- ================================================================
--  TYPE DEFINITIONS                                              --
-- ================================================================

IEEE8021SpbAreaAddress ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "1x:"
    STATUS current
    DESCRIPTION
        "This identifier is the 3 Byte IS-IS Area Address.
        Domain Specific part(DSP)."
    REFERENCE "12.25.1.1.2 a), 12.25.1.2.2 a), 12.25.1.3.2 a), 12.25.1.2.2 a)"
```


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```
    SYNTAX OCTET STRING (SIZE(3))

IEEE8021SpbEctAlgorithm ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "1x-"
    STATUS current
    DESCRIPTION
        "The 4 byte Equal Cost Multiple Tree Algorithm identifier.
        This identifies the tree computation algorithm and tie breakers."
    REFERENCE "12.3 q)"
    SYNTAX OCTET STRING (SIZE(4))

IEEE8021SpbMode ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
        "Auto allocation control for this instance
        of SPB. For SPBV it controls SPVIDs and for SPBM it controls
        SPSourceID."
    REFERENCE "27.10"
    SYNTAX INTEGER { auto(1), manual(2) }

IEEE8021SpbEctMode ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
        "The mode of the Base VID assigned for this instance of SPB.
        Modes are assigned in the FID to MSTI Allocation table."
    REFERENCE "12.25.5.1.3 c), 12.25.9.1.3 e)"
    SYNTAX INTEGER { disabled(1), spbm(2), spbv(3) }

IEEE8021SpbDigestConvention ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
        "The mode of the current Agreement Digest. This
        determines the level of loop prevention."
    REFERENCE "28.4.3"
    SYNTAX INTEGER { off(1), loopFreeBoth(2), loopFreeMcastOnly(3) }

IEEE8021SpbLinkMetric ::= TEXTUAL-CONVENTION

    DISPLAY-HINT "d"
    STATUS current
    DESCRIPTION
        "The 24 bit cost of an SPB link. A lower metric
        value means better. Value 16777215 equals Infinity."
    REFERENCE "28.2"
    SYNTAX Integer32(1..16777215)

IEEE8021SpbAdjState ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
        "The current state of this SPB adjacency or port.
        The values are up, down, and testing."
    REFERENCE "12.25.6.1.3 d), 12.25.6.2.3 d), 12.25.7.1.3 (e"
    SYNTAX INTEGER { up(1), down(2), testing(3) }

IEEE8021SpbmSPsourceId ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "1x:"
    STATUS current
    DESCRIPTION
         "It is the high order 3 bytes for Group Address DA from this
```


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