IEEE Standards

IEEE Std 802.1s™-2002
(Amendment to IEEE Std 802.1Q™, 1998 Edition)

802.1s™

IEEE Standards for Local and metropolitan area networks

Virtual Bridged Local Area Networks— Amendment 3: Multiple Spanning Trees

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

This amendment is an approved IEEE Standard. It will be incorporated into the base standard in a future edition.

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Local and metropolitan area networks—

Virtual Bridged Local Area Networks— Amendment 3: Multiple Spanning Trees

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LAN/MAN Standards Committee
of the
IEEE Computer Society

Approved 10 December 2002

IEEE-SA Standards Board

Abstract: This standard extends the architecture, protocols, and algorithms specified in IEEE Std 802.1Q, 1998 Edition, to allow data traffic belonging to different VLANs to be allocated to different spanning trees, while retaining interoperability with bridges conformant to that prior specification.
Keywords: local area networks, media access control (MAC) bridges, MAC bridge management, multiple spanning tree, virtual LANs

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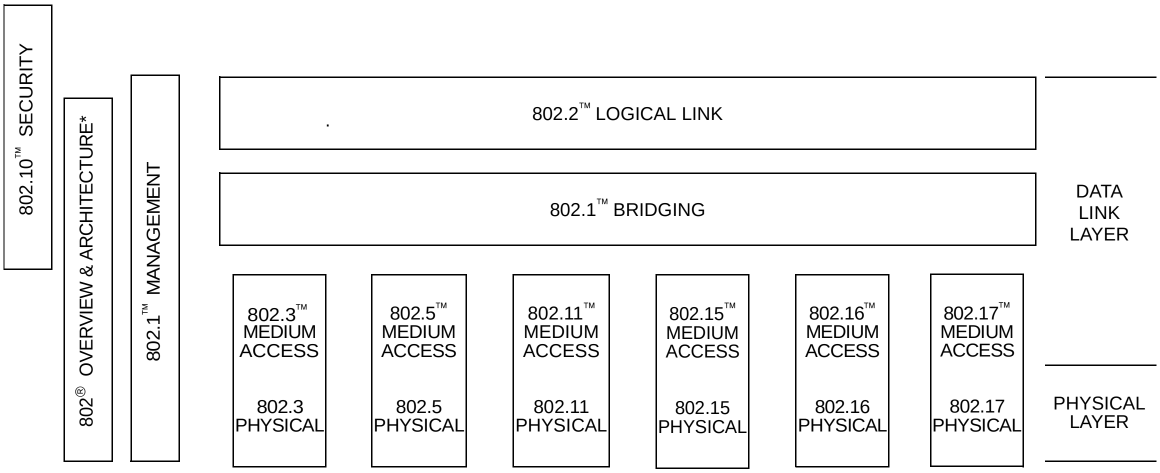
Introduction

[This introduction is not part of IEEE Std 802.1s-2002 (Amendment to IEEE Std 802.1Q, 1998 Edition), IEEE Standard for Local and metropolitan area networks—Virtual Bridged Local Area Networks—Amendment 3: Multiple Spanning Trees.]

IEEE 802.1Q, 1998 Edition, specifies the operation of virtual local area network (VLAN) bridges that support VLAN operation within an IEEE 802 bridged LAN. This amendment extends the scope of IEEE Std 802.1Q, 1998 Edition, to specify the use of multiple spanning trees, with data traffic allocated to spanning trees on the basis of the VLANs to which data frames belong.

This standard is part of a family of standards for local and metropolitan area networks. The relationship between the standard and other members of the family is shown below. (The numbers in the figure refer to IEEE standard designations.[1])



* Formerly IEEE Std 802.1A™.

This family of standards deals with the Physical and Data Link Layers as defined by the International Organization for Standardization (ISO) Open Systems Interconnection Basic Reference Model (ISO/IEC 7498-1:1994). The access standards define several types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. Other types are under investigation.

The standards defining the technologies noted above are as follows:

- IEEE Std 802:[2] *Overview and Architecture*. This standard provides an overview to the family of IEEE 802 Standards. This document forms part of the IEEE Std 802.1 scope of work.

- IEEE Std 802.1B™ and 802.1K™ [ISO/IEC 15802-2]: *LAN/MAN Management*. Defines an Open Systems Interconnection (OSI) management-compatible architecture, and services and protocol elements for use in a LAN/MAN environment for performing remote management.

[1] The IEEE Standards referred to in the above figure and list are trademarks owned by the Institute of Electrical and Electronics Engineers, Incorporated.

[2] The IEEE 802 Overview and Architecture Specification, originally known as IEEE Std 802.1A, has been renumbered as IEEE Std 802. This has been done to accommodate recognition of the base standard in a family of standards. References to IEEE Std 802.1A should be considered as references to IEEE Std 802.

- IEEE Std 802.1D™ — *Media Access Control (MAC) Bridges*. Specifies an architecture and protocol for the [ISO/IEC 15802-3]: interconnection of IEEE 802 LANs below the MAC service boundary.
- IEEE Std 802.1E™ [ISO/IEC 15802-4]: — System Load Protocol. Specifies a set of services and protocol for those aspects of management concerned with the loading of systems on IEEE 802 LANs.
- IEEE Std 802.1F™ — *Common Definitions and Procedures for IEEE 802 Management Information.*
- IEEE Std 802.1G™ [ISO/IEC 15802-5]: — *Remote Media Access Control (MAC) Bridging*. Specifies extensions for the interconnection, using non-LAN systems communication technologies, of geographically separated IEEE 802 LANs below the level of the logical link control protocol.
- IEEE Std 802.1H™ [ISO/IEC TR 11802-5] — *Recommended Practice for Media Access Control (MAC) Bridging of Ethernet V2.0 in IEEE 802 Local Area Networks.*
- IEEE Std 802.1Q™ — *Virtual Bridged Local Area Networks*. Defines an architecture for Virtual Bridged LANs, the services provided in Virtual Bridged LANs, and the protocols and algorithms involved in the provision of those services.
- IEEE Std 802.2 [ISO/IEC 8802-2]: — *Logical Link Control.*
- IEEE Std 802.3 [ISO/IEC 8802-3]: — *CSMA/CD Access Method and Physical Layer Specifications.*
- IEEE Std 802.5 [ISO/IEC 8802-5]: — *Token Ring Access Method and Physical Layer Specifications.*
- IEEE Std 802.10: — *Standard for Interoperable LAN Security (SILS).* Currently approved: Secure Data Exchange (SDE).
- IEEE Std 802.11: [ISO/IEC 8802-11] — *Wireless LAN Medium Access Control (MAC) Sublayer and Physical Layer Specifications.*
- IEEE Std 802.15: — *Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for: Wireless Personal Area Networks.*
- IEEE Std 802.16: — *Standard Air Interface for Fixed Broadband Wireless Access Systems.*
- IEEE Std 802.17: — *Resilient Packet Ring Access Method and Physical Layer Specifications.*

The reader of this standard is urged to become familiar with the complete family of standards.

Conformance test methodology

An additional standards series, identified by the number 1802™, has been established to identify the conformance test methodology documents for the IEEE 802 family of standards. Thus the conformance test documents for IEEE 802.3 are numbered 1802.3™, the conformance test documents for IEEE 802.5 will be 1802.5™, and so on. Similarly, ISO will use 18802 to number conformance test standards for 8802 standards.

Participants

When the IEEE 802.1 Working Group approved this standard, it had the following membership:

Tony Jeffree, *Chair and Editor*
Neil Jarvis, *Vice Chair*
Mick Seaman, *Chair, Interworking Task Group and Editor*
Norm Finn, *Editor*

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The following members of the balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

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Linda Cheng
Keith Chow
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Contents

IEEE Standards for Local and metropolitan area networks—

Virtual Bridged Local Area Networks— Amendment 3: Multiple Spanning Trees

EDITORIAL NOTE—This amendment to IEEE Std 802.1Q™, 1998 Edition, specifies changes to provide multiple spanning trees for VLANs. These changes are defined as a series of additions to, and modifications of, the combined base text that is generated by applying the changes specified in IEEE Std 802.1u™-2001 and IEEE Std 802.1v™-2001 to IEEE Std 802.1Q, 1998 Edition; this amendment therefore assumes all material, including references, abbreviations, definitions, procedures, services, and protocols defined in IEEE Std 802.1Q, 1998 Edition, IEEE Std 802.1u-2001, and IEEE Std 802.1v-2001. References to IEEE Std 802.1D™ assume that the changes specified in IEEE Std 802.1w™-2001 have been applied to IEEE Std 802.1D, 1998 Edition. Text shown in ***bold italics*** in this amendment defines the editing instructions necessary in order to incorporate the modifications and additions into the base text. Three editing instructions are used: ***change***, ***delete***, and ***insert***. ***Change*** is used to make a change to existing material. The editing instruction specifies the location of the change and describes what is being changed. Where necessary to clarify the nature of a change to existing text, ~~strike through~~ markings are used to indicate remove old material, and underscore markings are used to indicate addition of new material). ***Delete*** removes existing material. ***Insert*** adds new material without changing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. Editorial notes will not be carried over into future editions of IEEE Std 802.1Q.

1. Overview

1.1 Scope

Insert the following new bullet points after existing bullet i), and renumber bullet j) accordingly:

j) Defines the operation of the Multiple Spanning Tree algorithm and protocol (MSTP);

k) Defines the enhancements made to the Rapid Spanning Tree Algorithm and Protocol in order to create MSTP;

l) Describes the protocols and procedures necessary to support interoperation between MST and SST Bridges in the same Bridged LAN;

Change the heading of subclause 1.3, and the contents of Table 1-1, as shown:

1.3 Relationship with ~~ISO/IEC 15802-3~~IEEE Std 802.1D

Table 1-1—Relationship between this standard and ~~ISO/IEC 15802-3~~IEEE Std 802.1D

~~ISO/IEC 15802-3~~ IEEE Std 802.1D clause	Use in this standard
5. Conformance	Provision of this standard, as extended by Clause 5
6. Support of the MAC Service	Provision of this standard, as ~~extended~~ modified by Clause ~~7~~6
7. Principles of operation	Replaced by Clause 8
8. The spanning tree algorithm and protocol	Provision of this standard
9. Encoding of bridge protocol data units	Provision of this standard
10. GARP Multicast Registration Protocol (GMRP)	Provision of this standard, as modified by Clause 11
11. Example "C" code implementation of GMRP	Provision of this standard, as modified by Clause 11
12. Generic Attribute Registration Protocol (GARP)	Provision of this standard
13. Example "C" code implementation of GARP	Provision of this standard
14. Bridge management	Replaced by Clause 12
15. Management protocol	Not applicable
16. Bridge performance	Provision of this standard
17. Rapid Spanning Tree Algorithm and Protocol	Provision of this standard, as modified by Clauses 13 and 14
Annex A (normative) PICS proforma	Replaced by Annex A
Annex B (informative) Calculating Spanning Tree parameters	Provision of this standard
Annex C (normative) Source-routing transparent bridge operation	Provision of this standard
Annex D (normative) PICS proforma for source routing transparent bridge operation	Provision of this standard
Annex E (normative) Allocation of Object Identifier values	Not applicable
Annex F (informative) Target topology, migration, and interoperability	Provision of this standard
Annex G (informative) Preserving the integrity of FCS fields in MAC Bridges	Provision of this standard
Annex H (informative) Design considerations for Traffic Class Expediting and Dynamic Multicast Filtering	Provision of this standard

2. References

Insert the following references in appropriate collating sequence:

IEEE Std 802.1u-2001, IEEE Standard for Local and metropolitan area networks—Virtual Bridged Local Area Networks—Amendment 1: Technical and editorial corrections.[1], [2]

IEEE Std 802.1v-2001, IEEE Standard for Local and metropolitan area networks—Virtual Bridged Local Area Networks—Amendment 2: VLAN Classification by Protocol and Port.

IEEE Std 802.1w-2001, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 3: Media Access Control (MAC) Bridges—Amendment 2: Rapid Reconfiguration. [Amendment to IEEE Std 802.1D, 1998 Edition (ISO/IEC 15802-3:1998) and IEEE Std 802.1t-2001]

IEEE Std 802.1X™-2001, IEEE Standards for Local and Metropolitan Area Networks—Port Based Network Access Control.

IETF RFC 2104, HMAC: Keyed-Hashing for Message Authentication, Krawczyk, H., Bellare, M., and R. Canetti, February 1997.[3]

3. Definitions

Insert the following definitions in appropriate collating sequence.

3.21 Boundary Port: A Bridge Port attaching an MST Bridge to a LAN that is not in the same region.

3.22 Common and Internal Spanning Tree (CIST): The single Spanning Tree calculated by STP and RSTP together with the logical continuation of that connectivity through MST Bridges and regions, calculated by MSTP to ensure that all LANs in the Bridged Local Area Network are simply and fully connected.

3.23 Common Spanning Tree (CST): The single Spanning Tree calculated by STP and RSTP, and by MSTP to connect MST Regions.

3.24 Internal Spanning Tree (IST): The connectivity provided by the CIST within a given MST Region.

3.25 Multiple Spanning Tree (MST) Configuration Identifier: A name for, revision level, and a summary of a given allocation of VLANs to Spanning Trees.

NOTE—Each MST Bridge uses a single MST Configuration Table and Configuration Identifier.

3.26 MST Configuration Table: A configurable table that allocates each and every possible VLAN to the Common Spanning Tree or a specific Multiple Spanning Tree Instance.

3.27 Multiple Spanning Tree Algorithm and Protocol (MSTP): The Multiple Spanning Tree Algorithm and Protocol described in Clause 13 of this standard.

3.28 MST Bridge: A Bridge capable of supporting the CST, and one or more MSTIs, and of selectively mapping frames classified in any given VLAN to the CST or a given MSTI.

[1] The IEEE standards referred to in Clause 2 are trademarks owned by the Institute of Electrical and Electronics Engineers, Inc.

[2] IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).

[3] IETF documents are available at http://www.ietf.org.

3.29 MST Region: A set of LANs and MST Bridges physically connected via Ports on those MST Bridges, where each LAN's CIST Designated Bridge is an MST Bridge, and each Port is either the Designated Port on one of the LANs, or else a non-Designated Port of an MST Bridge that is connected to one of the LANs, whose MCID matches exactly the MCID of the Designated Bridge of that LAN.

NOTE—It follows from this definition that the MCID is the same for all LANs and Ports in the Region, and that the set of MST Bridges in the region are interconnected by the LANs.

3.30 Multiple Spanning Tree Bridge Protocol Data Unit (MST BPDU): The MST BPDU specified in Clause 14 of this standard.

3.31 Multiple Spanning Tree Instance (MSTI): One of a number of Spanning Trees calculated by MSTP within an MST Region, to provide a simply and fully connected active topology for frames classified as belonging to a VLAN that is mapped to the MSTI by the MST Configuration Table used by the MST Bridges of that MST Region.

3.32 Rapid Spanning Tree Algorithm and Protocol (RSTP): The Rapid Spanning Tree Algorithm and Protocol described in Clause 17 of IEEE Std 802.1w-2001.

3.33 Rapid Spanning Tree Bridge Protocol Data Unit (RST BPDU): The RST BPDU specified in Clause 9 of IEEE Std 802.1w-2001.

3.34 Single Spanning Tree (SST) Bridge: A Bridge capable of supporting only a single spanning tree, the CST. The single spanning tree may be supported by the Spanning Tree Algorithm and Protocol (STP) defined in IEEE Std 802.1D, 1998 Edition, or by the Rapid Spanning Tree Algorithm and Protocol (RSTP), defined in IEEE Std 802.1w-2001.

3.35 Spanning Tree: A simply and fully connected active topology formed from the arbitrary physical topology of connected Bridged Local Area Network components by relaying frames through selected bridge ports and not through others. The protocol parameters and states used and exchanged to facilitate the calculation of that active topology and to control the bridge relay function.

3.36 Spanning Tree Algorithm and Protocol (STP): The Spanning Tree Algorithm and Protocol described in Clause 8 of IEEE Std 802.1D, 1998 Edition.

3.37 Spanning Tree Bridge Protocol Data Unit (ST BPDU): A Bridge Protocol Data Unit specified for use by the Spanning Tree Algorithm and Protocol, i.e. a Configuration or Topology Change Notification BPDU as described in Clause 9 of IEEE Std 802.1D, 1998 Edition.

4. Abbreviations

Insert the following abbreviations, in the appropriate collating sequence.

CIST	Common and Internal Spanning Tree
CST	Common Spanning Tree
IST	Internal Spanning Tree
MCID	MST Configuration Identifier
MST	Multiple Spanning Tree
MST BPDU	Multiple Spanning Tree Bridge Protocol Data Unit
MSTI	Multiple Spanning Tree Instance
MSTP	Multiple Spanning Tree Protocol
RST BPDU	Rapid Spanning Tree Bridge Protocol Data Unit
RSTP	Rapid Spanning Tree Protocol

SST	Single Spanning Tree
ST BPDU	Spanning Tree Bridge Protocol Data Unit
STP	Spanning Tree Protocol

5. Conformance

5.1 Static conformance requirements

Change list item a) as follows:

a) Conform to the requirements of IEEE Std 802.1D ~~ISO/IEC 15802-3~~ and IEEE Std 802.1w, as modified by the provisions of this standard;

Insert a new list item and sub-items at the end of the numbered list, and a NOTE, as follows, renumbering the existing NOTE as NOTE 1:

j) A MAC bridge for which conformance to the provisions of this standard for an MST Bridge is claimed (5.2, 13) shall:
   1) Support the Multiple Spanning Tree Algorithm and Protocol, (MSTP) as specified in Clause 13 and the attendant conformance requirements stated in Clause 5 of IEEE Std 802.1w-2001;
   2) Support the CIST plus a stated maximum number of MSTIs, where that number is at least 2 (8.10.7) and at most 64 (13.14);

NOTE 2—In other words, a conformant MST Bridge must support a minimum of three spanning tree instances—the CIST and at least two additional MSTIs.

   3) Support a stated maximum number of FIDs that is at least as large as the number of MSTIs supported (8.10.7);
   4) Support the ability to associate each FID to a spanning tree (8.11.3);
   5) Support the transmission and reception of MST Configuration Identifier information (8.11.2).
   6) For each Port, be capable of supporting a set of port-state information for each spanning tree instance supported (8.4.1, 8.4.2, 13.34);
   7) For each Port, be capable of supporting an instance of the Spanning Tree Protocol and its associated parameters for each spanning tree instance supported (8.12, 13);
   8) Use the Bridge Group Address as specified in 8.14.3;
   9) Support the default values for Bridge Forward Delay and Bridge Priority parameters specified in 13.23;
   10) Support the operation of GVRP in each supported spanning tree context (11.2.3.3, 11.2.3.4);
   11) Support the VLAN bridge management functions for the bridge protocol entity for each supported spanning tree, independently (12.8)
   12) Support, in particular, management of the bridge priority parameters, and of the port priority and path cost parameters for every port, independently for each supported spanning tree (12.8.1.1, 12.8.1.3, 13.24);
   13) Support the VLAN management functions for each supported spanning tree (12.10.1 and 12.11.1);
   14) Support management of the MSTI configuration (12.12).

5.2 Options

Insert two new list items at the end of the numbered list (note that IEEE Std 802.1u-2001, IEEE Std 802.1v-2001 have added items l, m, and n to this list):

o) Support MST operation (7, 8.4.1, 8.4.2, 8.6.2, 8.10.7, 8.11, 8.12, 8.14.3, 11.2.3.4, 11.3.1, 13, 14.);
p) A MAC bridge for which support of MSTP is claimed (13) may support a greater number of FIDs than spanning trees (8.10.7).

Delete the existing contents of Clause 6, rename the clause and insert replacement contents as shown below.

6. Support of the MAC Service in VLANs

The provisions of Clause 6 of IEEE Std 802.1D apply to this standard, with the additions and modification defined in this clause.

6.1 Support of the MAC service

The MAC Service provided to end stations attached to a Virtual Bridged LAN is the (unconfirmed) connectionless mode MAC Service defined in ISO/IEC 15802-1. The MAC Service is defined as an abstraction of the features common to a number of specific MAC Services; it describes the transfer of user data between source and destination end stations, via MA-UNITDATA request primitives and corresponding MA-UNITDATA indication primitives issued at MAC Service access points. Each MA-UNITDATA request and indication primitive has four parameters: Destination Address, Source Address, MAC Service data unit (MSDU), and Priority.

The style of VLAN Bridge operation maximizes the availability of the MAC Service to end stations and assists in the maintenance of the Virtual Bridged LAN. It is therefore desirable that VLAN Bridges be capable of being configured in the Virtual Bridged LAN:

a) So as to provide redundant paths between end stations to enable the Virtual Bridged LAN to continue to provide the Service in the event of component failure (of VLAN Bridge or LAN).
b) So that the paths supported between end stations are predictable and configurable given the availability of Virtual Bridged LAN components.

The operation of VLAN Bridges supports the provision of the MAC Service only to devices that are authenticated and authorized for such use. Unauthorized devices may be denied access to the Virtual Bridged LAN, other than as necessary to support the protocol exchanges that are required by any authentication process that is supported.

NOTE—Authentication and authorization to access a LAN may be achieved by administrative or management mechanisms, or by means of an active authorization mechanism, such as is defined in IEEE Std 802.1X-2001.

6.2 Preservation of the MAC service

The MAC Service offered by a Virtual Bridged LAN consisting of LANs interconnected by VLAN Bridges is similar to that offered by a single LAN (see 6.3). In consequence,

a) A VLAN Bridge is not directly addressed by communicating end stations, except as an end station for management purposes: frames transmitted between end stations carry the MAC Address of the peer-end station in their Destination Address field, not the MAC Address, if any, of the VLAN Bridge.

b) All MAC Addresses must be unique within any set of VLANs supported by the Virtual Bridged LAN that share the same Filtering Identifier (FID).
c) The MAC Addresses of end stations are not restricted by the topology and configuration of the Virtual Bridged LAN.

6.3 Quality of service maintenance

6.3.1 Service availability

Service availability is measured as that fraction of some total time during which the MAC Service is provided. The operation of a VLAN Bridge can increase or lower the service availability.

The service availability can be increased by automatic reconfiguration of the Virtual Bridged LAN in order to avoid the use of a failed component (e.g., repeater, cable, or connector) in the data path. The service availability can be lowered by failure of a VLAN Bridge itself, through denial of service by the VLAN Bridge, or through frame filtering by the VLAN Bridge. Changes in topology, caused by component failures, the addition or removal of components, or by administrative changes, are detected and signalled by the following means:

a) Physical detection of component failure and signalling of that failure by the Enhanced Internal Sublayer Service (6.4 and 6.5);
b) Detection of component failure through the operation of a spanning tree algorithm and protocol;
c) Explicit signalling of reconfiguration events through the operation of a spanning tree algorithm and protocol.

Automatic reconfiguration can be achieved rapidly on the detection of a physical topology change (see Clause 17 of IEEE Std 802.1w-2001), thus minimizing any service denial that is caused by the reconfiguration.

A VLAN Bridge may deny service and discard frames (6.3.2) in order to preserve other aspects of the MAC Service (6.3.3 and 6.3.4) when automatic reconfiguration takes place. Service may be denied to end stations that do not benefit from the reconfiguration; hence, the service availability is lowered for those end stations. VLAN Bridges may filter frames in order to localize traffic in the Virtual Bridged LAN. Should an end station move, it may then be unable to receive frames from other end stations until the filtering information held by the VLAN Bridges is updated.

To minimize the effects of service denial caused by reconfiguration events, filtering information that has been dynamically learnt can be modified when automatic reconfiguration takes place, or in preparation for future reconfiguration events (Clause 17 and 17.10 of IEEE Std 802.1w-2001). However, filtering information that is statically configured cannot be modified in this way.

A VLAN Bridge may deny service and discard frames in order to prevent access to the network by devices that are not authorized for such access.

To maximize the service availability, no loss of service or delay in service provision should be caused by VLAN Bridges, except as a consequence of a failure, removal, or insertion of a Virtual Bridged LAN component, or as a consequence of the movement of an end station, or as a consequence of an attempt to perform unauthorized access. These are regarded as extraordinary events. The operation of any additional protocol necessary to maintain the quality of the MAC Service is thus limited to the configuration of the Virtual Bridged LAN, and is independent of individual instances of service provision.

NOTE 1—This is true only in circumstances where admission control mechanisms are not present, i.e., where the VLAN Bridges provide a “best effort” service. The specification and applicability of admission control mechanisms in VLAN Bridges is outside the scope of this standard.

NOTE 2—The operation of management upon the Bridge can result in the Bridge being reset, either as a result of a specific Bridge reset operation, or as a consequence of manipulating the Bridge's configuration. From the point of view of service availability, resetting the Bridge is an extraordinary event that has a similar effect to physical removal of the Bridge from the Virtual Bridged LAN, followed by reinsertion of the Bridge into the Virtual Bridged LAN.

6.3.2 Frame loss

The MAC Service does not guarantee the delivery of Service Data Units. Frames transmitted by a source station arrive, uncorrupted, at the destination station with high probability. The operation of a VLAN Bridge introduces minimal additional frame loss.

A frame transmitted by a source station can fail to reach its destination station as a result of

a) Frame corruption during physical layer transmission or reception.
b) Frame discard by a VLAN Bridge because
    1) It is unable to transmit the frame within some maximum period of time and, hence, must discard the frame to prevent the maximum frame lifetime (6.3.6) from being exceeded.
    2) It is unable to continue to store the frame due to exhaustion of internal buffering capacity as frames continue to arrive at a rate in excess of that at which they can be transmitted.
    3) The size of the service data unit carried by the frame exceeds the maximum supported by the MAC procedures employed on the LAN to which the frame is to be relayed.
    4) Changes in the connected topology of the Virtual Bridged LAN necessitate frame discard for a limited period of time to maintain other aspects of Quality of Service (see 8.3.3 of IEEE Std 802.1D, 1998 Edition, and 17.9 of IEEE Std 802.1w-2001).
    5) The device attached to the Port is not authorized for access to the network.
    6) The configuration of Static Filtering Entries or Static VLAN Registration Entries in the Filtering Database (8.11.1, 8.11.2) disallows the forwarding of frames with particular destination addresses or VLAN classifications on specific Ports.

NOTE—As Static Filtering Entries and Static VLAN Registration Entries are associated with particular Ports or combinations of Ports, there is a possibility that mis-configuration of such entries will lead to unintended frame discard during or following automatic reconfiguration of the Virtual Bridged LAN.

6.3.3 Frame misordering

The MAC Service (9.2 of ISO/IEC 15802-1) permits a negligible rate of reordering of frames with a given user priority for a given combination of destination address and source address, transmitted on a given VLAN. MA_UNITDATA.indication service primitives corresponding to MA_UNITDATA.request primitives, with the same requested priority and for the same combination of VLAN classification, destination and source addresses, are received in the same order as the request primitives were processed.

NOTE 1—The operation of the Forwarding Process in VLAN Bridges (8.7) is such that the frame-ordering characteristics of the MAC Service are preserved.

Where VLAN Bridges in a Virtual Bridged LAN are capable of connecting the individual MACs in such a way that multiple paths between any source station–destination station pairs exist, the operation of a protocol is required to ensure that a single path is used.

NOTE 2—Where STP is in use (see Clause 8 of IEEE Std 802.1D, 1998 Edition), frame misordering cannot occur during normal operation. Where RSTP is in use (see Clause 17 of IEEE Std 802.1w-2001), there is an increased probability that frames that are in transit through the Virtual Bridged LAN will be misordered, due to the fact that a VLAN Bridge can buffer frames awaiting transmission through its Ports. The probability of misordering occurring as a result of such an event is dependent upon implementation choices, and is associated with Spanning Tree reconfiguration events. Some known LAN protocols, for example, LLC Type 2, are sensitive to frame duplication; in order to allow VLAN Bridges that support RSTP to be used in environments where sensitive protocols are in use, the forceVersion parameter (17.16.1 of IEEE Std 802.1w-2001) can be used to force a VLAN Bridge that supports RSTP to operate in an STP-compatible manner. A more detailed discussion of misordering in RSTP can be found in F.2.4 of IEEE Std 802.1w-2001.

6.3.4 Frame duplication

The MAC Service (9.2 of ISO/IEC 15802-1) permits a negligible rate of duplication of frames. The operation of VLAN Bridges introduces a negligible rate of duplication of user data frames.

The potential for frame duplication in a Virtual Bridged LAN arises through the possibility of duplication of received frames on subsequent transmission within a VLAN Bridge, or through the possibility of multiple paths between source and destination end stations.

Where VLAN Bridges in a Virtual Bridged LAN are capable of connecting the individual MACs in such a way that multiple paths between any source station–destination station pairs exist, the operation of a protocol is required to ensure that a single path is used.

NOTE—Where RSTP is in use (see Clause 17 of IEEE Std 802.1w-2001), there is an increased probability that a Spanning Tree reconfiguration event can cause frames that are in transit through the Virtual Bridged LAN to be duplicated, due to the fact that a VLAN Bridge can buffer frames awaiting transmission through its Ports. As the probability of duplication occurring as a result of such an event is small, and the frequency of Spanning Tree reconfiguration events is also small, the degradation of the properties of the MAC service caused by this source of frame duplication is considered to be negligible. A more detailed discussion of frame duplication in RSTP can be found in F.2.4 of IEEE Std 802.1w-2001.

6.3.5 Transit delay

The MAC Service introduces a frame transit delay that is dependent on the particular media and MAC method employed. Frame transit delay is the elapsed time between an MA_UNITDATA.request primitive and the corresponding MA_UNITDATA.indication primitive. Elapsed time values are calculated only on Service Data Units that are successfully transferred.

Since the MAC Service is provided at an abstract interface within an end station, it is not possible to specify precisely the total frame transit delay. It is, however, possible to measure those components of delay associated with media access and with transmission and reception; and the transit delay introduced by an intermediate system, in this case a VLAN Bridge, can be measured.

The minimum additional transit delay introduced by a VLAN Bridge is the time taken to receive a frame plus that taken to access the media onto which the frame is to be relayed. Note that the frame is completely received before it is relayed as the Frame Check Sequence (FCS) is to be calculated and the frame discarded if in error.

6.3.6 Frame lifetime

The MAC Service ensures that there is an upper bound to the transit delay experienced for a particular instance of communication. This maximum frame lifetime is necessary to ensure the correct operation of higher layer protocols. The additional transit delay introduced by a VLAN Bridge is discussed in 6.3.5.

To enforce the maximum frame lifetime, a VLAN Bridge may be required to discard frames. Since the information provided by the MAC Sublayer to a VLAN Bridge does not include the transit delay already experienced by any particular frame, VLAN Bridges must discard frames to enforce a maximum delay in each VLAN Bridge.

The value of the maximum bridge transit delay is based on both the maximum delays imposed by all the VLAN Bridges in the Virtual Bridged LAN and the desired maximum frame lifetime. A recommended and an absolute maximum value are specified in Table 8-2 of IEEE Std 802.1D, 1998 Edition.

6.3.7 Undetected frame error rate

The MAC Service introduces a very low undetected frame error rate in transmitted frames. Undetected errors are protected against by the use of an FCS that is appended to the frame by the MAC Sublayer of the source station prior to transmission, and checked by the destination station on reception.

The FCS calculated for a given service data unit is dependent on the MAC method employed. It is therefore necessary to recalculate the FCS within a VLAN Bridge providing a relay function between IEEE 802 MACs of dissimilar types if differences in the method of calculation and/or the coverage of the FCS, or changes to the data that is within the coverage of the FCS, would lead to a different FCS being calculated for the service data unit by the two MAC methods. This introduces the possibility of additional undetected errors arising from the operation of a VLAN Bridge. For frames relayed between LANs of the same MAC type, the VLAN Bridge shall not introduce an undetected frame error rate greater than that which would have been achieved by preserving the FCS.

NOTE—Application of the techniques described in Annex G of IEEE Std 802.1D, 1998 Edition, allow an implementation to achieve an arbitrarily small increase in undetected frame error rate, even in cases where the data that is within the coverage of the FCS is changed. As a maintenance activity on this standard, revision of the wording of this requirement will be initiated, with a view to placing a quantitative limit on the increase in undetected frame error rate that is acceptable in a conformant implementation.

6.3.8 Maximum Service Data Unit Size

The Maximum Service Data Unit Size that can be supported by an IEEE 802 LAN varies with the MAC method and its associated parameters (speed, electrical characteristics, etc.). It may be constrained by the owner of the LAN. The Maximum Service Data Unit Size supported by a VLAN Bridge between two LANs is the smaller of that supported by the LANs. No attempt is made by a VLAN Bridge to relay a frame to a LAN that does not support the size of Service Data Unit conveyed by that frame.

6.3.9 Priority

The MAC Service includes user priority as a Quality of Service parameter. MA_UNITDATA.request primitives with a high priority may be given precedence over other request primitives made at the same station, or at other stations attached to the same LAN, and can give rise to earlier MA_UNITDATA.indication primitives.

The MAC Sublayer maps the requested user priorities onto the access priorities supported by the individual MAC method. The requested user priority may be conveyed to the destination station.

The transmission delay experienced by a frame in a VLAN Bridge can be managed by associating a user_priority with the frame.

The transmission delay comprises

a) A queuing delay until the frame becomes first in line for transmission on the Port, in accordance with the procedure for selecting frames for transmission described in 8.7.4;
b) The access delay for transmission of the frame.

Queueing delays can be managed using user_priority. Access delays can be managed using user_priority in MAC methods that support more than one access priority.

The user priority associated with a frame can be signaled by means of the priority signaling mechanisms inherent in some IEEE 802 LAN MAC types. Since not all IEEE 802 LAN MAC types are able to signal the user priority associated with a frame, VLAN Bridges regenerate user priority based upon a combination of signaled information and configuration information held in the VLAN Bridge.

The VLAN Bridge maps the user priority onto one or more traffic classes; VLAN Bridges that support more than one traffic class are able to support expedited classes of traffic. The Forwarding Process, 7.7 8.7, describes the use of user priority and traffic classes in VLAN Bridges. Given the constraints placed upon frame misordering in a VLAN Bridge, as expressed in 6.3.3, the mappings of priority and traffic class are static.

NOTE 1—The term Traffic Class, as used in this standard, is used only in the context of the operation of the priority handling and queueing functions of the Forwarding Process, as described in 8.7. Any other meanings attached to this term in other contexts do not apply to the use of the term in this standard.

The ability to signal user_priority in IEEE 802 LANs allows user_priority to be carried with end-to-end significance across a Virtual Bridged LAN. This, coupled with a consistent approach to the mapping of user_priority to traffic classes, and of user_priority to access_priority, allows consistent use of user_priority information to be made, according to the capabilities of the VLAN Bridges and MAC methods that are involved in the transmission path.

NOTE 2—This standard defines a frame format and associated procedures that can be used to carry user priority information across LAN MAC types that are not able to signal user priority. Use of the 802.1Q frame format allows the end-to-end significance of user_priority to be maintained regardless of the ability of individual LAN MAC types to signal priority.

Under normal circumstances, user_priority is not modified in transit through the relay function of a VLAN Bridge; however, there may be some circumstances where it is desirable for management purposes to control how user_priority is propagated. The User Priority Regeneration Table (Table ~~7-1~~ 8-1) provides the ability to map incoming user_priority values on a per-Port basis, under management control. In its default state, this table provides an identity mapping from user_priority values to Regenerated user_priority values; i.e., by default, the Regenerated user_priority is identical to the incoming user_priority.

6.3.10 Throughput

The total throughput provided by a Virtual Bridged LAN can be significantly greater than that provided by an equivalent single LAN. VLAN Bridges may localize traffic within the Virtual Bridged LAN by filtering frames. Filtering services available in Virtual Bridged LANs are described in 6.6 of IEEE Std 802.1D, 1998 Edition.

The throughput between end stations on individual LANs, communicating through a VLAN Bridge, can be lowered by frame discard in the VLAN Bridge due to the inability to transmit at the required rate on the LAN forming the path to the destination for an extended period.

6.4 Enhanced Internal Sublayer Service provided within VLAN Bridges

The Enhanced Internal Sublayer Service (E-ISS) is derived from the Internal Sublayer Service (ISS, defined in 6.4 of IEEE Std 802.1D, 1998 Edition) by augmenting that specification with elements necessary to the operation of the tagging and untagging functions of the VLAN Bridge. Within the attached end station, these elements can be considered to be either below the MAC Service boundary, and pertinent only to the operation of the service provider; or local matters not forming part of the peer-to-peer nature of the MAC Service.

Bridges that support these functions are known as *VLAN-aware Bridges* (3.17). The E-ISS defines the MAC Service provided to the relay function in VLAN-aware Bridges.

The relationships between the MAC Entity, the ISS, the E-ISS, and the MAC Relay Entity in a VLAN-aware Bridge are illustrated in Figure 6-1 and Figure 8-3.

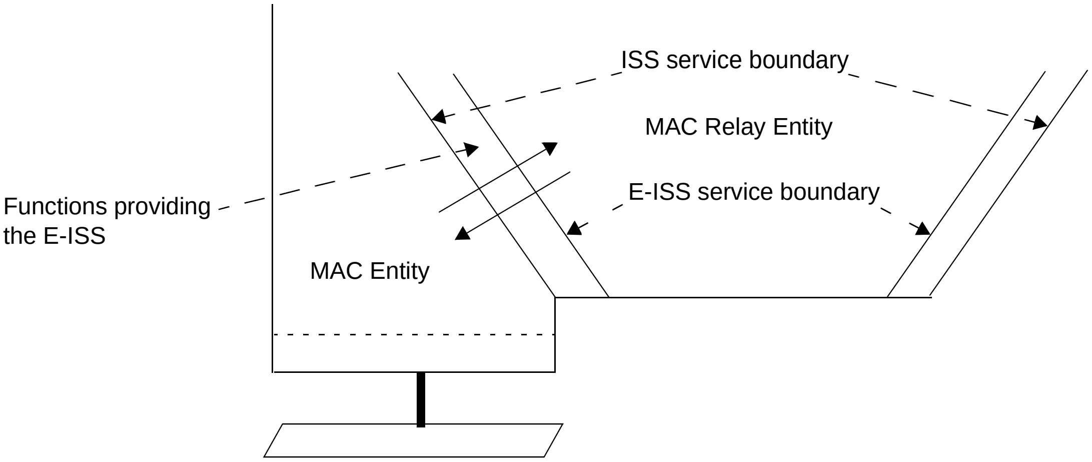


Figure 6-1—Relationships between MAC Entity, ISS, E-ISS, and MAC Relay Entity

6.4.1 E-ISS service definition

The unit-data primitives that define this service are

```
EM_UNITDATA.indication    (
                          frame_type,
                          mac_action,
                          destination_address,
                          source_address,
                          mac_service_data_unit,
                          user_ priority,
                          frame_check_sequence,
                          canonical_format_indicator,
                          vlan_identifier,
                          rif_information (optional)
                          )
```

Each data indication primitive corresponds to the receipt of a M_UNITDATA.indication primitive from the Internal Sublayer Service, as defined in 6.4 of IEEE Std 802.1D, 1998 Edition.

The **frame_type, mac_action, destination_address, source_address, mac_service_data_unit, user_ priority,** and **frame_check_sequence** parameters are as defined for the M_UNITDATA.indication primitive of the Internal Sublayer service.

The **canonical_format_indicator** parameter indicates whether embedded MAC Addresses carried in the mac_service_data_unit parameter are in Canonical format or Non-canonical format. The value False indicates Non-canonical format. The value True indicates Canonical format.

NOTE—The meanings of the terms Canonical format and Non-canonical format are discussed in Annex F.

The **vlan_identifier** parameter carries the VLAN identifier associated with the indication.

The **rif_information** parameter is present if a tag header was present in the indication, and if that tag header contained a Routing Information Field (RIF). Its value is equal to the value of the RIF.

```
EM_UNITDATA.request        (
                           frame_type,
                           mac_ action,
                           destination_address,
                           source_address,
                           mac_service_data_unit,
                           user_priority,
                           access_priority,
                           frame_check_sequence,
                           canonical_format_indicator,
                           vlan_classification,
                           rif_information (optional),
                           include_tag
                           )
```

A data request primitive is invoked in order to generate a M_UNITDATA.request primitive, as defined in the Internal Sublayer Service, 6.4 of IEEE Std 802.1D, 1998 Edition.

The **frame_type, mac_action, destination_address, source_address, mac_service_data_unit, user_priority, access_priority,** and **frame_check_sequence** parameters are as defined for the M_UNITDATA.request primitive of the Internal Sublayer service.

The definition of the **canonical_format_indicator** parameter is as defined for the EM_UNITDATA.indication.

The vlan_classification parameter carries the VLAN classification assigned to the frame by the forwarding process (8.6.1).

The **rif_information parameter**, if present, carries the value of any RIF information to be associated with the request.

The **include_tag** parameter carries a Boolean value. True indicates to the service provider that the mac_service_data_unit parameter of the data request shall include a tag header (9.3). False indicates that a tag header shall not be included.

6.4.2 Support of the E-ISS in VLAN-aware Bridges

6.4.2.1 Data indication primitives

On receipt of a data indication from the Internal Sublayer Service, an EM_UNITDATA.indication primitive is invoked, with parameter values as follows:

The **frame_type, mac_action, destination_address, source_address,** and **frame_check_sequence** parameters carry values equal to the corresponding parameters in the received data indication.

NOTE 1—The **mac_action** parameter only ever takes the value request_with_no_response for frames relayed by the Bridge. The **frame_check_sequence** parameter of the data indication carries the FCS value contained in the received frame. The original FCS associated with a frame is invalidated if there are changes to any fields of the frame, if fields are added or removed, or if bit ordering or other aspects of the frame encoding have changed. An invalid FCS is signalled in the E-ISS by an unspecified value in the frame_check_sequence parameter of the data request primitive. This signals the need for the FCS to be regenerated according to the normal procedures for the transmitting MAC. The options for regenerating the FCS under these circumstances are discussed in Annex G of IEEE Std 802.1D, 1998 Edition.

The value of the **mac_service_data_unit** parameter is determined as follows:

a) If the received mac_service_data_unit parameter contained a tag header (9.3), then the value used is equal to the value of the received mac_service_data_unit following removal of the tag header. Otherwise;
b) The value used is equal to the value of the received mac_service_data_unit.

The value of the **user_priority** parameter is determined as follows:

c) If the received mac_service_data_unit parameter contained a tag header (9.3), then the value contained in the user_priority field of the tag header is used. Otherwise;
d) The value of the received user_ priority parameter, regenerated as defined in 8.5.1 and 6.4 of IEEE Std 802.1D, 1998 Edition, is used.

The value of the **canonical_format_indicator** parameter is determined as follows:

e) If the received mac_service_data_unit parameter contained a tag header (9.3), then the value(s) contained in the Canonical Format Indicator (CFI) (and Non-Canonical Format Indicator [NCFI], if present) field(s) of the tag header are used to determine this parameter value, in accordance with the definition of the CFI and NCFI field(s) in Clause 9. Otherwise;
f) If the MAC entity that received the data indication was an ISO/IEC 8802-5 Token Ring MAC, then the parameter carries the value False. Otherwise;
g) The parameter carries the value True.

The value of the **vlan_identifier** parameter is determined as follows:

h) If the initial octets of the received mac_service_data_unit parameter contained a tag header (9.3), then the value contained in the VID field of the tag header is used. Otherwise;
i) A value equal to the null VLAN ID (as defined in Table 9-2) is used.

The value of the **rif_information** parameter is determined as follows:

j) If the initial octets of the received mac_service_data_unit parameter contained a tag header (9.3), and that tag header contained a RIF field in which one or more route descriptors were present, then the value contained in the RIF field is used. Otherwise;
k) The parameter is not present.

NOTE 2—This field can be present only in tag headers received using the 802.3/Ethernet or transparent FDDI MAC methods. The presence of one or more route descriptors indicates that there is source-routing information present in the received frame.

6.4.2.2 Data request primitives

On invocation of a data request primitive by a user of the E-ISS, an M-UNITDATA.request primitive is invoked, with parameter values as follows:

The **frame_type, mac_action, destination_address, source_address, user_priority,** and **access_priority** parameters carry values equal to the corresponding parameters in the received data request.

If the value of the **include_tag** parameter is False, the value of the mac_service_data_unit parameter is determined as follows:

a) If the destination MAC method is the same as the MAC method on which the corresponding data indication was received, then the value used is equal to the value of the mac_service_data_unit parameter received in the data request. Otherwise;

b) The value used is equal to the value of the mac_service_data_unit parameter received in the data request, modified, if necessary, in accordance with the procedures described in ISO/IEC 11802-5, IETF RFC 1042, and IETF RFC 1390.

c) If the canonical_format_indicator parameter indicates that the mac_service_data_unit may contain embedded MAC Addresses in a format inappropriate to the destination MAC method, then the Bridge shall either

    1) Convert any embedded MAC Addresses in the mac_service_data_unit to the format appropriate to the destination MAC method; or

    2) Discard the EISS data request without issuing a corresponding ISS data request.

If the value of the **include_tag parameter** is True, then a tag header, formatted as necessary for the destination MAC method, is inserted as the first N octets of the mac_service_data_unit parameter. The values of the user_priority, canonical_format_indicator, vlan_classification, and rif_information (if present) parameters are used to determine the contents of the tag header, in accordance with the structure defined in 9.2 and 9.3. The value inserted after the tag header is determined as follows:

d) If the destination MAC method is the same as the MAC method on which the corresponding data indication was received, then the value used is equal to the value of the mac_service_data_unit parameter received in the data request. Otherwise;

e) The value used is equal to the value of the mac_service_data_unit parameter received in the data request, modified, if necessary, in accordance with the procedures described in ISO/IEC 11802-5, IETF RFC 1042, and IETF RFC 1390.

The value of the **frame_check_sequence** parameter is determined as follows:

f) If the frame_check_sequence parameter received in the data request is either unspecified or still carries a valid value, then that value is used. Otherwise;

g) The value used is either derived from the received FCS information by modification to take account of the conditions that have caused it to become invalid, or the unspecified value is used.

NOTE—The original FCS associated with a frame is invalidated if there are changes to any fields of the frame, if fields are added or removed, or if bit ordering or other aspects of the frame encoding have changed. An invalid FCS is signalled in the E-ISS by an unspecified value in the frame_check_sequence parameter of the data request primitive. This signals the need for the FCS to be regenerated according to the normal procedures for the transmitting MAC. The options for regenerating the FCS under these circumstances are discussed in Annex G of IEEE Std 802.1D, 1998 Edition.

6.5 Support of the Internal Sublayer Service by IEEE Std 802.3 (CSMA/CD)

In addition to the provisions of 6.5.1 of IEEE Std 802.1D, 1998 Edition, on receipt of an M_UNITDATA.request primitive that represents a tagged frame, the implementation is permitted to adopt either of the following approaches with regard to the operation of Transmit Data Encapsulation for frames whose length would, using the procedure as described, be less than 68 octets:

a) Use the procedure as described in 6.5.1 of IEEE Std 802.1D, 1998 Edition. This can result in tagged frames of less than 68 octets (but at least 64 octets) being transmitted; or

b) Include additional octets before the FCS field in order for the transmitted frame length for such frames to be 68 octets. This results in a minimum tagged frame length of 68 octets.

When a tagged frame of less than 68 octets in length is received on a CSMA/CD LAN segment, and is forwarded as an untagged frame, the provisions of 6.5.1 of IEEE Std 802.1D, 1998 Edition, result in additional octets being included before the FCS field on transmission in order that the transmitted frame length meets the minimum frame size requirements of 3.2.7 in IEEE Std 802.3, 1998 Edition.

Delete the existing contents of Clause 7, rename the clause and insert replacement contents as shown below.

7. Principles of network operation

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

a) the operation of individual Bridges (Clause 8);
b) their participation in the Spanning Tree (Clause 8 of IEEE Std 802.1D, 1998 Edition), Rapid Spanning Tree (Clause 17 of IEEE Std 802.1w-2001), or Multiple Spanning Tree Protocol (Clause 13);
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

The operation of a Virtual Bridged Local Area Network, the Bridges, and the LANs, that compose that network comprises:

a) A physical topology comprising LANs, Bridges, and Bridge Ports. Each Bridge Port attaches a LAN to a Bridge and is capable of providing bidirectional connectivity for MAC user data frames. Each LAN is connected to every other LAN by a Bridge and zero or more other LANs and Bridges.
b) Calculation of one or more active topologies, each a loop-free subset of the physical topology.
c) Rules for the classification of MAC user data frames that allow each Bridge to allocate, directly or indirectly, each frame to one and only one active topology.
d) Management control of the connectivity provided for differently classified data frames by the selected active topology.
e) Implicit or explicit configuration of end station location information, identifying LANs with attached end stations that need to receive user data frames with a given destination address.
f) Communication of end station location information to allow Bridges to restrict user data frames to LANs in the path provided to their destination(s) by the chosen active topology.

These elements and their interrelationships are illustrated in Figure 7-1.

NOTE 1—The physical and active topologies can be represented as bi-partite graphs. Bridges and LANs are nodes in these graphs (including LANs that are point-to-point links) and the Bridge Ports are edges.

NOTE 2—This standard applies the notion of a physical topology to media access control methods, like wireless, where there is no tangible physical connection between a Bridge and an attached LAN. A Bridge Port models this association just as for wired connectivity.

NOTE 3—Each of the active topologies [(b) above] does not necessarily span the entire network, but does span all those Bridges and LANS between which data frame connectivity is desired for frames allocated to that active topology.

NOTE 4—The destination addressing information associated with a MAC user data frame includes the VLAN classification of the frame [see (d) above].

NOTE 5—Implicit configuration [(d) above], or recognition, of end station location includes observation of the source address of the user data frame transmitted by that station. The user data frame itself communicates that location information [(e) above] along the portion of the chosen active topology leading to the frame’s destination(s).

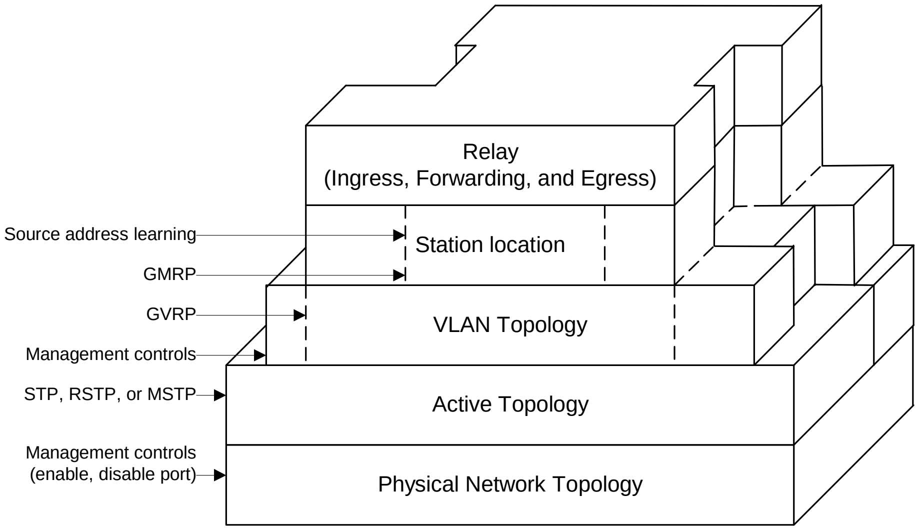


Figure 7-1—VLAN Bridging overview

7.2 Use of VLANs

Virtual Local Area Networks (VLANs) and their VLAN Identifiers (VIDs) provide a convenient and consistent network wide reference for Bridges to:

a) identify rules for the classification of user data frames into VLANs;
b) effectively extend the source and destination MAC addresses, by treating frames and addressing information for different VLANs independently.
c) identify and select from different active topologies;
d) identify the configuration parameters that partition or restrict access from one part of the network to another.

Taken together these capabilities allow VLAN aware Bridges to emulate a number of separately manageable, or virtual, Bridged Local Area Networks. A LAN segment that has been selected by network management to receive frames assigned to a given VLAN is said to form part of, belong to, or be a member of the VLAN. Similarly, end stations that are attached to those LAN segments and that can receive frames assigned to the VLAN are said to be attached to that VLAN.

NOTE—Separate control over the transmission and over the reception of frames to and from LAN segments and end stations is possible. To avoid ambiguity VLAN membership is defined by reception.

Inclusion of the VID in VLAN-tagged frames guards against connectivity loops arising from differing classifications by different Bridges, and permits enhanced classification rules to be used by some Bridges while others simply forward the previously classified frames.

The VLAN tag allows frames to carry priority information, even if the frame has not been classified as belonging to a particular VLAN.

7.3 VLAN Topology

Each Bridge cooperates with others to operate a spanning tree protocol to calculate, one or more loop free-fully connected active topologies, This calculation supports the quality of the MAC Service (Clause 6) and provides rapid recovery from network component failure, by using alternate physical connectivity, without requiring management intervention.

All user data frames classified as belonging to a given VLAN are constrained by the forwarding process of each Bridge to a single active topology. Each and every VLAN is thus associated with a spanning tree, although more than one VLAN can be associated with any given tree. Each VLAN may occupy the full extent of the active topology of its associated spanning tree or a connected subset of that active topology. The maximum extent of the connected subset may be bounded by management by explicitly excluding certain Bridge Ports from a VLAN's connectivity.

At any time the current extent of a VLAN can be further reduced from the maximum to include only those LAN segments that provide communication between attached devices, by the use of protocol that allows end stations to request and release services that use the VLAN. Such a protocol is specified in Clause 11. The dynamic determination of VLAN extent provides flexibility and bandwidth conservation, at the cost of network management complexity.

NOTE 1—Dynamic determination of VLAN extent is generally preferable to static configuration for bandwidth conservation, as the latter is error prone and can defeat potential alternate connectivity-requiring active management intervention to recover from network component failure.

NOTE 2—To accommodate end stations that do not participate in the GVRP protocol specified in Clause 11, management controls associated with each Bridge Port allow the Port to identify the attached LAN segment as connecting end stations that require services using specified VLANs.

7.4 Locating end stations

Functioning as a distributed system, Bridges within the current extent of a VLAN can, through explicit and or implicit cooperation, locate those LAN segments where an attached end station or end stations are intended to receive frames addressed to a specified individual address or group address. Bridges can thus reduce traffic by confining frames to the LAN segments where their transmission is necessary.

NOTE 1—Individually Bridges do not determine the precise location of end stations, but merely determine which of their Bridge Ports need to forward frames towards the destination(s). For the system of Bridges this is sufficient to restrict frames to the paths necessary to reach the destination segments.

The multicast registration protocol (GMRP), specified in Clause 10 of IEEE Std 802.1D, 1998 Edition, allows end stations to advertise their presence and their desire to join (or leave) a multicast group in the context of a VLAN. The protocol communicates this information to other Bridges, using the VLAN and its active topology.

NOTE 2—To accommodate end stations that do not participate in GMRP, management controls associated with each Bridge Port allow the Port to identify the attached LAN segment as connecting end stations that are intended to receive specified group addresses. The continuous operation of GMRP and the propagation of location information through Bridges using the current active topology for the VLAN support multicast traffic reduction, while ensuring rapid restoration of multicast connectivity without management intervention if alternate connectivity is selected following network component failure.

Each end station implicitly advertises its attachment to a LAN segment and its individual MAC address whenever it transmits a frame. Bridges learn from the source address as they forward the frame along the active topology to its destination or destinations – or throughout the VLAN if the location of the destination or destinations is unknown. The learnt information is stored in the Filtering Database used to filter frames on the basis of their destination addresses.

The Filtering Database architecture defined in this standard recognizes that

a) For some configurations, it is necessary to allow address information learned in one VLAN to be shared among a number of VLAN's. This is known as *Shared VLAN Learning* (3.9);
b) For some configurations, it is desirable to ensure that address information learned in one VLAN is not shared with other VLANs. This is known as *Independent VLAN Learning* (3.5);
c) For some configurations, it is immaterial as to whether learned information is shared between VLANs or not.

NOTE 1—Annex B discusses the need for Shared and Independent VLAN Learning, and also some of the related interoperability issues.

Shared VLAN Learning is achieved by including learned information from a number of VLANs in the same Filtering Database; Independent VLAN Learning is achieved by including information from each VLAN in distinct Filtering Databases.

NOTE 2—The actual Filtering Database specification specifies a single Filtering Database that, through the inclusion of VLAN identification information in each database entry, can model the existence of one or more distinct Filtering Databases.

Within a given VLAN-Bridged LAN, there may be a combination of configuration requirements, so that individual VLAN Bridges may be called upon to share learned information, or not share it, according to the requirements of particular VLANs or groups of VLANs. The Filtering Database structure that is defined in this standard allows both Shared and Independent VLAN Learning to be implemented within the same VLAN Bridge; i.e., allows learned information to be shared between those VLANs for which Shared VLAN Learning is necessary, while also allowing learned information not to be shared between those VLANs for which Independent VLAN Learning is necessary. The precise requirements for each VLAN with respect to sharing or independence of learned information (if any) are made known to VLAN Bridges by means of a set of *VLAN Learning Constraints* (8.10.7.2) and fixed allocations of VLANs to filtering databases (8.10.7.1), which may be configured into the Bridges by means of management operations. By analyzing the set of learning constraints and fixed allocations for the VLANs that are currently active, the Bridge can determine

d) How many independent Filtering Databases are required in order to meet the constraints;
e) For each VLAN, which Filtering Database it will feed any learned information into (and use learned information from).

The manner in which this mapping of VLANs onto Filtering Databases is achieved is defined in 8.10.7; the result is that each VLAN is associated with exactly one Filtering Database.

The most general application of the Filtering Database specification in this standard is a Bridge that can support M independent Filtering Databases, and can map N VLANs onto each Filtering Database. Such a Bridge is known as an SVL/IVL Bridge (3.11).

The conformance requirements in this standard (5.1, 5.2) recognize that VLAN Bridges will be implemented with differing capabilities in order to meet a wide range of application needs, and that the full generality of the SVL/IVL approach is not always either necessary or desirable, as observed in the discussion in Annex B. In a given conformant implementation, there may be restrictions placed upon the number of Filtering Databases that can be supported, and/or the number of VLANs that can be mapped onto each Filtering Database. The full spectrum of conformant Filtering Database implementations is therefore as follows:

f) The SVL/IVL Bridge, as described above. Such Bridges provide support for M Filtering Databases, with the ability to map N VLANs onto each one;
g) Support for a single Filtering Database only. MAC Address information that is learned in one VLAN can be used in filtering decisions taken relative to all other VLANs supported by the Bridge. Bridges that support a single Filtering Database are referred to as SVL Bridges;

h) Support for multiple Filtering Databases, but only a single VLAN can be mapped onto each Filtering Database. MAC Address information that is learned in one VLAN cannot be used in filtering decisions taken relative to any other VLAN. Bridges that support this mode of operation are referred to as IVL Bridges.

7.5 Ingress, Forwarding, and Egress Rules

The relay function provided by the Forwarding Process (8.6) of each individual Bridge controls:

a) Classification of each received frame as belonging to one and only one VLAN, and discard or acceptance of the frame for further processing on the basis of that classification and the received frame format, which can be one of three possible types:
    1) Untagged, and not explicitly identifying the frame as belonging to a particular VLAN;
    2) Priority-tagged, i.e., including a tag header conveying explicit user priority information but not identifying the frames as belonging to a specific VLAN;
    3) VLAN-tagged, i.e., explicitly identifying the frames as belonging to a particular VLAN.

    This aspect of relay implements the *ingress* rules.
b) Implementation of the decisions governing where each frame is to be forwarded as determined by the current extent of the VLAN topology (7.3), station location information (7.4), and the additional management controls specified in Clause 8. This aspect of relay implements the *forwarding* rules.
c) Determination of the appropriate frame format type, VLAN-tagged or untagged, for transmission through the selected Bridge Ports. This aspect of relay implements the *egress* rules.

The structuring of the relay functionality into the implementation of ingress, forwarding, and egress rules constitutes a generic approach to the provision of VLAN functionality. All VLAN-aware Bridges can correctly forward received frames that are already VLAN-tagged. These are classified as belonging to the VLAN identified by the VID in the tag header. All VLAN-aware Bridges can also classify untagged and priority-tagged frames received on any given port as belonging to a specified VLAN. In addition to this default Port-based ingress classification, this standard specifies an optional Port-and-Protocol-based classification.

The classification of untagged and priority-tagged frames, and the addition or removal of tag headers, is part of the relay functionality of a VLAN-aware Bridge and is only performed on frames that can be forwarded through other Bridge Ports. To facilitate coexistence with Bridges conforming to IEEE Std 802.1D, 1998 Edition, frames that carry control information to determine the active topology and current extent of each VLAN, i.e., spanning tree and GVRP BPDUs, are not forwarded. Permanently configured static entries in the filtering database (8.2, 8.3, and 8.13) ensure that such frames are discarded by the Forwarding Process (8.6).

NOTE 1—GARP PDUs destined for any GARP application are forwarded or filtered depending upon whether the application concerned is supported by the bridge, as specified in 8.13.

The forwarding rules specified for VLAN-tagged frames facilitate the interoperation of bridges conformant to this standard with end stations that directly support attachment of MAC service users to VLANs by transmitting VLAN-tagged frames, and with Bridges that are capable of additional proprietary ingress classification methods.

NOTE 1—Additional ingress classification methods may be the subject of future standardization.

NOTE 2—This classification of untagged and priority-tagged frames is part of the functionality of the MAC relay entity (Figure 8-3, Figure 8-4), and is therefore only of significance for received frames that are potentially to be forwarded through other Ports of the Bridge (see Spanning Tree).

Frames transmitted on a given LAN segment by a VLAN-aware Bridge for a given VLAN shall be either

d) All untagged; or
e) All VLAN tagged with the same VID.

NOTE 4—In other words, a Bridge can transmit untagged frames for some VLANs and VLAN-tagged frames for other VLANs on a given link, but cannot transmit using both formats for the same VLAN. The single format rule only applies to the frame transmission behavior of individual VLAN-aware stations; i.e., it does not express a requirement for a Bridge to police the behavior of the other stations attached to a segment and enforce a single format.

Delete the existing contents of Clause 8, rename the clause and insert replacement contents as shown below.

8. Principles of bridge operation

This clause establishes the principles of operation of a VLAN-aware Bridge, by reference to a model of that operation, as follows:

a) Explains the principal elements of Bridge operation and lists the functions that support these.
b) Establishes an architectural model for a Bridge that governs the provision of these functions.
c) Provides a model of the operation of a Bridge in terms of the processes and entities that support the functions.
d) Details the addressing requirements in a Bridged LAN and specifies the addressing of entities in a Bridge.

The provisions of this clause replace the provisions of Clause 7 of IEEE Std 802.1D, 1998 Edition in a VLAN-aware Bridge.

8.1 Bridge operation

The principal elements of Bridge operation are

a) Relay and filtering of frames.
b) Maintenance of the information required to make frame filtering and relaying decisions.
c) Management of the above.

8.1.1 Relay

A MAC Bridge relays individual MAC user data frames between the separate MACs of the Bridged LANs connected to its Ports. The order of frames shall be preserved as defined in 8.6.5.

The functions that support the relaying of frames and maintain the Quality of Service supported by the Bridge are

a) Frame reception.
b) Discard on received frame in error (6.3.2).
c) Frame discard if the frame_type is not user_data_frame, or if its mac_action parameter is not request_with_no_response (8.5, 6.4).
d) Regeneration of user priority, if required (6.4).
e) Application of VLAN ingress rules to classify each received frame to a particular VLAN (8.6.1).
f) Frame discard if the frame is not classified or the receiving port does not accept frame from that VLAN.
g) Frame discard following the application of filtering information.

h) Frame discard on transmittable service data unit size exceeded (6.3.8).
i) Forwarding of received frames to other Bridge Ports.
j) Frame discard following the application of VLAN egress rules if the service data unit cannot be mapped correctly or the receiving port does not transmit frames to the particular VLAN to which the frame belongs.
k) Selection of traffic class, following the application of filtering information.
l) Queuing of frames by traffic class.
m) Frame discard to ensure that a maximum bridge transit delay is not exceeded (6.3.6).
n) Selection of queued frames for transmission.
o) Selection of outbound access priority (6.3.9).
p) Mapping of service data units and recalculation of Frame Check Sequence, if required (8.6.9, 6.3.7).
q) Frame transmission.

8.1.2 Filtering and relaying information

A Bridge maintains filtering and relaying information for the following purposes:

a) Prevention of frame duplication: to ensure that frame duplication does not occur, by maintaining a loop-free logical topology;
b) Traffic segregation: to separate communication by different sets of users or groups of users of the Bridged LAN;
c) Traffic reduction: to confine frames to those parts of the Bridged LAN that lie on the path(s) between their source and destination(s);
d) Traffic expediting: to classify frames in order to expedite time critical traffic;
e) Conversion of frame formats: to present frames in a format (tagged or untagged) that is appropriate for the destination LAN and its attached stations.

8.1.2.1 Prevention of frame duplication

A Bridge filters frames, i.e., does not relay frames received by a Bridge Port to other Ports on that Bridge, in order to prevent the duplication of frames (6.3.4). The functions that support the use and maintenance of information for this purpose are

a) Configuration and calculation of Bridged LAN topology.
b) In MST Bridges, explicit configuration of the relationship between VIDs and spanning trees (8.11).

8.1.2.2 Traffic segregation

A Bridge can filter frames to confine them to the LAN segments that belong to the VLAN to which they are assigned, and thus define the VLAN's maximum extent (7.3). The functions that support the use and maintenance of information for this purpose are

a) Explicit configuration of the Ingress Rules associated with each Port (8.4, 8.6.1 8.9):
    1) Configuration of <commentRef>PVID for each Port, to associate a VID with untagged and priority-tagged frames;
    2) In Bridges implementing Port-and-Protocol based classification, the configuration of a VID for untagged and priority-tagged frames for each protocol;
    3) Enabling or disabling the application of Static VLAN Registration Entries to received frames through configuration of the Enable Ingress Filtering parameter;
b) Explicit configuration of the Egress Rules associated with each Port (8.6.4):
    1) Configuration of Static VLAN Registration Entries.

A Bridge can filter frames to partially partition a Virtual Bridged Local Area Network. Frames assigned to any given VLAN and addressed to specific end stations or groups of end stations can be excluded from relay to certain Bridge Ports. The functions that support the use and maintenance of information for this purpose are:

c) Permanent configuration of Reserved Addresses (Table 8-10);
d) Configuration of Static Filtering Entries (8.10.1) and Group Registration Entries (8.10.4).

NOTE—The use of VLANs is generally less error prone and is preferred to filtering using destination addresses if a Bridged Local Area Network is to be partitioned for reasons of scale, efficiency, management, or security. Destination address filtering is the only mechanism available to Bridges that are not VLAN aware.

8.1.2.3 Traffic reduction

A Bridge can filter frames to confine them to LAN segments that either have end stations attached to their assigned VLAN or that connect those LAN segments, and thus define the current practical extent of the VLAN (7.4). LANs not attaching to or forming part of the path between the source and destination(s) of any given communication do not have to support the transmission of related frames, potentially improving the quality of the MAC service for other communications. The functions that support the use and maintenance of information for this purpose are:

a) Automatic learning of dynamic filtering information for unicast destination addresses through observation of source addresses of frames, together with the ageing out or flushing of that information to support the movement of end stations and changes in active topology;
b) Ageing out or flushing of dynamic filtering information that has been learned;
c) Automatic inclusion and removal of Bridge Ports in the VLAN, through configuration of Dynamic VLAN Registration Entries by means of GVRP (8.10.5 and 11.2);
d) Explicit configuration of management controls associated with the operation of GVRP by means of Static VLAN Registration Entries (8.10.2 and 11.2);
e) Automatic configuration of Group Registration Entries by means of GMRP exchanges;
f) Explicit configuration of the management controls associated with the operation of GMRP by means of Group Registration Entries.

8.1.2.4 Traffic expediting

A Bridge classifies frames into traffic classes in order to expedite transmission of frames generated by critical or time-sensitive services. The function that supports the use and maintenance of information for this purpose is

a) Explicit configuration of traffic class information associated with the Ports of the Bridge.

8.1.2.5 Conversion of frame formats

A Bridge adds and removes tag headers (9.3) from frames, and performs the associated frame translations that may be required, in accordance with the egress rules (8.6.4). The function that supports the use and maintenance of information for this purpose is

a) Explicit configuration of tagging requirements on egress for each Port (8.10.2 and 8.10.9).

8.1.3 Bridge management

The functions that support Bridge Management control and monitor the provision of the above functions. They are specified in Clause 12.

8.2 Bridge architecture

8.2.1 Architectural model of a Bridge

Figure 8-1 gives an example of the physical topology of a Bridged LAN. The component LANs are interconnected by means of MAC Bridges; each Port of a MAC Bridge connects to a single LAN. Figure 7-1 illustrates a Bridge with two Ports, and Figure 6-1 illustrates the architecture of such a Bridge.

A Bridge is modeled as consisting of

a) A MAC Relay Entity that interconnects the Bridge's Ports;
b) At least two Ports;
c) Higher layer entities, including at least a Spanning Tree Protocol Entity[4].

8.2.2 MAC Relay Entity

The MAC Relay Entity handles the MAC independent functions of relaying frames between Bridge Ports, filtering frames, and learning filtering information. It uses the Enhanced Internal Sublayer Service provided by the separate MAC Entities for each Port. (The Enhanced Internal Sublayer Service and its support are described in 6.4 and 6.5.) Frames are relayed between Ports attached to different LANs.

8.2.3 Ports

Each Bridge Port transmits and receives frames to and from the LAN to which it is attached. An individual MAC Entity permanently associated with the Port provides the Enhanced Internal Sublayer Service used for frame transmission and reception. The MAC Entity handles all the MAC method dependent functions (MAC protocol and procedures) as specified in the relevant standard for that IEEE 802 LAN MAC technology.

[4] The Spanning Tree Protocol Entity was formerly known as the Bridge Protocol Entity.

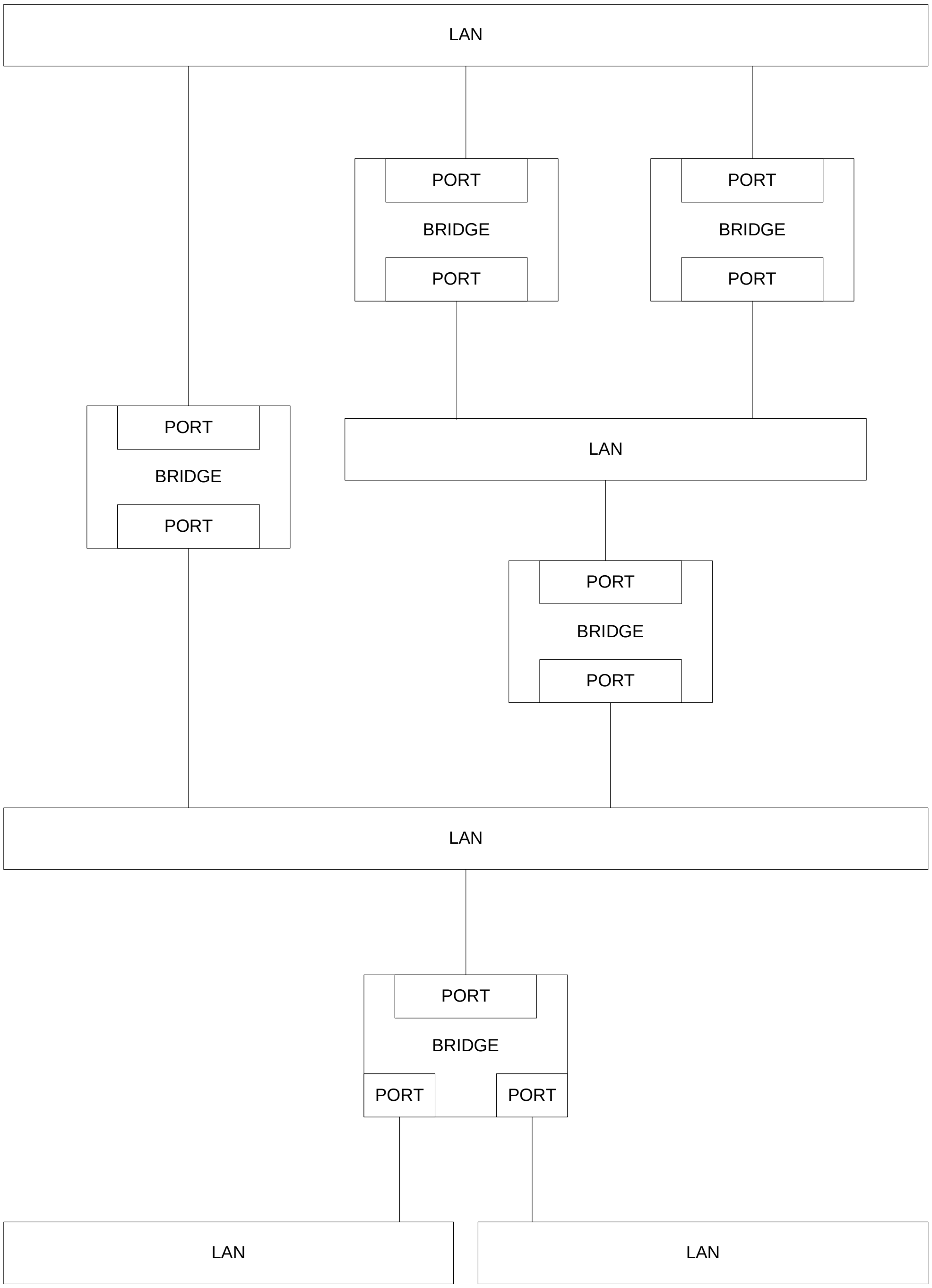


Figure 8-1—Example of a Bridged LAN

8.2.4 Higher Layer Entities

The Spanning Tree Protocol Entity handles calculation and configuration of Bridged LAN topology.

The Spanning Tree Protocol Entity and other higher layer protocol users, such as Bridge Management (8.1.3) and GARP application entities including GARP Participants (Clause 12 of IEEE Std 802.1D, 1998 Edition), make use of Logical Link Control procedures. These procedures are provided separately for each Port, and use the MAC Service provided by the individual MAC Entities.

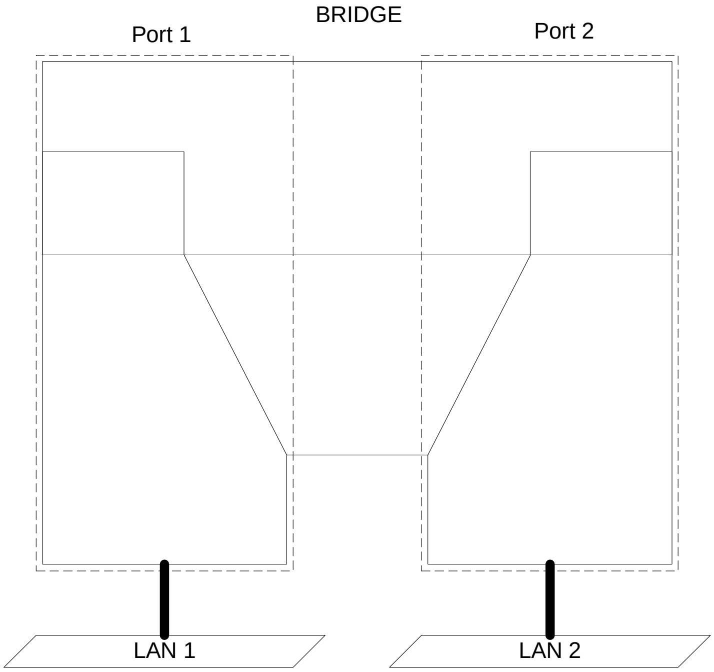


Figure 8-2—Bridge ports

8.3 Model of operation

The model of operation is simply a basis for describing the functionality of the MAC Bridge. It is in no way intended to constrain real implementations of a MAC Bridge; these may adopt any internal model of operation compatible with the externally visible behavior that this standard specifies. Conformance of equipment to this standard is purely in respect of observable protocol.

Subclauses 8.5 and 8.7 specify the MAC Relay Entity’s use of the Enhanced Internal Sublayer Service. State information associated with each Port governs the Port’s participation in the Bridged LAN. (Port States are specified in detail in 17.5 of IEEE Std 802.1D, 1998 Edition.)

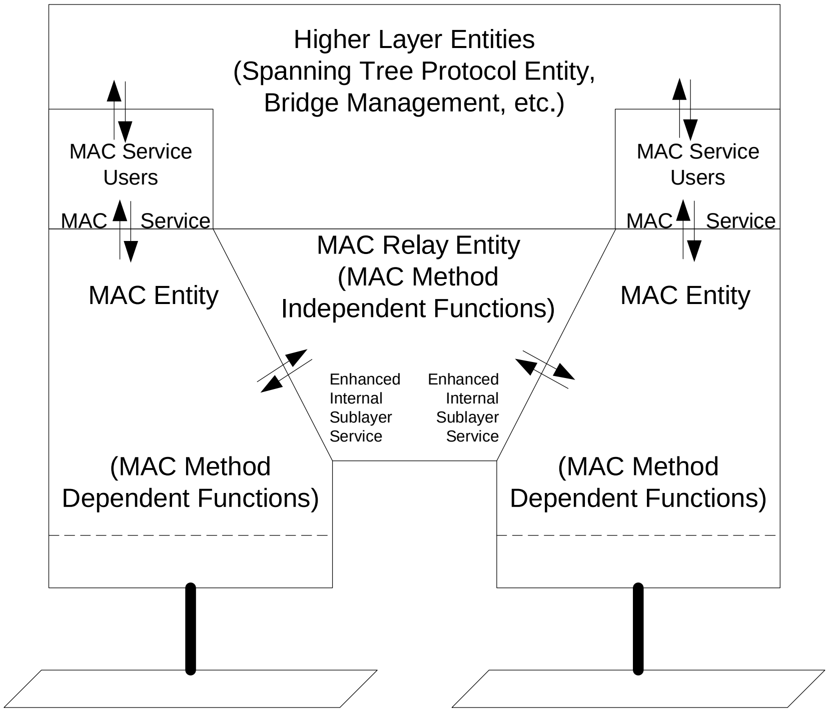


Figure 8-3—VLAN Bridge architecture

Frames are accepted for transmission and delivered on reception to and from processes and entities that model the operation of the MAC Relay Entity in a Bridge. These are

a) The Forwarding Process (8.6), that:
   1) Classifies received frames according to their VLAN membership (8.6.1), can filter frames based on the absence of a VID in the received frame (8.4.3), and can filter frames based on the frame's VLAN identifier (8.4.5), on the basis of the ingress rules (8.6.1) for the receiving Port;
   2) Forwards received frames that are to be relayed to other Bridge Ports, filtering frames on the basis of information contained in the Filtering Database (8.10), the state of the Bridge Ports (8.4), and, in MST Bridges, the mapping of VIDs to spanning trees supported by the Bridge (8.6.2, 8.11);
   3) Determines, for a given VLAN, through which Ports frames may be transmitted, and in what format, on the basis of the egress rules (8.6.4) for the transmitting Port.
b) The Learning Process (8.8), which, by observing the source addresses and VIDs of frames classified by the Forwarding Process according to the ingress rules (8.6.1), updates the Filtering Database (8.10), conditionally on the Port state (8.4);
c) The Filtering Database (8.10), which holds filtering information and supports queries by the Forwarding Process as to whether frames with given values of the destination MAC Address field and VID should be forwarded to a given Port.

Each Bridge Port also functions as an end station providing the MAC Service to LLC, which in turn supports operation of the Spanning Tree Protocol Entity (8.12) and of other possible users of LLC, such as protocols providing Bridge Management (8.13).

Each Bridge Port shall support the operation of LLC Type 1 procedures in order to support the operation of the Spanning Tree Protocol Entity. Bridge Ports may support other types of LLC procedures, which may be used by other protocols.

Figure 8-4 illustrates a single instance of frame relay between the Ports of a Bridge with two Ports.

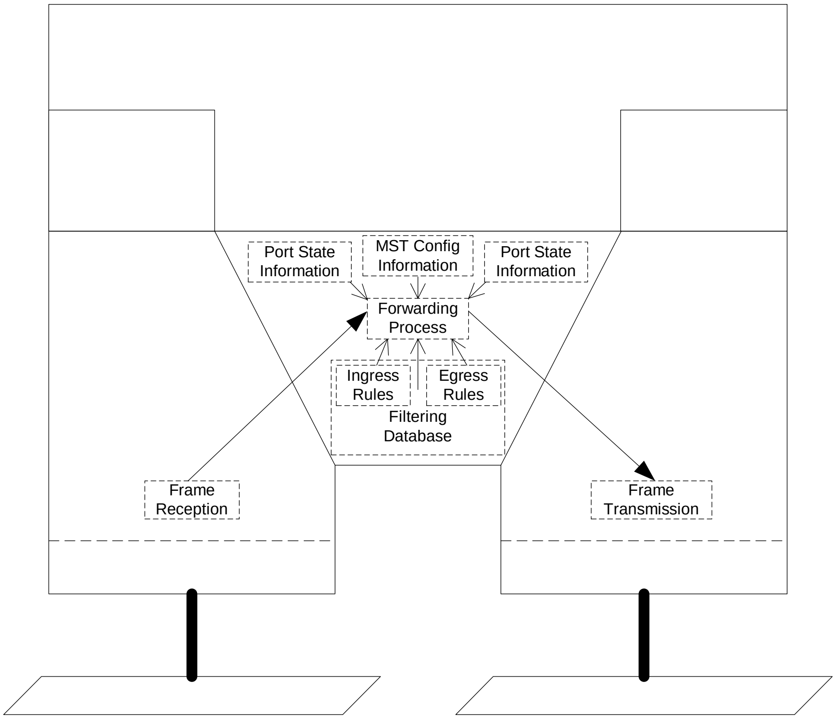


Figure 8-4—Relaying MAC frames

Figure 8-5 illustrates the inclusion of information carried by a single frame, received on one of the Ports of a Bridge with two Ports, in the Filtering Database.

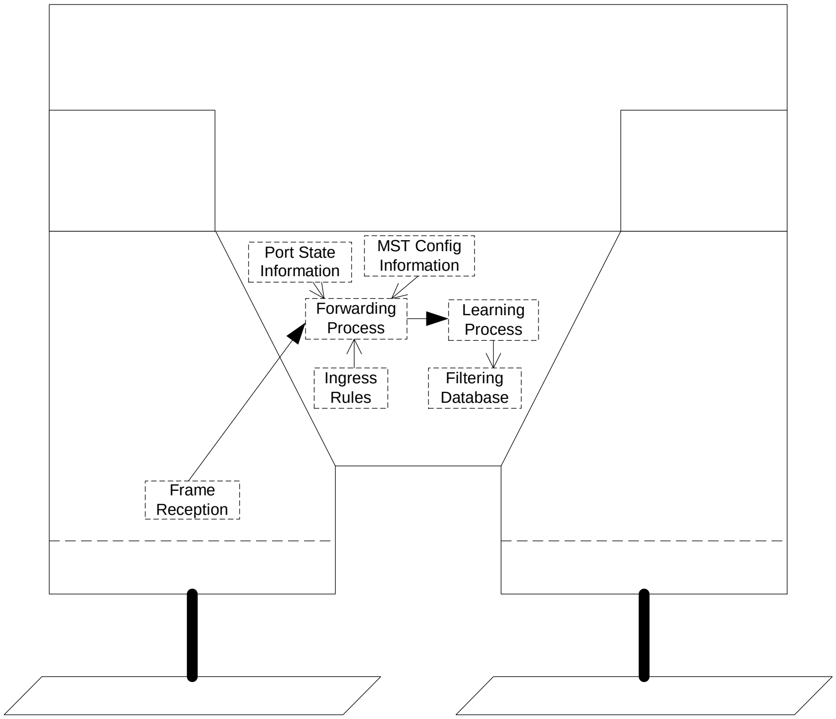


Figure 8-5—Observation of network traffic

Figure 8-6 illustrates the reception and transmission of Bridge Protocol Data Units by the Spanning Tree Protocol Entity.

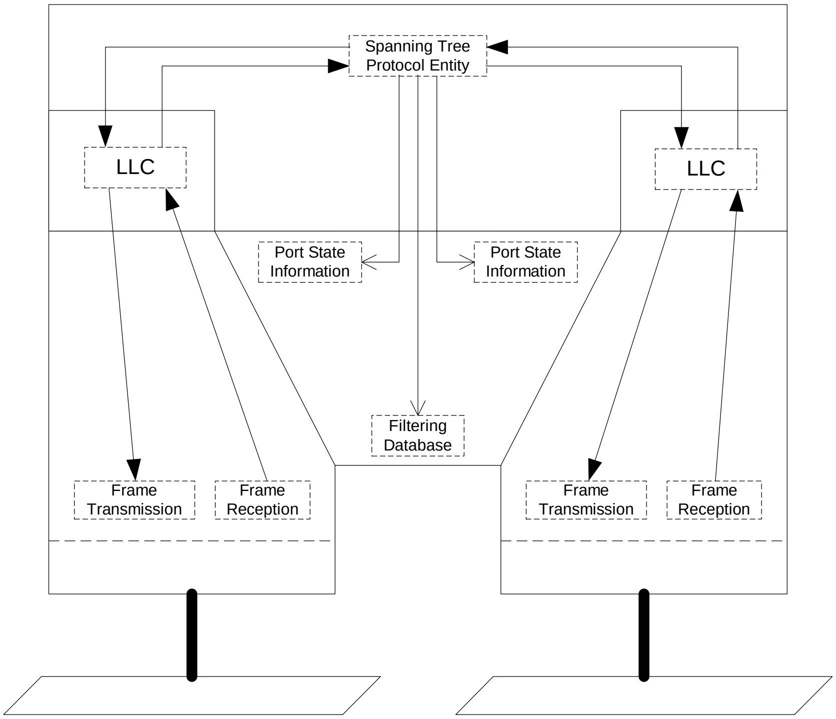


Figure 8-6—Operation of Spanning Tree protocol

Figure 8-7 illustrates the reception and transmission of GARP Protocol Data Units by a GARP Protocol Entity (8.12).

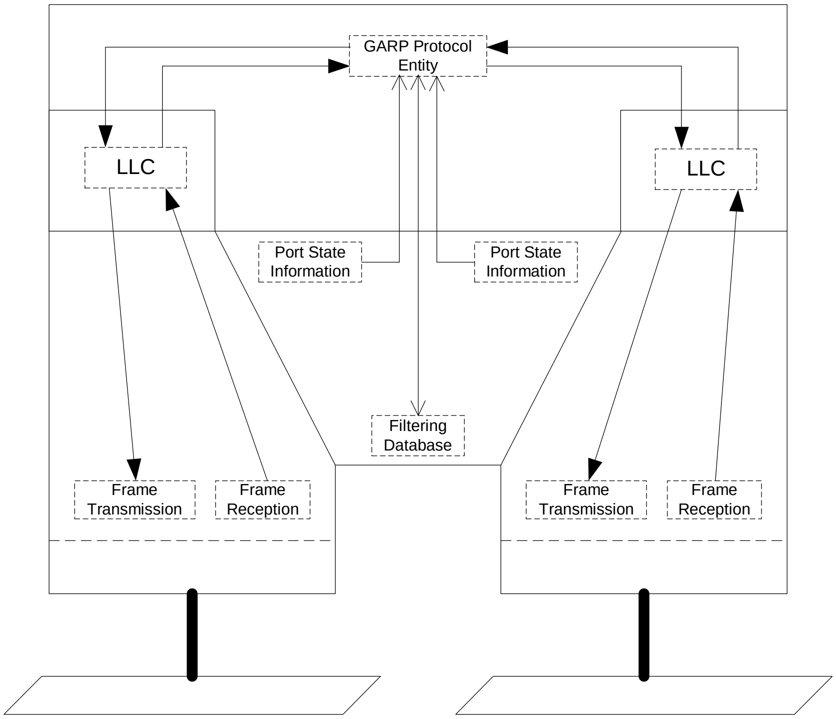


Figure 8-7—Operation of the GARP protocol

8.4 Port states and parameters

8.4.1 Forwarding states

The active topology of a Bridged LAN at any time is the set of communication paths formed by interconnecting the LANs and Bridges by the forwarding Ports. The function of the distributed Spanning Tree (STP, Clause 8 of IEEE Std 802.1D, 1998 Edition), and Rapid Spanning Tree (RSTP, Clause 17 of IEEE Std 802.1D, 1998 Edition) protocols used by SST Bridges, is to construct an active topology that is simply connected relative to communication between any given pair of MAC Addresses used to address end stations on the LANs, irrespective of the VLAN classification of frames used in that communication. The Multiple Spanning Tree Protocol (MSTP, Clause 13) used by MST Bridges constructs one or more active topologies. Each active topology is simply and fully connected relative to communication between any given pair of end stations using frames consistently classified by Bridges as belonging to a given VLAN or VLANs.

STP and RSTP construct a single spanning tree, the Common Spanning Tree (CST). MSTP constructs multiple spanning trees, the Common and Internal Spanning Tree (CIST) and additional Multiple Spanning Tree Instances (MSTIs). An MST Bridge allocates all frames classified as belonging to a given VLAN to the CIST or to one of the MSTIs.

State information associated with each Bridge Port for each spanning tree governs whether or not the Port participates in relaying MAC frames allocated to that tree. A Port can be disabled by management, in which case it plays no part in the operation of the Bridged LAN; a Port that is not disabled can be dynamically excluded from participation in frame relaying by operation of the Spanning Tree algorithm. If neither of these applies to a Port, it is described as forwarding for that spanning tree.

Figure 8-6 illustrates the operation of the Spanning Tree Protocol Entity, which operates the Spanning Tree algorithm and its related protocols, and its modification of Port state information as part of determining the active topology of the Bridged LAN. The Port states associated with the determination of the active topology are specified in detail in 17.5 of IEEE Std 802.1D, 1998 Edition.

Figure 8-4 illustrates the Forwarding Process's use of Port state information: first, for a Port receiving a frame, in order to determine whether the received frame is to be relayed through any other Ports; and second, for another Port in order to determine whether the relayed frame is to be forwarded through that particular Port.

8.4.2 Learning states

The incorporation of end station location information in the Filtering Database by the Learning Process also depends on the active topology. If information associated with frames received on a Port and allocated to a given spanning tree is to be incorporated in the Filtering Database by the Learning Process, then the Port is described as being in a learning state for that spanning tree; otherwise, it is in a non-learning state. Figure 8-5 illustrates the use of the Port state information for a Port receiving a frame, by the Learning Process, in order to determine whether the station location information is to be incorporated in the Filtering Database.

8.4.3 Acceptable Frame Types

Associated with each Port of a VLAN Bridge is an Acceptable Frame Types parameter that controls the reception of VLAN-tagged and non VLAN-tagged frames on that Port. Valid values for this parameter are

a) *Admit Only VLAN-tagged frames*;
b) *Admit All Frames*.

If this parameter is set to Admit Only VLAN-tagged frames, any frames received on that Port that carry no VID (i.e., untagged frames or priority-tagged frames) are discarded by the ingress rule checking function of the Forwarding Process (8.6.1).

Frames that are not discarded as a result of this parameter value are classified and processed according to the ingress rules (8.6.1) that apply to that Port.

Each Port of the Bridge shall support at least one of these values, and may support both. Where both values are supported,

c) The implementation shall support the ability to configure the value of the parameter by means of the management operations defined in Clause 12; and
d) The default value of the parameter shall be *Admit All Frames*.

8.4.4 Port VLAN identifier and VID Set

A VLAN Bridge supports Port-based VLAN classification, and may, in addition, support Port-and-Protocol-based VLAN classification.

In Port-based VLAN classification within a Bridge, the VID associated with an untagged or priority-tagged frame (i.e., a frame with no tag header, or a frame with a tag header that carries the null VLAN ID) is determined, based on the Port of arrival of the frame into the Bridge, as described in 8.6.1 and 8.9. This classification mechanism requires the association of a specific Port VLAN Identifier, or PVID, with each of the Bridge’s Ports. In this case, the PVID for a given Port provides the VID for untagged and priority-tagged frames received through that Port.

In addition to the PVID, for bridges that implement Port-and-Protocol-based VLAN classification, the VID associated with an Untagged or Priority-tagged Frame is determined based on the Port of arrival of the frame into the bridge and on the protocol identifier of the frame, as described in 8.6.1 and 8.9. This classification mechanism requires the association of multiple VIDs with each of the Ports of the Bridge: this is known as the “VID Set” for that port. Each VID of a Port of a Bridge that supports Port-and-Protocol-based VLAN classification is also associated with a Protocol Group Identifier. A Protocol Group Identifier is not relevant in a Bridge that supports only Port-based VLAN classification. The contents of the VID Set for each port may be configured by management. The VID Set is in addition to the PVID value described above.

The PVID and VID Set for each Port shall contain valid VID values (Table 9-2).

NOTE 1—This rule ensures that the process of ingress classification of frames always associates a valid VID with each received frame. As a consequence, a VLAN-aware Bridge can never transmit priority-tagged frames; all frames transmitted are either untagged or carry a valid VID in their tag header.

The PVID and VID Set values may be configured by management, if management operations are supported by the implementation. If no PVID value has been explicitly configured for a Port, the PVID shall assume the value of the default PVID defined in Table 9-2 and the VID Set shall be empty.

NOTE 2—If a Bridge is configured so that, for any Port, all the members of the VID Set of that port assume the same VID, then it is impossible to tell from the frame relay behavior of the bridge whether the Bridge supports Port-based or Port-and-Protocol-based VLAN classification. In particular, the default frame relay behavior (the frame relay behavior before any administrative actions on the Bridge) of a Bridge that supports Port-and-Protocol-based VLAN classification is the same as the default frame relay behavior of a Bridge that supports only Port-based VLAN classification.

8.4.5 Enable Ingress Filtering

An Enable Ingress Filtering parameter is associated with each Port. If the Enable Ingress Filtering parameter for a given Port is set, the ingress rule checking function of the Forwarding Process (8.6.1) shall discard any frame received on that Port whose VLAN classification does not include that Port in its Member set (8.10.9). If the parameter is reset for that Port, the ingress rules shall not discard frames received on that Port on the basis of their VLAN classification.

The default value for this parameter is reset, i.e., Disable Ingress Filtering, for all Ports. The value of this parameter may be configured by means of the management operations defined in Clause 12, if management operations are supported by the implementation. If the implementation supports the ability to enable Ingress Filtering on any Port, then it shall also support the ability to disable Ingress Filtering on those Ports.

8.5 Frame reception

The individual MAC Entity associated with each Bridge Port examines all frames received on the LAN to which it is attached.

All error-free received frames give rise to EM_UNITDATA indication primitives, which shall be handled as follows.

NOTE 1—A frame that is in error, as defined by the relevant MAC specification, is discarded by the MAC Entity without giving rise to any EM_UNITDATA indication: see 7.2 and 6.4.

Frames with EM_UNITDATA.indication primitive frame_type and mac_action parameter values of user_data_frame and request_with_no_response, respectively (7.2 and 6.4), shall be submitted to the Forwarding Process (8.6).

Frames with other values of frame_type and mac_action parameters, (e.g., request_with_response and response frames), shall not be submitted to the Forwarding Process (8.6).

Frames with a frame_type of user_data_frame and addressed to the Bridge Port as an end station shall be submitted to the MAC Service user. Such frames carry either the individual MAC Address of the Port or a group address associated with the Port (8.14) in the destination address field. Frames submitted to the MAC Service user can also be submitted to the Forwarding Process (8.6), as specified above.

Frames addressed to a Bridge Port as an end station, and relayed to that Bridge Port from other Bridge Ports in the same Bridge by the Forwarding Process, shall also be submitted to the MAC Service user.

NOTE 2—The consequence of the above is that frames “relayed to that Bridge Port” are both submitted to that Port’s MAC Service user and transmitted on the LAN to which that Port is attached (see 8.14.7).

No other frames shall be submitted to the MAC Service user.

8.5.1 Regenerating user priority

The user_priority of received frames is regenerated using priority information contained in the frame and the User Priority Regeneration Table for the reception Port. For each reception Port, the User Priority Regeneration Table has eight entries, corresponding to the eight possible values of user_priority (0 through 7). Each entry specifies, for the given value of received user_priority, the corresponding Regenerated user_priority value.

NOTE 1—IEEE 802 LAN technologies signal a maximum of eight user_priority values. H.2 of IEEE Std 802.1D, 1998 Edition contains further explanation of the use of user_priority values and how they map to traffic classes.

NOTE 2—User priority is regenerated only for frames that do not carry tag headers; see 7.1.2.1.

Table 8-1 defines the default values of Regenerated user_priority for the eight possible values of the user_priority parameter received in a data indication; these values shall be used as the initial values of the corresponding entries of the User Priority Regeneration Table for each Port.

Optionally, the ability to modify the values in the User Priority Regeneration Table by management means may be supported, as described in Clause 12. If this capability is provided, the value of the table entries may be independently settable for each reception Port and for each value of received user_priority, and the Bridge may have the capability to use the full range of values in the parameter ranges specified in Table 8-1.

NOTE 3—It is important to ensure that the regeneration and mapping of user priority within the Bridge is consistent with the end-to-end significance attached to that user priority in the Bridged LAN. Within a given Bridge, the values chosen for the User Priority Regeneration Table for a given Port should be consistent with the priority to be associated with traffic received through that Port across the rest of the Bridged LAN, and should generate appropriate access priority values for each transmission MAC method. The user priority value regenerated via the User Priority Regeneration Table on reception is used:

- Via the traffic class table (8.6.5) to determine the traffic class for a given outbound Port, and
- Via fixed, MAC method-specific mappings (8.6.7) to determine the access priority that will be used for a given outbound MAC method.

Table 8-1 shows the default values for the regeneration of user priority. Table 8-2 shows the default values for the traffic class table, for all possible numbers of supported traffic classes. Table 8-3 shows the fixed mappings from user priority to access priority that are required for different outbound MAC methods.

Table 8-1—User priority regeneration

Received user priority	Default regenerated user priority	Range
0	0	0–7
1	1	0–7
2	2	0–7
3	3	0–7
4	4	0–7
5	5	0-7
6	6	0–7
7	7	0–7

8.6 The Forwarding Process

Frames submitted to the Forwarding Process after being received at any given Bridge Port (8.5) shall be forwarded through the other Bridge Ports subject to the constituent functions of the Forwarding Process. These functions classify frames according to their VLAN membership (8.6.1), enforce topology restrictions (8.6.2), use Filtering Database information to filter frames (8.6.3), use the Egress Rules to discard frames (8.6.4), queue frames (8.6.5), select queued frames for transmission (8.6.6), map priorities (8.6.7), determine the format (tagged or untagged) of the transmitted frame (8.6.8), and recalculate FCS if required (8.6.9).

The Forwarding Process functions are described in 8.6.1–8.6.9 in terms of the action taken for a given frame received on a given Port (termed "the reception Port"). The frame can be forwarded for transmission on some Ports (termed "transmission Ports"), and is discarded without being transmitted at the other Ports.

NOTE—The model of operation of the Forwarding Process described in this standard is limited to the operation of the relay function of the MAC Bridge, and does not take into consideration what may occur in real implementations once frames are passed to the MAC for transmission. In some MAC implementations, and under some traffic conditions, a degree of indeterminacy may be introduced between the modeled description of the process of passing selected frames to the MAC for transmission and the actual sequence of frames as visible on the LAN medium itself. Examples can be found in the handling of access_priority in Token-Passing Bus MACs, or in the effect of different values for Token Holding Time in FDDI LANs. Such indeterminacy could result in apparent violation of the queuing/de-queueing and prioritizing rules described for the Forwarding Process, when observing traffic on the medium. As a consequence, in some implementations of this standard, it may prove to be impossible to test conformance to the standard simply by relating observed LAN traffic to the described model of the forwarding process; conformance tests would have to allow for the (permissible) behavior of the MAC implementations as well.

Figure 8-4 illustrates the operation of the Forwarding Process in a single instance of frame relay between the Ports of a Bridge with two Ports. Figure 8-8 illustrates the detailed operation of the Forwarding Process.

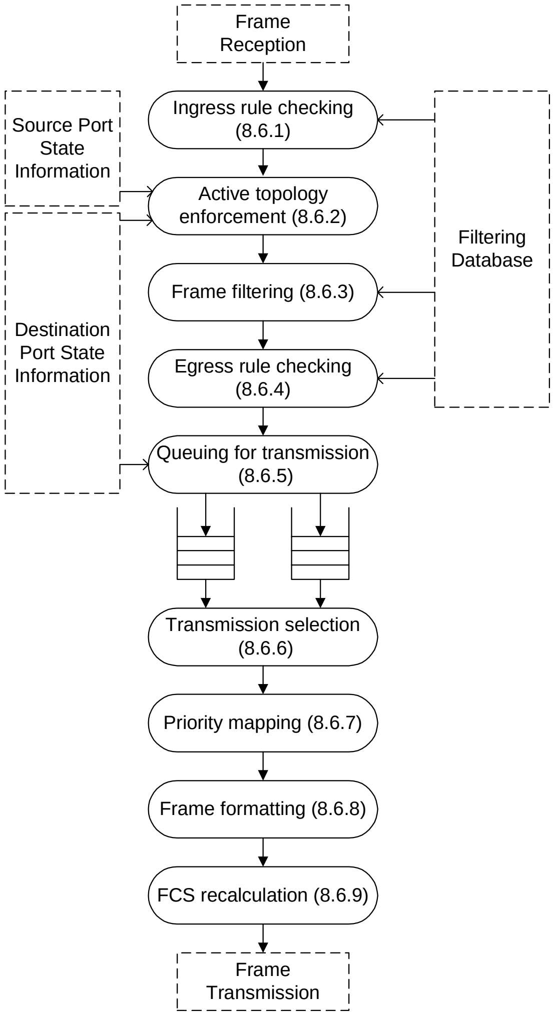

Frame Reception
Source Port State Information
Ingress rule checking (8.6.1)
Active topology enforcement (8.6.2)
Filtering Database
Destination Port State Information
Frame filtering (8.6.3)
Egress rule checking (8.6.4)
Queuing for transmission (8.6.5)
Transmission selection (8.6.6)
Priority mapping (8.6.7)
Frame formatting (8.6.8)
FCS recalculation (8.6.9)
Frame Transmission

Figure 8-8—Illustration of the detailed operation of the Forwarding Process

8.6.1 Ingress rule checking

Each received frame is assigned to a VLAN, and the corresponding VID is associated with the frame, as specified by the VLAN classification rules (8.9).

The frame shall be discarded and not forwarded to any other Port or submitted to the Learning Process if:

a) The VID is the value FFF, reserved in Table 9-2 for implementation use; or
b) The Acceptable Frame Types parameter (8.4.3) for the receiving Port is set to the value Admit Only VLAN-tagged frames, and the VID is the null VLAN ID; or
c) The Enable Ingress Filtering parameter (8.4.5) is set for the receiving Port, and that Port is not in the Member set (11.9) associated with the VID.

Otherwise the frame is permitted ingress to the VLAN, and shall be forwarded through the other Bridge Ports subject to the additional constituent functions of the Forwarding Process (8.6.2 through 8.6.9), and submitted to the Learning Process (8.8).

8.6.2 Active topology enforcement

Each received frame is allocated to a spanning tree by the Forwarding Process, using the VID. The Forwarding Process selects each Port as a potential transmission Port if, and only if

a) The Port on which the frame was received is in a forwarding state for that spanning tree (8.4 of IEEE Std 802.1D, 1998 Edition), and
b) The Port considered for transmission is in a forwarding state for that spanning tree, and
c) The Port considered for transmission is not the same as the Port on which the frame was received, and
d) The size of the mac_service_data_unit conveyed by the frame does not exceed the maximum size of mac_service_data_unit supported by the LAN to which the Port considered for transmission is attached.

For each Port not selected as a potential transmission Port the frame shall be discarded.

An SST Bridge allocates all frames to a single spanning tree, the Common Spanning Tree (CST).

An MST Bridge allocates all frames with a given VID to the CIST or to a Multiple Spanning Tree Instance (MSTI). The allocation can be controlled by configuration of the MST Configuration Table (8.11.1) maintained by the Forwarding Process, subject to constraints (if any) imposed by the allocation of VIDs to FIDs (8.10.7). VIDs allocated to different spanning trees shall also be allocated to different FIDs. VIDs allocated to a given spanning tree may share the same FID.

8.6.3 Frame filtering

Filtering decisions are taken by the Forwarding Process on the basis of

a) The destination MAC Address carried in a received frame;
b) The VID associated with the received frame;
c) The information contained in the Filtering Database for that MAC Address and VID;
d) The default Group filtering behavior for the potential transmission Port (8.10.6).

For each potential transmission Port selected as in 8.6.2, the frame shall be forwarded, or discarded (i.e., filtered), on the basis of this information, in accordance with the definition of the Filtering Database entry types (8.10.1, 8.10.3, and 8.10.4). The required forwarding and filtering behavior is summarized in 8.10.6, 8.10.8, Table 8-5, Table 8-6, and Table 8-7.

8.6.4 Egress rule checking

Frames shall be filtered, i.e., discarded, if

a) For the frame’s VID, as determined by applying the ingress rules (8.6.1), the transmission Port is not present in the Member set (8.10.9); or
b) The value of the include_tag parameter, determined as shown below, is False, and the Bridge does not support the ability to translate embedded MAC Address information from the format indicated by the canonical_format_indicator parameter to the format appropriate to the MAC method on which the data request will be carried.

NOTE 1—The meanings of the terms Canonical format and Non-canonical format are discussed in Annex F.

The value of the include_tag parameter in the EM_UNITDATA.request primitive is determined as follows:

c) If, for the frame’s VID, as determined by ingress rule checking (8.6.1), the transmission Port is present in the untagged set (8.10.9), then the value False is used. Otherwise;
d) The value True is used.

NOTE 2—As all incoming frames, including priority-tagged frames, are classified as belonging to a VLAN by the ingress rule checking (8.6.1), the transmitting Port only transmits VLAN-tagged frames or untagged frames, and can never transmit priority-tagged frames. Hence, a station sending a priority-tagged frame via a VLAN Bridge will receive a response that is either VLAN-tagged or untagged, depending upon the state of the untagged set for the VLAN concerned.

The value of the canonical_format_indicator parameter of the data request primitive is equal to the value of that parameter as received in the corresponding data indication.

8.6.5 Queuing for transmission

The Forwarding Process provides storage for queued frames, awaiting an opportunity to submit these for transmission to the individual MAC Entities associated with each Bridge Port. The order of frames received on the same Bridge Port shall be preserved for

a) Unicast frames with a given user_priority (regenerated as defined in 8.5.1) for a given combination of destination_address and source_address;
b) Group-addressed frames with a given user_priority (regenerated as defined in 8.5.1) for a given destination_address.

The Forwarding Process may provide more than one transmission queue for a given Bridge Port. Frames are assigned to storage queue(s) on the basis of their user_priority using a traffic class table that is part of the state information associated with each Port. The table indicates, for each possible value of user_priority, the corresponding value of traffic class that shall be assigned. Values of user_priority range from 0 through 7. Queues correspond one-to-one with traffic classes.

NOTE 1—Annex H.2 of IEEE Std 802.1D, 1998 Edition contains further explanation of the use of user_priority values and how they map to traffic classes.

For management purposes, up to eight traffic classes are supported by the traffic class tables in order to allow for separate queues for each level of user_priority. Traffic classes are numbered 0 through N-1, where N is the number of traffic classes associated with a given outbound Port. Management of traffic class information is optional. Traffic class 0 corresponds to non-expedited traffic; non-zero traffic classes are expedited classes of traffic.

NOTE 2—In a given Bridge, it is permissible to implement different numbers of traffic classes for each Port. Ports associated with MAC methods that support a single transmission priority, such as CSMA/CD, can support more than one traffic class.

Where the Forwarding Process does not support expedited classes of traffic for a given Port, in other words, where there is a single traffic class associated with the Port, all values of user_priority map to traffic class 0. In bridges which support expedited traffic, the recommended mapping of user_priority to traffic class, for the number of traffic classes implemented, is as shown in Table 8-2. Each entry in the body of the table is the traffic class assigned to traffic with a given user_priority, for a given number of available traffic classes.

Table 8-2—Recommended user priority to traffic class mappings

		Number of Available Traffic Classes							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
User Priority	**0 (Default)**	0	0	0	1	1	1	1	2
	1	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	1
	3	0	0	0	1	1	2	2	3
	4	0	1	1	2	2	3	3	4
	5	0	1	1	2	3	4	4	5
	6	0	1	2	3	4	5	5	6
	7	0	1	2	3	4	5	6	7

NOTE—The rationale behind the choice of values shown in this table is discussed in Annex H.2 of IEEE Std 802.1D, 1998 Edition. A consequence of the mapping shown is that frames carrying the default user priority are given preferential treatment relative to user priority 1 and 2 in Bridges that implement four or more Traffic Classes.

A frame queued by the Forwarding Process for transmission on a Port shall be removed from that queue on submission to the individual MAC Entity for that Port. No further attempt shall be made to transmit the frame on that Port even if the transmission is known to have failed.

A frame queued by the Forwarding Process for transmission on a Port can be removed from that queue, and not subsequently transmitted, if the time for which buffering is guaranteed has been exceeded for that frame.

A frame queued for transmission on a Port shall be removed from that queue if that is necessary to ensure that the maximum bridge transit delay (6.3.6) will not be exceeded at the time at which the frame would subsequently be transmitted.

A frame queued for transmission on a Port shall be removed from that queue if the associated Port leaves the forwarding state.

Removal of a frame from a queue for any particular Port does not of itself imply that it shall be removed from a queue for transmission on any other Port.

NOTE 3—The assumption underlying the model of operation of the Forwarding Process is that it is fed by frame reception with the parameters present in data indication primitives, and feeds these parameters to frame transmission in the form of data request primitives. The act of queueing a frame therefore amounts to placing the parameters of a data request primitive on an outbound queue.

8.6.6 Transmission selection

The following algorithm shall be supported by all Bridges as the default algorithm for selecting frames for transmission:

a) For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports. For a given supported value of traffic class, frames are selected from the corresponding queue for transmission only if all queues corresponding to numerically higher values of traffic class supported by the Port are empty at the time of selection;
b) For a given queue, the order in which frames are selected for transmission shall maintain the ordering requirement specified in 8.6.5.

Additional algorithms, selectable by management means, may be supported as an implementation option so long as the requirements of 8.6.5 are met.

8.6.7 Priority mapping

The user_priority parameter in an EM_UNITDATA.request primitive (7.1) shall be equal to the user_priority parameter in the corresponding data indication.

The mapping of user_priority to outbound access_priority is achieved via fixed, MAC method-specific mappings. The access_priority parameter in an EM_UNITDATA.request primitive (7.1) shall be determined from the user_priority in accordance with the values shown in Table 8-3 for the MAC methods that will carry the data request. The values shown in Table 8-3 are not modifiable by management or other means.

The table shows two columns for the 8802-5 MAC method. The mapping in the column marked “8802-5 (alternate)” is included in order to permit backwards compatibility with equipment manufactured in accordance with ISO/IEC 10038: 1993; however, the use of this mapping reduces the number of available access priority values to three. For this reason, it is recommended that the column marked “8802-5 (default)” is supported as the default mapping where backward compatibility is not an issue.

8.6.8 Frame formatting

The format of the frame transmitted on an outbound Port is determined by the value of the include_tag and the canonical_format_indicator parameters in the EM_UNITDATA.request primitive, and the MAC method supported by the Port. Where the include_tag parameter is TRUE, the frame shall be formatted in accordance with the tagged frame format defined in Clause 9.

8.6.9 FCS recalculation

Where a frame is being forwarded between two individual MAC Entities of the same IEEE 802 LAN type, and relaying the frame involves no changes to the data that is within the FCS coverage, the FCS received in the EM_UNITDATA.indication primitive may be supplied in the corresponding EM_UNITDATA.request primitive and not recalculated (7.1, 7.2, 6.3.7).

Table 8-3—Outbound access priorities

user_priority	Outbound Access Priority per MAC method								
	802.3	8802-4	8802-5 (default)	8802-5 (alternate)	8802-6	802.9a*	8802.11	8802-12	FDDI
0	0	0	0	4	0	0	0	0	0
1	0	1	1	4	1	0	0	0	1
2	0	2	2	4	2	0	0	0	2
3	0	3	3	4	3	0	0	0	3
4	0	4	4	4	4	0	0	4	4
5	0	5	5	5	5	0	0	4	5
6	0	6	6	6	6	0	0	4	6
7	0	7	6	6	7	0	0	4	6

*In the absence of a definition, in 6.5 of IEEE Std 802.1D, 1998 Edition, of support by IEEE Std 802.9a-1995, it is assumed that for this MAC method, access priority 0 will map to “low.”

Where a frame is being forwarded between two individual MAC Entities of different types, recalculation of the FCS is necessary if the differences between the LAN MAC methods is such that an FCS calculated according to the MAC procedures for the destination MAC method would differ from the FCS carried by the received frame, or if relaying the frame involves changes to the data that is within the FCS coverage. Where necessary, the FCS is recalculated according to the specific MAC procedures of the transmitting MAC entity.

NOTE—There are two possibilities for recreating a valid FCS. The first is to generate a new FCS by algorithmically modifying the received FCS, based on knowledge of the FCS algorithm and the transformations that the frame has undergone between reception and transmission. The second is to rely on the normal MAC procedures to recalculate the FCS for the outgoing frame. The former approach may be preferable in terms of its ability to protect against increased levels of undetected frame errors. Annex G of IEEE Std 802.1D, 1998 Edition discusses these possibilities in more detail. The frame_check_sequence parameter of the Enhanced Internal Sublayer Service (7.1) is able to signal the validity, or otherwise, of the FCS; an unspecified value in this parameter in a data request indicates to the transmitting MAC that the received FCS is no longer valid, and the FCS must therefore be recalculated.

FCS recalculation is necessary if any of the following conditions are true:

a) The algorithm used to determine the FCS differs between the MAC methods used by the two MAC entities;
b) The FCS coverage differs between the MAC methods used by the two MAC entities;
c) Relaying the frame between the two MAC entities involves changes to the data that is within the coverage of the FCS (e.g., the frame was tagged on one link, but not on the other).

8.7 Frame transmission

The individual MAC Entity associated with each Bridge Port transmits frames submitted to it by the MAC Relay Entity.

Relayed frames are submitted for transmission by the Forwarding Process. The EM_UNITDATA.request primitive associated with such frames conveys the values of the source and destination address fields received in the corresponding EM_UNITDATA.indication primitive.

LLC Protocol Data Units are submitted by LLC as a user of the MAC Service provided by the Bridge Port. Frames transmitted to convey such Protocol Data Units carry the individual MAC Address of the Port in the source address field.

Each frame is transmitted subject to the MAC procedures to be observed for that specific IEEE 802 LAN technology. The values of the frame_type and mac_action parameters of the corresponding EM_UNITDATA.request primitive shall be user_data_frame and request_with_no_response respectively (7.2; 6.5 of IEEE Std 802.1D, 1998 Edition).

Frames transmitted following a request by the LLC user of the MAC Service provided by the Bridge Port shall also be submitted to the MAC Relay Entity.

8.8 The Learning Process

The Learning Process observes the source MAC Addresses of frames received on each Port and updates the Filtering Database conditionally on the state of the receiving Port. The VID associated with the frame is used to ensure that the address information is learned relative to the frame’s VLAN.

Frames are submitted to the Learning Process following VLAN classification, as specified in 8.6.1.

The Learning Process can deduce the Port through which particular end stations in the Bridged LAN can be reached by inspection of the source MAC Address field and VID of received frames. It records such information in the Filtering Database (8.10). It shall create or update a Dynamic Filtering Entry (8.10.3) associated with the frame’s VID (8.10.9), associating the reception Port with the source MAC Address, if and only if

a) The Port on which the frame was received is in a state that allows learning (17.5 of IEEE Std 802.1D, 1998 Edition), and
b) The source address field of the frame denotes a specific end station, i.e., is not a group MAC Address, and
c) The resulting number of entries would not exceed the capacity of the Filtering Database, and
d) The Member set (8.10.9) for the frame’s VID includes at least one Port.

NOTE—If the Member set for a given VID is the empty set, then that VLAN is not currently active, and the Bridge will therefore filter all frames destined for that VLAN, regardless of their destination address. There is therefore no reason to include MAC Address filtering information in the Filtering Database for that VLAN until such a time as it becomes active.

If the Filtering Database is already filled up to its capacity, but a new entry would otherwise be made, then an existing entry may be removed to make room for the new entry.

Figure 8-5 illustrates the operation of the Learning Process in the inclusion of station location information carried by a single frame, received on one of the Ports of a Bridge, in the Filtering Database.

8.9 VLAN classification

Each frame received by a VLAN Bridge shall be classified as belonging to exactly one VLAN by associating a VID value with the received frame. The classification is achieved as follows:

a) If the vlan_identifier parameter carried in a received data indication is the null VLAN ID (Table 9-2), and the Bridge supports only Port-based VLAN classification, then the VID for the Frame is the unique PVID associated with the Port through which the frame was received (8.4.4). Otherwise:
b) If the vlan_identifier parameter carried in a received data indication is the null VLAN ID and the Bridge supports Port-and-Protocol-based VLAN classification, then the VID for the Frame is selected from the VID Set of the port through which the Frame was received. The VID selected is the member of the VID Set (8.4.4) for which the associated Protocol Group Identifier (8.9.3) is equal to the Protocol Group Identifier of the Frame. If no matches are found then the VID for the frame is the PVID associated with the Port. Otherwise:
c) The VID for the Frame is the vlan_identifier parameter value.

NOTE 1—As defined in 6.4.2.1, the vlan_identifier parameter carries the null VLAN ID if the frame was not VLAN-tagged. There are two cases; either the frame was untagged, or the frame was tagged and the tag header carried a VID value equal to the null VLAN ID (i.e., a priority-tagged frame).

NOTE 2—VIDs of value FFF cannot be configured in any Filtering Database entry (see Table 9-2). Consequently, any incoming frame whose VLAN classification is FFF will be discarded by the Forwarding Process.

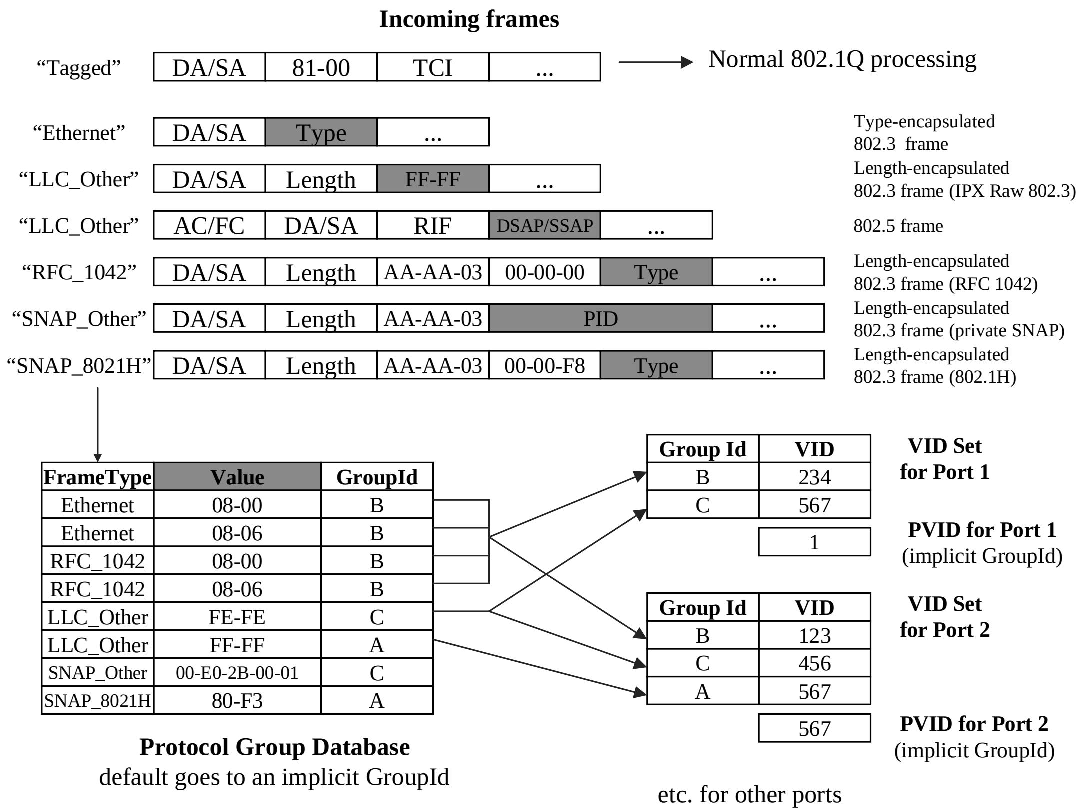
The VID value thus identified, known as the *VLAN classification* of the frame, is used as the value of the vlan_classification parameter of any corresponding data request primitives.

8.9.1 Protocol Classification

For frames received from the E-ISS on bridge ports which implement Port-and-Protocol-based VLAN classification, the following procedures are followed in order to classify the frame's format and protocol. These procedures are described as if they assigned values to parameters that are used as input to ingress rule checking (8.6.1).

The **detagged_frame_type** parameter indicates the frame format. The value is determined as follows:

a) If the frame is Untagged or Priority Tagged, this parameter is present and indicates the link-layer encapsulation format of the *Detagged Frame*. The Detagged Frame of an Untagged Frame is the Frame itself. The Detagged Frame of a Tagged Frame or Priority Tagged Frame is the Frame which results from untagging the Frame by the procedure described in 9.1. The value of detagged_frame_type is as follows:
    1) Ethernet, if the Detagged Frame uses Type-encapsulated 802.3 format
    2) RFC_1042, if the Detagged Frame is of the format specified by 10.5 in IEEE Std 802-2001 for the encoding of an IEEE 802.3 Type Field in an 802.2/SNAP header (this supersedes the original definition, which appeared in RFC 1042)
    3) SNAP_8021H, if the Detagged Frame is of the format specified by IEEE Std 802.1H, 1997 Edition, for the encoding of an IEEE 802.3 Type Field in an 802.2/SNAP header
    4) SNAP_Other, if the Detagged Frame contains an LLC UI PDU with DSAP and SSAP fields equal to the LLC address reserved for SNAP and the 5-octet SNAP Protocol Identifier (PID) value is not in either of the ranges used for RFC_1042 or SNAP_8021H above
    5) LLC_Other, if the Detagged Frame contains both a DSAP and an SSAP address field in the positions specified by IEEE 802.2 Logical Link Control, but is not any of the formats described for LLC frames above
b) Else the parameter is not present.


Incoming frames
“Tagged” DA/SA 81-00 TCI ...
Normal 802.1Q processing
“Ethernet” DA/SA Type ...
Type-encapsulated 802.3 frame
“LLC_Other” DA/SA Length FF-FF ...
Length-encapsulated 802.3 frame (IPX Raw 802.3)
“LLC_Other” AC/FC DA/SA RIF DSAP/SSAP ...
802.5 frame
“RFC_1042” DA/SA Length AA-AA-03 00-00-00 Type ...
Length-encapsulated 802.3 frame (RFC 1042)
“SNAP_Other” DA/SA Length AA-AA-03 PID ...
Length-encapsulated 802.3 frame (private SNAP)
“SNAP_8021H” DA/SA Length AA-AA-03 00-00-F8 Type ...
Length-encapsulated 802.3 frame (802.1H)
VID Set for Port 1
PVID for Port 1 (implicit GroupId)
1
VID Set for Port 2
PVID for Port 2 (implicit GroupId)
567
Protocol Group Database
default goes to an implicit GroupId
etc. for other ports

FrameType	Value	GroupId
Ethernet	08-00	B
Ethernet	08-06	B
RFC_1042	08-00	B
RFC_1042	08-06	B
LLC_Other	FE-FE	C
LLC_Other	FF-FF	A
SNAP_Other	00-E0-2B-00-01	C
SNAP_8021H	80-F3	A

Group Id	VID
B	234
C	567

Group Id	VID
B	123
C	456
A	567

NOTE—The PID shown in this figure is a Protocol Identifier, as defined in 5.3 of IEEE Std 802. It is a 5-octet value, consisting of a 3-octet OUI value followed by a 2-octet locally administered identifier.

Figure 8-9—Example of operation of port-and-protocol based classification

The **ethertype** parameter is present if the detagged_frame_type parameter is present and has the value Ethernet, RFC_1042, or SNAP_8021H. Its value is the IEEE 802.3 Type Field present in the Detagged Frame.The value is determined as follows:

c) If the detagged_frame_type parameter is present and has the value Ethernet, RFC_1042, or SNAP_8021H, then this parameter is present and has the value of the IEEE 802.3 Type Field present in the Detagged Frame.
d) Else the parameter is not present.

The **llc_saps** parameter is present if the detagged_frame_type parameter is present and has the value LLC_Other. Its value is determined as follows:

e) If the detagged_frame_type parameter is present and has the value LLC_Other then this parameter is present and its value is the pair of LLC 802.2 DSAP and SSAP address field values.
f) Else the parameter is not present.

NOTE 1—A frame that is encapsulated using values of hex FF/FF in the position where an LLC header is to be expected (as defined by IEEE Std 802.2, 1998 Edition) is known as a “Novell IPX Raw” encapsulation. Such frames do not conform to IEEE Std 802.2, 1998 Edition, in that they do not include some of the other required LLC fields. For the purposes of this standard, they are treated as LLC_Other, regardless of whether they are legal LLC frames or not.

NOTE 2—Bridges are not required, for the purposes of this standard, to completely verify the format of frames as meeting IEEE Std 802.2 or not: they are only required to recognize the DSAP and SSAP fields of such frames.

The **snap_pid** parameter is present if the detagged_frame_type parameter is present and has the value SNAP_Other. Its value is determined as follows:

g) If the detagged_frame_type parameter is present and has the value SNAP_Other then the parameter is present and its value is the contents of the 5 octets following the LLC header, i.e., the PID field.
h) Else the parameter is not present.

8.9.2 Protocol Templates

In a Bridge that supports Port-and-Protocol-based VLAN classification, a Protocol Template is a tuple that specifies a protocol to be identified in received frames. A Protocol Template has one of the following formats:

a) A value “Ethernet” and a 16-bit IEEE 802.3 Type Field value
b) A value “RFC_1042” and a 16-bit IEEE 802.3 Type Field value
c) A value “SNAP_8021H” and a 16-bit IEEE 802.3 Type Field value
d) A value “SNAP_Other” and a 40-bit PID value
e) A value “LLC_Other” and a pair of IEEE 802.2 LSAP values: DSAP and SSAP

A Protocol Template *matches* a Frame if

f) The Frame’s detagged_frame_type is Ethernet, the Protocol Template is of type Ethernet, and the frame’s IEEE 802.3 Type Field is equal to the value of the IEEE 802.3 Type Field of the Protocol Template, or
g) The Frame’s detagged_frame_type is RFC_1042, the Protocol Template is of type RFC_1042 and the frame’s IEEE 802.3 Type Field is equal to the IEEE 802.3 Type Field of the Protocol Template, or
h) The Frame’s detagged_frame_type is SNAP_8021H, the Protocol Template is of type SNAP_8021H, and the frame’s IEEE 802.3 Type Field is equal to the IEEE 802.3 Type Field of the Protocol Template, or
i) The Frame’s detagged_frame_type is SNAP_Other, the Protocol Template is of type SNAP_Other, and the frame’s snap_pid is equal to the PID of the Protocol Template, or
j) The Frame’s detagged_frame_type is LLC_Other, the Protocol Template is of type LLC_Other, and the frame’s llc_saps matches the value of the DSAP and SSAP of the Protocol Template.

NOTE—If a port does not support Protocol Templates of the Frame’s detagged_frame_type then no match will occur.

8.9.3 Protocol Group Identifiers

A Bridge that supports Port-and-Protocol-based VLAN classification shall support Protocol Group Identifiers.

A Protocol Group Identifier, shown as “Group Id” in Figure 8-9, designates a group of protocols that will be associated with one member of the VID Set of a Port. The association of protocols into groups is established by the contents of the Protocol Group Database, as described in 8.9.4. The identifier has scope only within a single bridge.

There is an implicit Protocol Group Identifier that is assigned to frames that match none of the entries in the Protocol Group Database. Therefore, every incoming Frame can be assigned to a Protocol Group Identifier.

8.9.4 Protocol Group Database

A Bridge that supports Port-and-Protocol-based VLAN classification~~,~~ shall support a single Protocol Group Database. The Protocol Group Database groups together a set of one or more Protocols by assigning them the same Protocol Group Identifier (8.9.3). Each entry of the Protocol Group Database comprises the following:

a) A Protocol Template
b) A Protocol Group Identifier

The Protocol Group Database specifies a mapping from Protocol Templates to Protocol Group Identifiers: if two entries of the Protocol Group Database contain different Protocol Group Identifiers then their Protocol Templates must also be different.

The entries of the Protocol Group Database may be configured by management. A Bridge that supports Port-and-Protocol-based VLAN classification shall support at least one of the formats of Protocol Template.

An implicit Protocol Group Database entry exists that matches all frames: this entry is invoked for frames that do not match the template of any of the other entries. It references an implicit Protocol Group Identifier that selects the PVID on each port. In this way, it is ensured that all incoming Frames are matched by a Protocol Group Identifier and, hence, are assigned to a VID.

NOTE—If there are no entries in the Protocol Group Database, then the frame relay behavior of this Bridge is identical to the frame relay behavior of a Bridge having the same number of Ports that supports only Port-based VLAN classification.

8.10 The Filtering Database

The Filtering Database supports queries by the Forwarding Process as to whether frames received by the Forwarding Process, with given values of destination MAC Address parameter and VID, are to be forwarded through a given potential transmission Port (8.6.2 and 8.6.3). It contains filtering information in the form of filtering entries that are either

a) Static, and explicitly configured by management action; or
b) Dynamic, and automatically entered into the Filtering Database by the normal operation of the bridge and the protocols it supports.

Two entry types are used to represent static filtering information. The Static Filtering Entry represents static information in the Filtering Database for individual and for group MAC Addresses. It allows administrative control of

c) Forwarding of frames with particular destination addresses; and
d) The inclusion in the Filtering Database of dynamic filtering information associated with Extended Filtering Services, and use of this information.

The Filtering Database shall contain entries of the Static Filtering Entry type.

The Static VLAN Registration Entry represents all static information in the Filtering Database for VLANs. It allows administrative control of

e) Forwarding of frames with particular VIDs;

f) The inclusion/removal of tag headers in forwarded frames; and
g) The inclusion in the Filtering Database of dynamic VLAN membership information, and use of this information.

The Filtering Database may contain entries of the Static VLAN Registration Entry type.

Static filtering information is added to, modified, and removed from the Filtering Database only under explicit management control. It shall not be automatically removed by any ageing mechanism. Management of static filtering information may be carried out by use of the remote management capability provided by Bridge Management (8.13) using the operations specified in Clause 12.

Three entry types are used to represent dynamic filtering information:

h) Dynamic Filtering Entries are used to specify the Ports on which individual MAC Addresses have been learned. They are created and updated by the Learning Process (8.8), and are subject to ageing and removal by the Filtering Database.
i) Group Registration Entries support the registration of group MAC Addresses. They are created, updated, and removed by the GMRP protocol in support of Extended Filtering Services (8.10.4; 6.6.5 of IEEE Std 802.1D, 1998 Edition; Clause 10 of IEEE Std 802.1D, 1998 Edition), subject to the state of the Restricted_Group_Registration management control (10.3.2.3 of IEEE Std 802.1D, 1998 Edition). If the value of this control is TRUE, then the creation of a Group Registration Entry is not permitted unless a Static Filtering Entry exists that permits dynamic registration for the Group concerned.
j) Dynamic VLAN Registration Entries are used to specify the Ports on which VLAN membership has been dynamically registered. They are created, updated, and removed by the GVRP protocol, in support of automatic VLAN membership configuration (Clause 11), subject to the state of the Restricted_VLAN_Registration management control (11.2.3.2.3). If the value of this control is TRUE, then the creation of a Dynamic VLAN Registration Entry is not permitted unless a Static VLAN Registration Entry exists that permits dynamic registration for the VLAN concerned.

Static Filtering Entries and Group Registration Entries comprise

k) A MAC Address specification;
l) A VLAN Identifier (VID);
m) A Port Map, with a control element for each outbound Port to specify filtering for that MAC Address specification and VID.

Dynamic Filtering Entries comprise

n) A MAC Address specification;
o) A locally significant Filtering Identifier (FID; see 8.10.7);
p) A Port Map, with a control element for each outbound Port to specify filtering for that MAC Address specification in the VLAN(s) allocated to that FID.

Static and Dynamic VLAN Registration Entries comprise

q) A VLAN Identifier;
r) A Port Map, with a control element for each outbound Port to specify filtering for the VLAN.

Dynamic filtering information may be read by use of the remote management capability provided by Bridge Management (8.13) using the operations specified in Clause 12.

The Filtering Services supported by a Bridge (Basic and Extended Filtering Services) determine the default behavior of the Bridge with respect to the forwarding of frames destined for group MAC Addresses. In Bridges that support Extended Filtering Services, the default forwarding behavior for group MAC Addresses, for each Port, and for each VID, can be configured both statically and dynamically by means of Static Filtering Entries and/or Group Registration Entries that can carry the following MAC Address specifications:

s) All Group Addresses, for which no more specific Static Filtering Entry exists;
t) All Unregistered Group Addresses (i.e., all group MAC Addresses for which no Group Registration Entry exists), for which no more specific Static Filtering Entry exists.

NOTE 1—The All Group Addresses specification s) above, when used in a Static Filtering Entry with an appropriate control specification, provides the ability to configure a Bridge that supports Extended Filtering Services to behave as a Bridge that supports only Basic Filtering Services on some or all of its Ports. This might be done for the following reasons:

— The Ports concerned serve "legacy" devices that wish to receive multicast traffic, but are unable to register Group membership;
— The Ports concerned serve devices that need to receive all multicast traffic, such as routers or diagnostic devices.

The Filtering Database shall support the creation, updating and removal of Dynamic Filtering Entries by the Learning Process (8.8). In Bridges that support Extended Filtering Services, the Filtering Database shall support the creation, updating, and removal of Group Registration Entries by GMRP (Clause 10 of IEEE Std 802.1D, 1998 Edition).

Figure 8-4 illustrates use of the Filtering Database by the Forwarding Process in a single instance of frame relay between the Ports of a Bridge with two Ports.

Figure 8-5 illustrates the creation or update of a dynamic entry in the Filtering Database by the Learning Process. The entries in the Filtering Database allow MAC Address information to be learned independently for each VLAN or set of VLANs, by relating a MAC Address to the VLAN or set of VLANs on which that address was learned. This has the effect of creating independent Filtering Databases for each VLAN or set of VLANs that is present in the Bridged LAN.

NOTE 2—This standard specifies a single Filtering Database that contains all Filtering Database entries; however, the inclusion of VIDs and FIDs in the filtering entries effectively provides distinct IEEE Std 802.1D-style Filtering Databases per VLAN or set of VLANs.

NOTE 3—The ability to create VLAN-dependent Filtering Database entries allows a VLAN Bridge to support

— Multiple end stations with the same individual MAC Address residing on different VLANs;
— End stations with multiple interfaces, each using the same individual MAC Address,
as long as not more than one end station or interface that uses a given MAC Address resides in a given VLAN.

Figure 8-6 illustrates the operation of the Spanning Tree Protocol Entity (8.12), which operates the Spanning Tree Algorithm and Protocol, and its notification of the Filtering Database of changes in active topology signaled by that protocol.

There are no standardized constraints on the size of the Filtering Database in an implementation for which conformance to this standard is claimed. The PICS Proforma in Annex A requires the following to be specified for a given implementation:

u) The total number of entries (Static Filtering Entries, Dynamic Filtering Entries, Group Registration Entries, Static VLAN Registration Entries, and Dynamic VLAN Registration Entries) that the implementation of the Filtering Database can support, and
v) Of that total number, the total number of VLAN Registration Entries (static and dynamic) that the Filtering Database can support.

8.10.1 Static Filtering Entries

A Static Filtering Entry specifies

a) A MAC Address specification, comprising
   1) An Individual MAC Address; or
   2) A group MAC Address; or
   3) All Group Addresses, for which no more specific Static Filtering Entry exists; or
   4) All Unregistered Group Addresses, for which no more specific Static Filtering Entry exists.

b) The VID of the VLAN to which the static filtering information applies;

c) A Port Map, containing a control element for each outbound Port, specifying that a frame with a destination MAC Address and VID that meets this specification is to be
   1) Forwarded, independently of any dynamic filtering information held by the Filtering Database; or
   2) Filtered, independently of any dynamic filtering information; or
   3) Forwarded or filtered on the basis of dynamic filtering information, or on the basis of the default Group filtering behavior for the outbound Port (8.10.6) if no dynamic filtering information is present specifically for the MAC Address.

All Bridges shall have the capability to support the first two values for the MAC Address specification, and all three values for each control element for all Static Filtering Entries (i.e., shall have the capability to support a1, a2, c1, c2, and c3 above).

A Bridge that supports Extended Filtering Services shall have the capability to support all four values for the MAC Address specification and all three control element values for all Static Filtering Entries.

For a given MAC Address specification, a separate Static Filtering Entry with a distinct Port Map may be created for each VLAN from which frames are received by the Forwarding Process.

In addition to controlling the forwarding of frames, Static Filtering Entries for group MAC Addresses provide the Registrar Administrative Control values for the GMRP protocol (Clauses 10, 12, and 12.9.1 of IEEE Std 802.1D, 1998 Edition). Static configuration of forwarding of specific group addressed frames to an outbound port indicates Registration Fixed on that port: a desire to receive frames addressed to that Group even in the absence of dynamic information. Static configuration of filtering of frames that might otherwise be sent to an outbound port indicates Registration Forbidden. The absence of a Static Filtering Entry for the group address, or the configuration of forwarding or filtering on the basis of dynamic filtering information, indicates Normal Registration.

8.10.2 Static VLAN Registration Entries

A Static VLAN Registration Entry specifies

a) The VID of the VLAN to which the static filtering information applies;

b) A Port Map, consisting of a control element for each outbound Port, specifying
   1) The Registrar Administrative Control values for the GVRP protocol (Clause 11) for the VLAN specified. In addition to providing control over the operation of GVRP, these values can also directly affect the forwarding behavior of the Bridge, as described in 8.10.9. The values that can be represented are
      i) Registration Fixed; or
      ii) Registration Forbidden; or
      iii) Normal Registration.
   2) Whether frames destined for the VLAN specified are to be VLAN-tagged or untagged when forwarded through this Port.

All Bridges shall be capable of supporting all values for each control element for all Static VLAN Registration Entries; however, the ability to support more than one untagged VLAN on egress on any given Port is optional (see 5.1 and 5.2).

NOTE—In other words, it shall be possible to configure any VLAN as untagged on egress, but it is an implementation option as to whether only a single untagged VLAN per Port on egress is supported, or whether multiple untagged VLANs per Port on egress are supported.

A separate Static VLAN Registration Entry with a distinct Port Map may be created for each VLAN from which frames are received by the Forwarding Process.

8.10.3 Dynamic Filtering Entries

A Dynamic Filtering Entry specifies

a) An individual MAC Address;
b) The FID, an identifier assigned by the MAC Bridge (8.10.7) to identify a set of VIDs for which no more than one Dynamic Filtering Entry can exist for any individual MAC Address;

NOTE 1—An FID identifies a set of VLANs among which *Shared VLAN Learning* (3.9) takes place. Any pair of FIDs identifies two sets of VLANs between which *Independent VLAN Learning* (3.5) takes place. The allocation of FIDs by a Bridge is described in 8.10.7.

c) A Port Map that specifies forwarding of frames destined for that MAC Address and FID to a single Port.

NOTE 2—This is equivalent to specifying a single port number; hence, this specification is directly equivalent to the specification of dynamic entries in ISO/IEC 10038: 1993.

Dynamic Filtering Entries are created and updated by the Learning Process (8.8). They shall be automatically removed after a specified time, the Ageing Time, has elapsed since the entry was created or last updated. No more than one Dynamic Filtering Entry shall be created in the Filtering Database for a given combination of MAC Address and FID.

Dynamic Filtering Entries cannot be created or updated by management.

NOTE 3—Dynamic Filtering Entries may be read by management (Clause 12). The FID is represented in the management Read operation by any one of the VIDs that it represents. For a given VID, the set of VIDs that share the same FID may also be determined by management.

The ageing out of Dynamic Filtering Entries ensures that end stations that have been moved to a different part of the Bridged LAN will not be permanently prevented from receiving frames. It also takes account of changes in the active topology of the Bridged LAN that can cause end stations to appear to move from the point of view of the bridge; i.e., the path to those end stations subsequently lies through a different Bridge Port.

The Ageing Time may be set by management (Clause 12). A range of applicable values and a recommended default is specified in Table 8-4; this is suggested to remove the need for explicit configuration in most cases. If the value of Ageing Time can be set by management, the Bridge shall have the capability to use values in the range specified, with a granularity of 1 s.

NOTE 4—The granularity is specified in order to establish a common basis for the granularity expressed in the management operations defined in Clause 12, not to constrain the granularity of the actual timer supported by a conformant implementation. If the implementation supports a granularity other than 1 s, then it is possible that the value read back by management following a Set operation will not match the actual value expressed in the Set.

Table 8-4—Ageing time parameter value

Parameter	Recommended default value	Range
Ageing time	300.0 s	10.0–1 000 000.0 s

The Spanning Tree Algorithm and Protocol specified in Clause 8 of IEEE Std 802.1D, 1998 Edition includes a procedure for notifying all Bridges in the Bridged LAN of topology change. It specifies a short value for the Ageing Timer, to be enforced for a period after any topology change (8.3.5 of IEEE Std 802.1D, 1998 Edition). While the topology is not changing, this procedure allows normal ageing to accommodate extended periods during which addressed end stations do not generate frames themselves, perhaps through being powered down, without sacrificing the ability of the Bridged LAN to continue to provide service after automatic configuration.

8.10.4 Group Registration Entries

A Group Registration Entry specifies

a) A MAC Address specification, comprising
   1) A group MAC Address; or
   2) All Group Addresses, for which no more specific Static Filtering Entry exists; or
   3) All Unregistered Group Addresses, for which no more specific Static Filtering Entry exists.
b) The VID of the VLAN in which the dynamic filtering information was registered;
c) A Port Map, consisting of a control element for each outbound Port, which specifies forwarding (Registered) or filtering (Not registered) of frames destined to the MAC Address and VID.

Group Registration Entries are created, modified and deleted by the operation of GMRP (Clause 10 of IEEE Std 802.1D, 1998 Edition, as modified by Clause 10 of this standard). No more than one Group Registration Entry shall be created in the Filtering Database for a given combination of MAC Address specification and VID.

NOTE—It is possible to have a Static Filtering Entry which has values of Forward or Filter on some or all Ports that mask the dynamic values held in a corresponding Group Registration Entry. The values in the Group Registration Entry will continue to be updated by GMRP; hence, subsequent modification of that entry to allow the use of dynamic filtering information on one or more Ports immediately activates the true GMRP registration state that was hitherto masked by the static information.

The creation of Group Registration Entries is subject to the Restricted_Group_Registration management control (10.3.2.3 of IEEE Std 802.1D, 1998 Edition). If the value of this control is TRUE, a dynamic entry for a given Group may only be created if a Static Filtering Entry already exists for that Group, in which the Registrar Administrative Control value is Normal Registration.

8.10.5 Dynamic VLAN Registration Entries

A Dynamic VLAN Registration Entry specifies

a) The VID of the VLAN to which the dynamic filtering information applies;
b) A Port Map with a control element for each outbound Port specifying whether the VLAN is registered on that Port.

A separate Dynamic VLAN Registration Entry with a distinct Port Map may be created for each VLAN from which frames are received by the Forwarding Process.

The creation of Dynamic VLAN Registration Entries is subject to the Restricted_VLAN_Registration management control (11.2.3.2.3). If the value of this control is TRUE, a dynamic entry for a given VLAN may only be created if a Static VLAN Registration Entry already exists for that VLAN, in which the Registrar Administrative Control value is Normal Registration.

8.10.6 Default Group filtering behavior

Forwarding and filtering of group-addressed frames may be managed by specifying defaults for each VLAN and outbound Port. The behavior of each of these defaults, as modified by the control elements of more explicit Filtering Database entries applicable to a given frame's MAC Address, VLAN classification, and outbound Port is as follows:

NOTE 1—As stated in 8.10.1, for a given MAC Address there may be separate Static Filtering Entries with a distinct Port Map for each VLAN.

a) *Forward All Groups.* The frame is forwarded, unless an explicit Static Filtering Entry specifies filtering independent of any dynamic filtering information.
b) *Forward Unregistered Groups.* The frame is forwarded, unless
   1) An explicit Static Filtering Entry specifies filtering independent of any dynamic filtering information; or
   2) An explicit Static Filtering Entry specifies forwarding or filtering on the basis of dynamic filtering information, and an applicable explicit Group Registration Entry exists specifying filtering; or
   3) An applicable explicit Static Filtering Entry does not exist, but an applicable Group Registration entry specifies filtering.
c) *Filter Unregistered Groups.* The frame is filtered unless
   1) An explicit Static Filtering Entry specifies forwarding independent of any dynamic filtering information; or
   2) An explicit Static Filtering Entry specifies forwarding or filtering on the basis of dynamic filtering information, and an applicable explicit Group Registration Entry exists specifying forwarding; or
   3) An applicable explicit Static Filtering Entry does not exist, but an applicable Group Registration entry specifies forwarding.

In Bridges that support only Basic Filtering Services, the default Group filtering behavior is Forward All Groups for all Ports of the Bridge, for all VLANs.

NOTE 2—Forward All Groups corresponds directly to the behavior specified in ISO/IEC 10038: 1993 when forwarding group MAC Addressed frames for which no static filtering information exists in the Filtering Database. Forward All Groups makes use of information contained in Static Filtering Entries for specific group MAC Addresses, but overrides any information contained in Group Registration Entries. Forward Unregistered Groups is analogous to the forwarding behavior of a Bridge with respect to individual MAC Addresses. If there is no static or dynamic information for a specific group MAC Address, then the frame is forwarded; otherwise, the frame is forwarded in accordance with the statically configured or dynamically learned information.

In Bridges that support Extended Filtering Services, the default Group filtering behavior for each outbound Port for each VLAN is determined by the following information contained in the Filtering Database:

d) Any Static Filtering Entries applicable to that VLAN with a MAC Address specification of All Group Addresses or All Unregistered Group Addresses;
e) Any Group Registration Entries applicable to that VLAN with a MAC Address specification of All Group Addresses or All Unregistered Group Addresses.

The means whereby this information determines the default Group filtering behavior is specified in 8.10.8, Table 8-6, and Table 8-7.

NOTE 3—The result is that the default Group filtering behavior for each VLAN can be configured for each Port of the Bridge via Static Filtering Entries, determined dynamically via Group Registration Entries created/updated by GMRP (Clause 10), or both. For example, in the absence of any static or dynamic information in the Filtering Database for All Group Addresses or All Unregistered Group Addresses, the default Group filtering behavior will be Filter Unregistered Groups on all Ports, for all VLANs. Subsequently, the creation of a Dynamic Group Registration Entry for All Unregistered Group Addresses indicating "Registered" for a given VLAN on a given Port would cause that Port to exhibit Forward Unregistered Groups behavior for that VLAN. Similarly, creating a Static Filtering Entry for All Group Addresses indicating "Registration Fixed" on a given Port for that VLAN would cause that Port to exhibit Forward All Groups behavior.

Hence, by using appropriate combinations of "Registration Fixed," "Registration Forbidden," and "Normal Registration" in the Port Maps of Static Filtering Entries for the All Group Addresses and All Unregistered Group Addresses address specifications, it is possible, for a given Port and VLAN, to

- Fix the default Group filtering behavior to be just one of the three behaviors described above; or
- Restrict the choice of behaviors to a subset of the three, and allow GMRP registrations (or their absence) to determine the final choice; or
- Allow any one of the three behaviors to be adopted, in accordance with any registrations received via GMRP.

8.10.7 Allocation of VIDs to FIDs

The allocation of VIDs to FIDs within a Bridge determines how learned individual MAC Address information is used in forwarding/filtering decisions within a Bridge; whether such learned information is confined to individual VLANs, shared among all VLANs, or confined to specific sets of VLANs.

The allocation of VIDs to FIDs is determined on the basis of

a) The set of *VLAN Learning Constraints* that have been configured into the Bridge (by means of the management operations defined in Clause 12);
b) Any fixed mappings of VIDs to FIDs that may have been configured into the Bridge (by means of the management operations defined in Clause 12);
c) The *set of active VLANs* (i.e., those VLANs on whose behalf the Bridge may be called upon to forward frames). A VLAN is active if either of the following is true:
    1) The VLAN's Member set (8.10.9) contains one Port that is in a forwarding state, and at least one other Port of the Bridge is both in a forwarding state and has Ingress Filtering (8.4.5) disabled;
    2) The VLAN's Member set contains two or more Ports that are in a forwarding state.
d) The capabilities of the Bridge with respect to the number of FIDs that it can support, and the number of VIDs that can be allocated to each FID.

A VLAN Bridge shall support a minimum of one FID, and may support up to 4094 FIDs. For the purposes of the management operations, FIDs are numbered from 1 through N, where N is the maximum number of FIDs supported by the implementation.

A VLAN Bridge shall support the ability to allocate at least one VID to each FID, and may support the ability to allocate more than one VID to each FID.

The number of VLAN Learning Constraints supported by a VLAN Bridge is an implementation option.

NOTE—In an SVL/IVL Bridge (3.11), a number of FIDs are supported, and one or more VID can be mapped to each FID. In an SVL Bridge (3.10), a single FID is supported, and all VIDs are mapped to that FID. In an IVL Bridge (3.6), a number of FIDs are supported, and only one VID can be mapped to each FID.

An MST Bridge shall support the ability to allocate at least one FID to each spanning tree, and may support the ability to allocate more than one FID to each spanning tree

NOTE—In other words, the number of FIDs supported by the Bridge must be greater than or equal to the number of spanning trees supported by the Bridge.

An MST Bridge shall ensure that the maximum supported numbers of FIDs and VLANs can be associated unambiguously. This requires either 1) a number of fixed VID to FID allocations at least equal to the maximum number of VLANs supported; or 2) one I Constraint entry per FID supported and one S Constraint entry per MSTI supported, or both. (8.10.7.1).

8.10.7.1 Fixed and dynamic VID to FID allocations

A Bridge may support the ability to define fixed allocations of specific VIDs to specific FIDs, via an allocation table that may be read and modified by means of the management operations defined in Clause 12. For each VID supported by the implementation, the allocation table indicates one of the following:

a) The VID is currently not allocated to any FID; or
b) A fixed allocation has been defined (via management), allocating this VID to a specific FID; or
c) A dynamic allocation has been defined (as a result of applying the VLAN Learning Constraints), allocating this VID to a specific FID.

For any VID that has no fixed allocation defined, the Bridge can dynamically allocate that VID to an appropriate FID, in accordance with the current set of VLAN Learning Constraints.

8.10.7.2 VLAN Learning Constraints

There are two types of VLAN Learning Constraint:

a) A Shared Learning Constraint (or S Constraint) asserts that Shared VLAN Learning shall occur between a pair of identified VLANs. S Constraints are of the form {A S B}, where A and B are VIDs. An S constraint is interpreted as meaning that Shared VLAN Learning shall occur between the VLANs identified by the pair of VIDs;
b) An Independent Learning Constraint (or I Constraint) asserts that a given VLAN is a member of a set of VLANs amongst which Independent VLAN Learning shall occur. I Constraints are of the form {A I N}, where A is a VID and N is an Independent Set Identifier. An I Constraint is interpreted as meaning that Independent VLAN Learning shall occur among the set of VLANs comprising VLAN A and all other VLANs identified in I Constraints that carry the same Independent Set Identifier, N.

A given VID may appear in any number (including zero) of S Constraints and/or I Constraints.

NOTE 1—S Constraints are

— *Symmetric*: e.g., {A S B} and {B S A} both express an identical constraint;
— *Transitive*: e.g., {A S B}, {B S C} implies the existence of a third constraint, {A S C};
— *Reflexive*: e.g., {A S A} is a valid S Constraint.

I Constraints are not

— *Symmetric*: e.g., {A I 1} and {1 I A} express different constraints;
— *Transitive*: e.g., ({A I 1}, {B I 1}, {B I 2}, {C I 2}) does not imply either {A I 2} or {C I 1}.

The allocation of VIDs to FIDs shall be such that, for all members of the set of active VLANs (8.10.7),

c) A given VID shall be allocated to exactly one FID;
d) If a given VID appears in an I Constraint, then it shall not be allocated to the same FID as any other VID that appears in an I Constraint with the same Independent Set Identifier;

e) If a given VID appears in an S Constraint (either explicit, or implied by the transitive nature of the specification), then it shall be allocated to the same FID as the other VID identified in the same S Constraint;

f) If a VID does not appear in any S or I Constraints, then the Bridge may allocate that VID to any FID of its choice.

NOTE 2—The intent is that the set of Learning Constraints is defined on a global basis; i.e., that all VLAN-aware Bridges are configured with the same set of constraints (although individual constraints may well be defined and distributed by different managers/administrators). Any Bridge therefore sees the complete picture in terms of the Learning Constraints that apply to all VLANs present in the Bridged LAN, regardless of whether they all apply to VLANs that are present in that particular Bridge. This standard provides the definition, in Clause 12, of managed objects and operations that model how individual constraints can be configured in a Bridge; however, the issue of how a distributed management system might ensure the consistent setting of constraints in all Bridges in a Bridged LAN is not addressed by this standard.

8.10.7.3 VLAN Learning Constraint inconsistencies and violations

The application of the rules specified in 8.10.7.2, coupled with any fixed allocations of VIDs to FIDs that may have been configured, can result in the Bridge detecting Learning Constraint inconsistencies and/or violations (i.e., can result in situations where there are inherent contradictions in the combined specification of the VLAN Learning Constraints and the fixed allocations, or the Bridge’s own limitations mean that it cannot meet the set of VLAN Learning Constraints that have been imposed upon it).

A Bridge detects a Learning Constraint inconsistency if

a) The VLAN Learning Constraints, coupled with any fixed VID to FID allocations, are such that, if any given pair of VLANs became members of the set of active VLANs (8.10.7), the result would be a simultaneous requirement for Independent VLAN Learning and for Shared VLAN Learning for those two VLANs. Such an inconsistency would require the Bridge to allocate that pair of VIDs both to the same FID and to different FIDs.

Learning Constraint inconsistencies are detected when a management operation (12.10.3) attempts to set a new Learning Constraint value, or to modify the fixed VID to FID allocations. If the new constraint or allocation that is the subject of the operation is inconsistent with those already configured in the Bridge, then the management operation shall not be performed and an error response shall be returned.

A Bridge detects a Learning Constraint violation if

b) The Bridge does not support the ability to map more than one VID to any given FID, and the VLAN Learning Constraints indicate that two or more members of the active set of VLANs require to be mapped to the same FID; or

c) The number of FIDs required in order to correctly configure the Bridge to meet the VLAN Learning Constraints and fixed VID to FID allocations for all members of the active set of VLANs exceeds the number of FIDs supported by the Bridge.

Learning Constraint violations are detected

d) When a VLAN that was hitherto not a member of the set of active VLANs (8.10.7) becomes active, either as a result of management action or as a result of the operation of GVRP, resulting in the Bridge no longer being able to support the defined set of constraints and/or fixed allocations for the set of active VLANs; or

e) When other management reconfiguration actions, such as defining a new Learning Constraint or fixed VID to FID allocation, results in the Bridge no longer being able to support the defined set of constraints and/or fixed allocations for the set of active VLANs.

On detection of a violation, the Bridge issues the Notify Learning Constraint Violation management notification (12.10.3.10), in order to alert any management stations to the existence of the violation. There is the potential for a single change in configuration to result in more than one VLAN whose constraints cannot be met; in such cases, multiple notifications are generated.

8.10.8 Querying the Filtering Database

If a frame is classified into a VLAN containing a given outbound Port in its member set (8.10.9), forwarding or filtering through that Port is determined by the control elements of filtering entries for the frame's destination MAC Address and for VLANs with the same VID or Filtering Identifier (FID, 8.10.7) as the frame's VLAN.

Each entry in the Filtering Database for a MAC Address comprises

a) A MAC Address specification;
b) A VID or, in the case of Dynamic Filtering Entries, an FID;
c) A Port Map, with a control element for each outbound Port.

For Dynamic Filtering Entries, the FID that corresponds to a given VID is determined as specified in 8.10.7.

For a given VID, a given individual MAC Address specification can be included in the Filtering Database in a Static Filtering Entry, a Dynamic Filtering Entry, both or neither. Table 8-5 combines Static Filtering Entry and Dynamic Filtering Entry information for an individual MAC Address to specify forwarding, or filtering, of a frame with that destination MAC Address and VID through an outbound Port.

NOTE 1—The use of FID in this table for Static Filtering Entries, and the text in parentheses in the headings, reflects the fact that, where more than one VID maps to a given FID, there may be more than one Static Filtering Entry that affects the forwarding decision for a given individual MAC Address. The effect of all Static Filtering Entries for that address, and for VIDs that correspond to that FID, is combined, such that, for a given outbound Port:
— IF <any static entry for any VIDs that map to that FID specifies Forwarding> THEN <result = Forwarding>
— ELSE IF <any static entry for any VIDs that map to that FID specifies Filtering> THEN <result = Filtering>
— ELSE <result = Use Dynamic Filtering Information>

Table 8-5—Combining Static and Dynamic Filtering Entries for an individual MAC Address

Filtering Information	**Control Elements in any Static Filtering Entry or Entries for this individual MAC Address, FID, and outbound Port specify:**				
	Forward (Any Static Filtering Entry for this Address/FID/Port specifies Forward)	**Filter (No Static Filtering Entry for this Address/FID/Port specifies Forward)**	**Use Dynamic Filtering Information (No Static Filtering Entry for this Address/FID/Port specifies Forward or Filter), or no Static Filtering Entry present. Dynamic Filtering Entry Control Element for this individual MAC Address, FID and outbound Port specifies:**		
			Forward	**Filter**	**No Dynamic Filtering Entry present**
Result	Forward	Filter	Forward	Filter	Forward

Table 8-6 specifies the result, Registered or Not Registered, of combining a Static Filtering Entry and a Group Registration Entry for the "All Group Addresses" address specification, and for the "All Unregistered Group Addresses" address specification for an outbound Port.

Table 8-6—Combining Static Filtering Entry and Group Registration Entry for “All Group Addresses” and “All Unregistered Group Addresses”

Filtering Information	Static Filtering Entry Control Element for this group MAC Address, VID, and outbound Port specifies:				
	Registration Fixed (Forward)	**Registration Forbidden (Filter)**	**Use Group Registration Information, or no Static Filtering Entry present. Group Registration Entry Control Element for this group MAC Address, VID and outbound Port specifies:**		
			Registered (Forward)	**Not Registered (Filter)**	**No Group Registration Entry present**
Result	Registered	Not Registered	Registered	Not Registered	Not Registered

Table 8-7 combines Static Filtering Entry and Group Registration Entry information for a specific group MAC Address with the Table 8-6 results for All Group Addresses and All Unregistered Group Addresses to specify forwarding, or filtering, of a frame with that destination group MAC Address through an outbound Port.

Table 8-7—Forwarding or Filtering for specific group MAC Addresses

				Static Filtering Entry Control Element for this group MAC Address, VID and outbound Port specifies:				
				Registration Fixed (Forward)	**Registration Forbidden (Filter)**	**Use Group Registration Information, or no Static Filtering Entry present. Group Registration Entry Control Element for this group MAC Address, VID and outbound Port specifies:**		
						Registered (Forward)	**Not Registered (Filter)**	**No Group Registration Entry present**
All Group Addresses control elements for this VID and Port specify (Table 8-6):	Not Registered	**All Unregistered Group Addresses control elements for this VID and Port specify (Table 8-6):**	Not Registered	Forward	Filter	Forward	Filter	Filter (Filter Unregistered Groups)
			Registered	Forward	Filter	Forward	Filter	Forward (Forward Unregistered Groups)
	Registered			Forward	Filter	Forward (Forward All Groups)	Forward (Forward All Groups)	Forward (Forward All Groups)

Where a given VID is allocated to the same FID as one or more other VIDs, it is an implementation option as to whether

d) The results shown in Table 8-7 directly determine the forwarding/filtering decision for a given VID and group MAC Address (i.e., the operation of the Bridge with respect to group MAC Addresses ignores the allocation of VIDs to FIDs); or
e) The results for a given MAC Address and VID are combined with the corresponding results for that MAC Address for each other VID that is allocated to the same FID, so that if the Table 8-7 result is Forward in any one VLAN that shares that FID, then frames for that group MAC Address will be forwarded for all VLANs that share that FID (i.e., the operation of the Bridge with respect to group MAC Addresses takes account of the allocation of VIDs to FIDs).

NOTE 2—In case d), the implementation effectively operates a single FDB per VLAN for group MAC Addresses. In case e), the implementation combines static and registered information for group MAC Addresses in accordance with the VID to FID allocations currently in force, in much the same manner as for individual MAC Addresses.

8.10.9 Determination of the member set and untagged set for a VLAN

The VLAN configuration information contained in the Filtering Database for a given VLAN may include a Static VLAN Registration Entry (8.10.2) and/or a Dynamic VLAN Registration Entry (8.10.5). This information defines, for that VLAN:

a) The *member set*, consisting of the set of Ports through which members of the VLAN can currently be reached;
b) The *untagged set*, consisting of the set of Ports through which, if frames destined for the VLAN are to be transmitted, they shall be transmitted without tag headers. For all other Ports (i.e., all Ports that are not members of the untagged set), if frames destined for the VLAN are to be transmitted, they shall be transmitted with tag headers.

NOTE 1—As the ingress rule checking function of the Forwarding Process (8.6.1) always associates a non-null VLAN ID with an incoming frame, all frames (including received frames that were priority-tagged and carried the null VLAN ID in their tag header) will be transmitted with or without a tag header in accordance with the membership of the untagged set for their VID.

For a given VID, the Filtering Database can contain a Static VLAN Registration Entry, a Dynamic VLAN Registration Entry, both or neither. Table 8-8 combines Static VLAN Registration Entry and Dynamic VLAN Registration Entry information for a VLAN and Port to give a result *member*, or *not member*, for the Port. The member set for a given VLAN consists of all Ports for which the result is member.

Table 8-8—Determination of whether a Port is in a VLAN's member set

Filtering Information	**Static VLAN Registration Entry Control Element for this VID and Port specifies:**				
	Registration Fixed	**Registration Forbidden**	**Normal Registration, or no Static VLAN Registration Entry present. Dynamic VLAN Registration Entry Control Element for this VID and Port specifies:**		
			Registered	**Not Registered**	**No Dynamic VLAN Registration Entry present**
Result	Member	Not member	Member	Not member	Not member

Membership of the untagged set for a given VLAN is derived from Static VLAN Registration Entry information contained in the Filtering Database as follows:

c) If there is no Static VLAN Registration Entry for the VLAN, then the untagged set is the empty set; otherwise,
d) The untagged set is equal to the set of Ports for which the Port Map in the Static VLAN Registration Entry indicates that frames are to be transmitted untagged.

The untagged set and the member set for a given VLAN are used by the Forwarding Process in applying the ingress rules (8.6.1) and the egress rules (8.6.4) for that VLAN.

The initial state of the Permanent Database contains a Static VLAN Registration Entry for the VLAN corresponding to the Default PVID (Table 9-2). The Port Map in this entry specifies Registration Fixed and forwarding untagged for all Ports of the Bridge. This entry may be modified or removed from the Permanent Database by means of the management operations defined in Clause 12 if the implementation supports these operations.

NOTE 2—This causes the default tagging state for the PVID to be untagged, and for all other VIDs to be tagged, unless otherwise configured; however, the management configuration mechanisms allow any VID (including the PVID) to be specified as VLAN-tagged or untagged on any Port. Under normal circumstances, the appropriate configuration for the PVID would be untagged on an access Port or a hybrid Port, and VLAN-tagged on a trunk Port (Annex D discusses the terms *access Port*, *hybrid Port*, and *trunk Port*).

8.10.10 Permanent Database

The Permanent Database provides fixed storage for a number of Static Filtering Entries and Static VLAN Registration Entries. The Filtering Database shall be initialized with the Filtering Database Entries contained in this fixed data store.

Entries may be added to and removed from the Permanent Database under explicit management control, using the management functionality defined in Clause 12. Changes to the contents of Static Filtering Entries or Static VLAN Registration Entries in the Permanent Database do not affect forwarding and filtering decisions taken by the Forwarding Process or the egress rules until such a time as the Filtering Database is re-initialized.

NOTE 1—This aspect of the Permanent Database can be viewed as providing a “boot image” for the Filtering Database, defining the contents of all initial entries, before any dynamic filtering information is added.

NOTE 2—Subclause 10.3.2.3 of IEEE Std 802.1D, 1998 Edition defines an initial state for the contents of the Permanent Database, required for the purposes of GMRP operation.

8.11 MST configuration information

In order to support multiple spanning trees, an MST Bridge has to be configured with an unambiguous assignment of VIDs to spanning trees. This is achieved by:

a) Ensuring that the allocation of VIDs to FIDs (8.10.7) is unambiguous; and
b) Ensuring that each FID supported by the Bridge is allocated to exactly one Spanning Tree.

The first of these requirements is met by configuring a set of VLAN learning constraints and/or fixed VID to FID mappings that are self-consistent, and which define an I Constraint, an S Constraint, or a fixed VID to FID allocation for all VIDs supported by the Bridge.

The second requirement is met by means of the FID to MSTI Allocation Table (8.11.3).

The combination of the VID to FID allocations and the FID to MSTI allocations defines a mapping of VIDs to spanning trees, represented by the MST Configuration Table (8.11.1).

8.11.1 MST Configuration Table

The MST Configuration Table defines, for each VID, the MSTID of the spanning tree instance to which the VID is allocated.

The MST Configuration Table cannot be configured directly; configuration of the table occurs as a consequence of configuring the relationships between VIDs and FIDs (8.10.7), and between FIDs and spanning trees (8.11.3).

8.11.2 MST Configuration Identification

In order for two or more MST Bridges to be members of the same MST Region (3.29), it is necessary for those Bridges to be directly connected together (i.e., interconnected only by means of LAN segments, without intervening Bridges that are not members of the region), and for them to support the same MST Region configuration. Two MST Region configurations are considered to be the same if the correspondence between VIDs and spanning trees is identical in both configurations.

NOTE 1—If two adjacent MST Bridges consider themselves to be in the same MST Region despite having different mappings of VIDs to spanning trees, then the possibility exists of undetectable loops arising within the MST Region.

In order to ensure that adjacent MST Bridges are able to determine whether they are part of the same MST Region, the MST BPDU supports the communication of an MST Configuration Identifier (13.7).

NOTE 2—As the MST Configuration Identifier is smaller than the mapping information that it summarizes, there is a small but finite possibility that two MST Bridges will assume that they have the same MST Region Configuration when this is not actually the case. However, given the size of the identifier, this standard assumes that this possibility is sufficiently small that it can safely be ignored. Appropriate use of the Configuration Name and Revision Level portions of the identifier can remove the possibility of an accidental match between MST Configuration Identifiers that are derived from different configurations within a single administrative domain (see 13.7).

8.11.3 FID to MSTI Allocation Table

The FID to MSTI Allocation Table defines, for all FIDs that the Bridge supports, the MSTID of the spanning tree instance to which the FID is allocated. An MSTID of zero is used to identify the CIST.

NOTE—The management operations defined in Clause 12.12 make use of the concept of an MSTI List to instantiate/deinstantiate MST instances, and will only permit the allocation of FIDs to MSTIDs that are present in the MSTI List.

8.12 Spanning Tree Protocol Entity and GARP Protocol Entities

The Spanning Tree Protocol Entity operates the Spanning Tree Algorithm and associated protocol (STP, RSTP, or MSTP).

The Spanning Tree Protocol Entities of Bridges attached to a given individual LAN in a Bridged LAN communicate by exchanging Bridge Protocol Data Units (BPDUs).

Figure 8-6 illustrates the operation of the Spanning Tree Protocol Entity including the reception and transmission of frames containing BPDUs, the modification of the state information associated with individual Bridge Ports, and notification of the Filtering Database of changes in active topology.

A given MST bridge is not required to support all of the spanning trees that exist within the MST bridged LAN. That is, the number of spanning trees operated by the Spanning Tree Protocol Entity in a given bridge may be different from the number operated by that in another bridge. However, as a direct consequence of the conditions stated in 8.11.2, the number of instances of the Spanning Tree Protocol operated by a given MST Bridge is the same for all Bridges that are members of a given MST Region.

The GARP Protocol Entities operate the Algorithms and Protocols associated with the GARP Applications supported by the Bridge, and consist of the set of GARP Participants for those GARP Applications (Clause 10 and 12.3 of IEEE Std 802.1D, 1998 Edition).

The GARP Protocol Entities of Bridges attached to a given individual LAN in a Bridged LAN communicate by exchanging GARP Protocol Data Units (GARP PDUs).

Figure 8-7 illustrates the operation of a GARP Protocol Entity including the reception and transmission of frames containing GARP PDUs, the use of control information contained in the Filtering Database, and notification of the Filtering Database of changes in filtering information.

8.13 Bridge Management

Remote management facilities may be provided by the Bridge. Bridge Management is modeled as being performed by means of the Bridge Management Entity. The facilities provided by Bridge Management, and the operations that support these facilities, are specified in Clause 12.

Bridge Management protocols use the MAC Service provided by the Bridged LAN.

8.14 Addressing

All MAC Entities communicating across a Bridged LAN shall use 48-bit addresses. These may be Universally Administered Addresses, Locally Administered Addresses, or a combination of both.

8.14.1 End stations

Frames transmitted between end stations using the MAC Service provided by a Bridged LAN carry the MAC Address of the source and destination end stations in the source and destination address fields of the frames, respectively. The address, or other means of identification, of a Bridge is not carried in frames transmitted between end stations for the purpose of frame relay in the Bridged LAN.

The broadcast address and other group MAC Addresses apply to the use of the MAC Service provided by a Bridged LAN as a whole. In the absence of explicit filters configured via management as Static Filtering Entries, or via GMRP as Group Registration Entries (8.10 and Clause 12 of this standard, and Clause 10 of IEEE Std 802.1D, 1998 Edition), frames with such destination addresses are relayed throughout the Bridged LAN.

8.14.2 Bridge Ports

The individual MAC Entity associated with each Bridge Port shall have a separate individual MAC Address. This address is used for any MAC procedures required by the particular MAC method employed.

Frames that are received from the LAN to which a Port is attached and that carry a MAC Address for the Port in the destination address field are submitted to the MAC Service User (LLC) exactly as for an end station.

8.14.3 Bridge Protocol Entities and GARP Protocol Entities

Bridge Protocol Entities only receive and transmit BPDUs. These are only received and transmitted from other Bridge Protocol Entities (or where two Bridge Ports are connected to the same LAN, to and from themselves).

GARP Protocol Entities only receive and transmit GARP PDUs (12.11 of IEEE Std 802.1D, 1998 Edition) that are formatted according to the requirements of the GARP Applications they support. These are only received and transmitted from other GARP Protocol Entities.

A Spanning Tree Protocol Entity or a GARP Protocol Entity uses the DL_UNITDATA.request primitive (see ISO/IEC 8802-2) provided by the individual LLC Entities associated with each active Bridge Port to transmit BPDUs or GARP PDUs. Each PDU is transmitted on one selected Bridge Port. PDUs are received through corresponding DL_UNITDATA.indication primitives. The source_address and destination_address parameters of the DL_UNITDATA.request primitive shall both denote the standard LLC address assigned to the Bridge Spanning Tree Protocol. This identifies the Spanning Tree Protocol Entity and the GARP Protocol Entity among other users of LLC.

Each DL_UNITDATA.request primitive gives rise to the transmission of an LLC UI command PDU, which conveys the BPDU or GARP PDU in its information field. The source and destination LLC address fields are set to the values supplied in the request primitive.

The value assigned to the Bridge Spanning Tree Protocol LLC address is given in Table 8-9.[5]

Table 8-9—Standard LLC address assignment

Assignment	Value
Bridge spanning tree protocol	01000010

Code Representation: The least significant bit of the value shown is the right-most. The bits increase in significance from right to left. It should be noted that the code representation used here has been chosen in order to maintain consistency with the representation used elsewhere in this standard; however, it differs from the representation used in ISO/IEC 11802-1: 1997.

IEEE Std 802.1D, 1998 Edition defines a Protocol Identifier field, present in all BPDUs (Clause 9 of IEEE Std 802.1D, 1998 Edition) and GARP PDUs (12.11 of IEEE Std 802.1D, 1998 Edition), which serves to identify different protocols supported by Bridge Protocol Entities and GARP Protocol Entities, within the scope of the LLC address assignment. This standard specifies a single value of the Protocol Identifier, defined in Clause 9 of IEEE Std 802.1D, 1998 Edition, for use in BPDUs. This value serves to identify BPDUs exchanged between Bridge Protocol Entities operating the Spanning Tree Algorithm and Protocol specified in Clause 8 of IEEE Std 802.1D, 1998 Edition. A second value of this protocol identifier for use in GARP PDUs is defined in 12.11 of IEEE Std 802.1D, 1998 Edition. This value serves to identify GARP PDUs exchanged between GARP Participants operating the GARP protocol specified in Clause 12 of IEEE Std 802.1D, 1998 Edition. Further values of this field are reserved for future standardization.

A Spanning Tree Protocol Entity or GARP Protocol Entity that receives a BPDU or a GARP PDU with an unknown Protocol Identifier shall discard that PDU.

[5] ISO/IEC TR 11802-1: 1997, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Technical reports and guidelines—Part 1: The structure and coding of Logical Link Control addresses in Local Area Networks, contains the full list of standard LLC address assignments, and documents the criteria for assignment.

A Spanning Tree Protocol Entity that operates the Spanning Tree Algorithm and Protocol specified in Clause 8 of IEEE Std 802.1D, 1998 Edition always transmits BPDUs addressed to all other Bridge Protocol Entities attached to the LAN on which the frame containing the BPDU is transmitted. A group address shall be used in the destination address field to address this group of Entities. This group address shall be configured in the Permanent Database (8.14.6) in order to confine BPDUs to the individual LAN on which they are transmitted.

A 48-bit universally administered address, known as the Bridge Group Address, has been assigned for this purpose. Its value is specified inTable 8-10. SST Bridges that use 48-bit universally administered addresses shall use this address as the destination address of all MAC frames conveying BPDUs in an SST environment. MST Bridges shall use this address as the destination address of all MAC frames conveying BPDUs for the Multiple Spanning Tree Protocol (MSTP, clause 13) and the Internal Sub-Tree Protocol (ISTP, 14.3).

Table 8-10—Reserved addresses

Assignment	Value
Bridge Group Address	01-80-C2-00-00-00
IEEE Std 802.3, 1998 Edition, Full Duplex PAUSE operation	01-80-C2-00-00-01
IEEE Std 802.3ad Slow_Protocols_Multicast address	01-80-C2-00-00-02
IEEE Std 802.1X PAE address	01-80-C2-00-00-03
Reserved for future standardization	01-80-C2-00-00-04
Reserved for future standardization	01-80-C2-00-00-05
Reserved for future standardization	01-80-C2-00-00-06
Reserved for future standardization	01-80-C2-00-00-07
Reserved for future standardization	01-80-C2-00-00-08
Reserved for future standardization	01-80-C2-00-00-09
Reserved for future standardization	01-80-C2-00-00-0A
Reserved for future standardization	01-80-C2-00-00-0B
Reserved for future standardization	01-80-C2-00-00-0C
Reserved for future standardization	01-80-C2-00-00-0D
Reserved for future standardization	01-80-C2-00-00-0E
Reserved for future standardization	01-80-C2-00-00-0F

A GARP Protocol Entity that

a) Operates the GARP protocol specified in Clause 12 of IEEE Std 802.1D, 1998 Edition; and
b) Supports a given GARP Application,

always transmits GARP PDUs addressed to all other GARP Protocol Entities that

c) Implement the same GARP Application; and
d) Are attached to the LAN on which the frame containing the GARP PDU is transmitted.

A group MAC Address, specific to the GARP Application concerned, shall be used as the destination MAC Address field to address this group of GARP Protocol Entities. A set of 48-bit Universal Addresses, known as GARP Application addresses, have been assigned for that purpose. The values of the GARP Application addresses are defined in Table 12-1 of IEEE Std 802.1D, 1998 Edition. These group MAC Addresses are reserved for assignment to standard protocols, according to the criteria for such assignments (Clause 5.5 of ISO/IEC TR 11802-2).

NOTE—Table 11-1 allocates a group MAC Address for use by the GVRP application; however, the value allocated in that table is one of the GARP Application addresses reserved by Table 12-1 of IEEE Std 802.1D, 1998 Edition.

In Bridges that do not support any GARP applications, the set of GARP Application addresses should not be configured in the Filtering Database (8.10) or the Permanent Database (8.10.10). In Bridges that support one or more GARP applications, the set of GARP Application addresses should be configured as Static Filtering Entries in the Filtering Database (8.10.1) and Permanent Database (8.10.10) as follows:

e) GARP Application addresses assigned to GARP Applications that are supported by the Bridge should be configured in order to confine GARP PDUs for that GARP Application to the individual LAN on which they are transmitted;

f) GARP Application addresses assigned to GARP Applications that are not supported by the Bridge should not be configured in the Filtering Database or Permanent Database.

The source address field of MAC frames conveying BPDUs or GARP PDUs contains the individual MAC Address for the Bridge Port through which the PDU is transmitted (8.14.2).

8.14.4 Bridge Management Entities

Bridge Management Entities transmit and receive protocol data units using the Service provided by the individual LLC Entities associated with each Bridge Port. Each of these in turn uses the MAC Service, which is provided by the individual MAC Entities associated with that Port and supported by the Bridged LAN as a whole.

As a user of the MAC Service provided by a Bridged LAN, the Bridge Management Entity may be attached to any point in the Bridged LAN. Frames addressed to the Bridge Management Entity will be relayed by Bridges if necessary to reach the LAN to which it is attached.

In order to ensure that received frames are not duplicated, the basic requirement in a single LAN or a Bridged LAN that a unique address be associated with each point of attachment shall be met.

A Bridge Management Entity for a specific Bridge is addressed by one or more individual MAC Addresses in conjunction with the higher layer protocol identifier and addressing information. It may share one or more points of attachment to the Bridged LAN with the Ports of the Bridge with which it is associated. It is recommended that it make use of the MAC Service provided by all the MAC Entities associated with each Bridge Port, i.e., that it be reachable through each Bridge Port using frames carrying the individual MAC Address of that Port in the destination address field.

This standard specifies a standard group MAC Address for public use which serves to convey management requests to the Bridge Management Entities associated with all Bridge Ports attached to a Bridged LAN. A management request that is conveyed in a MAC frame carrying this address value in the destination address field will generally elicit multiple responses from a single Bridge. This address is known as the All LANs Bridge Management Group Address and takes the value specified in Table 8-11.

Table 8-11—Addressing bridge management

Assignment	Value
All LANs Bridge Management Group Address	01-80-C2-00-00-10

8.14.5 Unique identification of a Bridge

A unique 48-bit Universally Administered MAC Address, termed the Bridge Address, shall be assigned to each Bridge. The Bridge Address may be the individual MAC Address of a Bridge Port, in which case use of the address of the lowest numbered Bridge Port (Port 1) is recommended.

NOTE—The Spanning Tree Protocol (Clause 8 of IEEE Std 802.1D, 1998 Edition) requires that a single unique identifier be associated with each Bridge. That identifier is derived from the Bridge Address as specified in 8.5.1.3, 8.5.3.7, and 9.2.5 of IEEE Std 802.1D, 1998 Edition.

8.14.6 Reserved addresses

Frames containing any of the group MAC Addresses specified in Table 8-1 in their destination address field shall not be relayed by the Bridge. They shall be configured in the Permanent Database. Management shall not provide the capability to modify or remove these entries from the Permanent or the Filtering Databases. These group MAC Addresses are reserved for assignment to standard protocols, according to the criteria for such assignments (Clause 5.5 of ISO/IEC TR 11802-2).

8.14.7 Points of attachment and connectivity for Higher Layer Entities

Higher Layer Entities such as the Spanning Tree Protocol Entity and GARP Protocol Entity (8.12), and Bridge Management (8.13) are modeled as being connected directly to the Bridged LAN via one or more points of attachment. From the point of view of their attachment to the Bridged LAN, Higher Layer Entities associated with a Bridge can be regarded as if they are distinct end stations, directly connected to one or more of the LAN segments served by the Bridge Ports, in the same way as any other end station is connected to the Bridged LAN. In practice, the Higher Layer Entities will, in many cases, share the same physical points of attachment used by the relay function of the Bridge, as stated in 8.14; however, from the point of view of the transmission and reception of frames by these functions, the behavior is the same as if they were contained in logically separate end stations with points of attachment “outside” the Port(s) with which they are associated. Figure 8-10 is functionally equivalent to Figure 6-1, but illustrates this logical separation between the points of attachment used by the Higher Layer Entities and points of attachment used by the MAC Relay Entity.

Higher Layer Entities fall into two distinct categories:

a) Those entities, such as the Bridge Management Entity, that require only a single point of attachment to the Bridged LAN;
b) Those entities, such as Bridge Protocol Entities and GARP Participants, that require a point of attachment per Port of the Bridge.

The fundamental distinction between these two categories is that for the latter, it is essential for the operation of the entity concerned that it is able to associate received frames with the LAN segment on which those frames were originally seen by the Bridge, and that it is able to transmit frames to peer entities that are connected directly to that LAN segment. It is therefore essential that

c) It does not receive frames via a point of attachment associated with one Port that have been relayed by the Bridge from other Ports; and
d) Frames that it transmits via one point of attachment are not relayed by the Bridge to any other Ports.

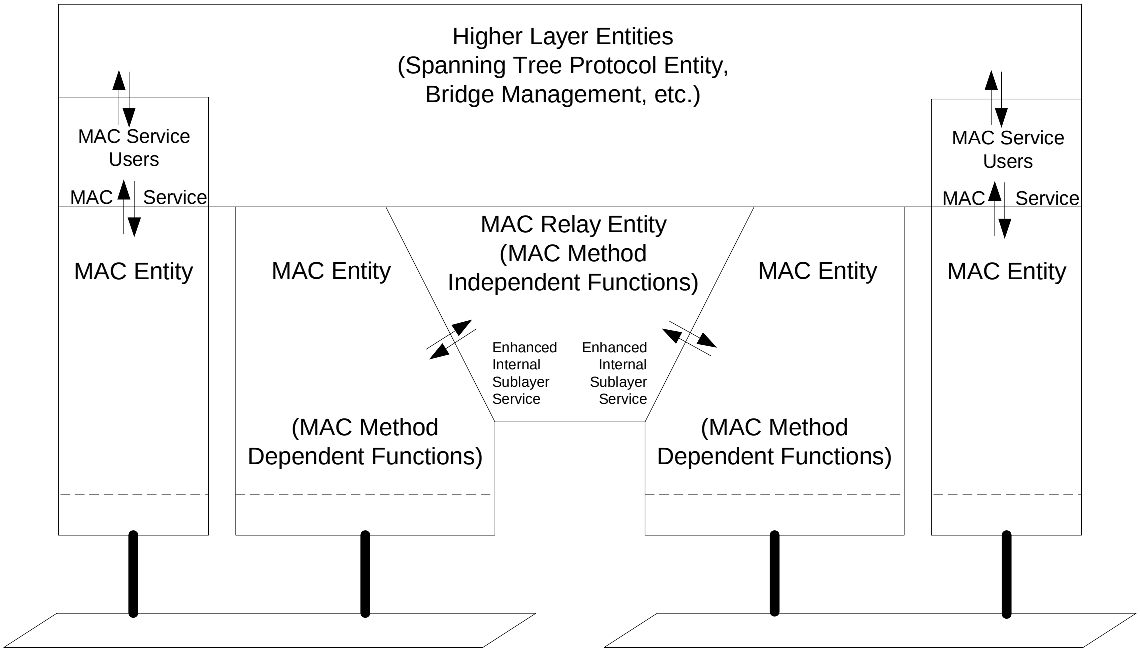


Figure 8-10—Logical separation of points of attachment used by Higher Layer Entities and the MAC Relay Entity

For this reason, the MAC Addresses used to reach entities of this type are permanently configured in the Filtering Database in order to prevent the Bridge from relaying such frames received via any Port to any other Port of the Bridge, as defined in 8.14.3 and 8.14.6.

NOTE 1—The MAC Addresses used to address such entities are generally group MAC Addresses.

The MAC Relay Entity forwards a frame received on one Port through the other Port(s) of the Bridge, subject to the following control information permitting such forwarding to take place:

e) The Port state information (8.4) associated with the Port on which the frame was received;
f) The information held in the Filtering Database (8.10);
g) The Port state information (8.4) associated with the Port(s) on which the frame is potentially to be transmitted.

This is illustrated in Figure 8-11, where the control information represented by the Port state and Filtering Database information is represented as a series of switches (shown in the open, disconnected state) inserted in the forwarding path provided by the MAC Relay Entity. For the Bridge to forward a given frame between two Ports, all three switches must be in the closed state. This figure also illustrates that the controls placed in the forwarding path have no effect upon the ability of a Higher Layer Entity to transmit and receive frames directly onto a given LAN segment via the point of attachment to that segment (e.g., from entity A to segment A); they only affect the path taken by any indirect transmission/reception (e.g., from entity A to segment B).

Figure 8-12 illustrates the state of the forwarding path with respect to frames destined for Higher Layer Entities that require per-Port points of attachment. The fact that the Filtering Databases in all Bridges are permanently configured to prevent relay of frames addressed to these entities means that they can receive frames only via their direct points of attachment (i.e., from segment A to entity A, and from segment B to entity B), regardless of the Port states.

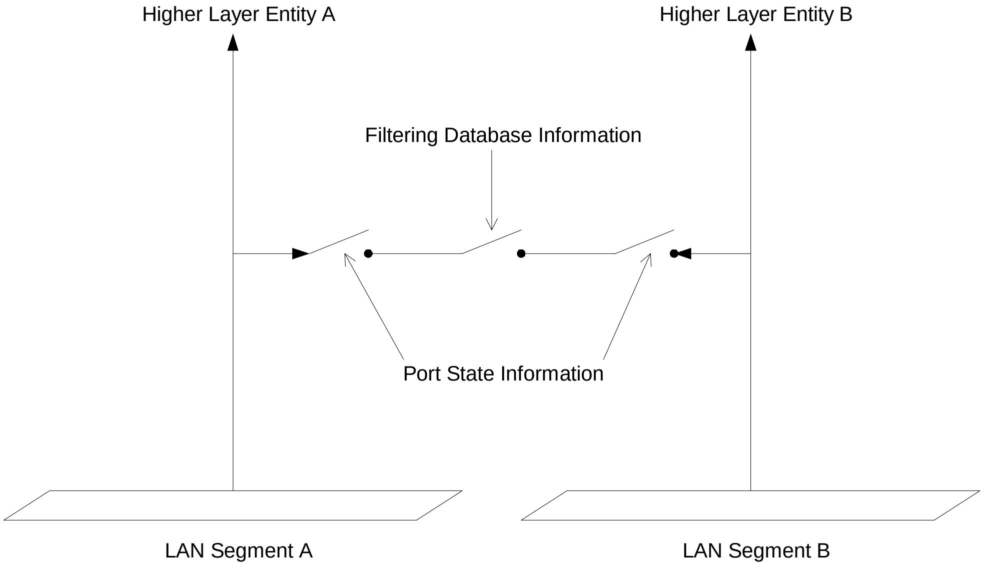


Figure 8-11—Effect of control information on the forwarding path

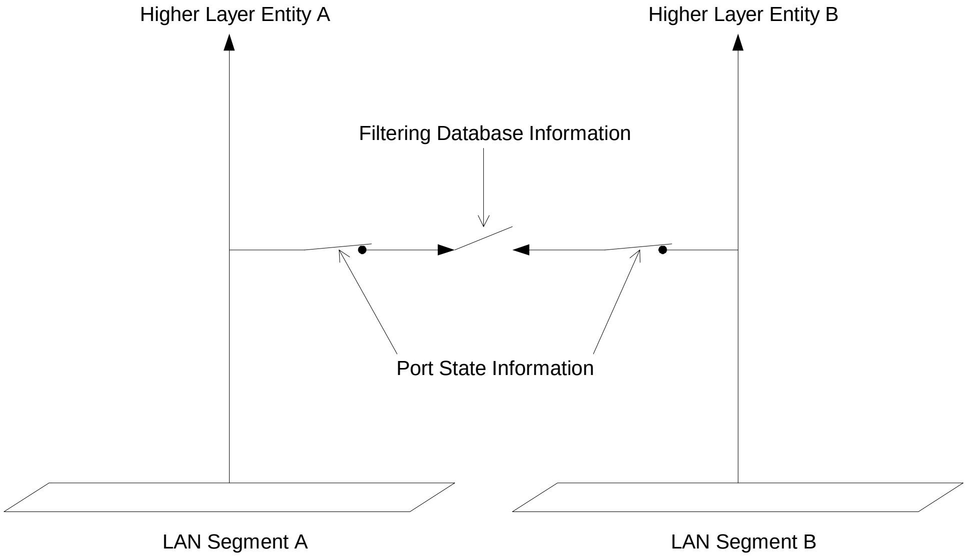


Figure 8-12—Per-Port points of attachment

Figure 8-13 illustrates the state of the forwarding path with respect to frames destined for a Higher Layer Entity that requires only a single point of attachment, for the case where the Port states and Filtering Database states permit relay of frames. Frames destined for the Higher Layer Entity that originate on LAN segment B are relayed by the Bridge, and are both received by the entity and transmitted on LAN segment A.

Figure 8-14 illustrates the state of the forwarding path with respect to frames destined for a Higher Layer Entity that requires only a single point of attachment, for the case where one of the Port states does not permit relay. Frames destined for the Higher Layer Entity that originate on LAN segment A are received by the entity; however, frames that originate on LAN segment B are not relayed by the Bridge, and can therefore only be received by the entity if there is some other forwarding path provided by other components of the Bridged LAN between segments A and B.

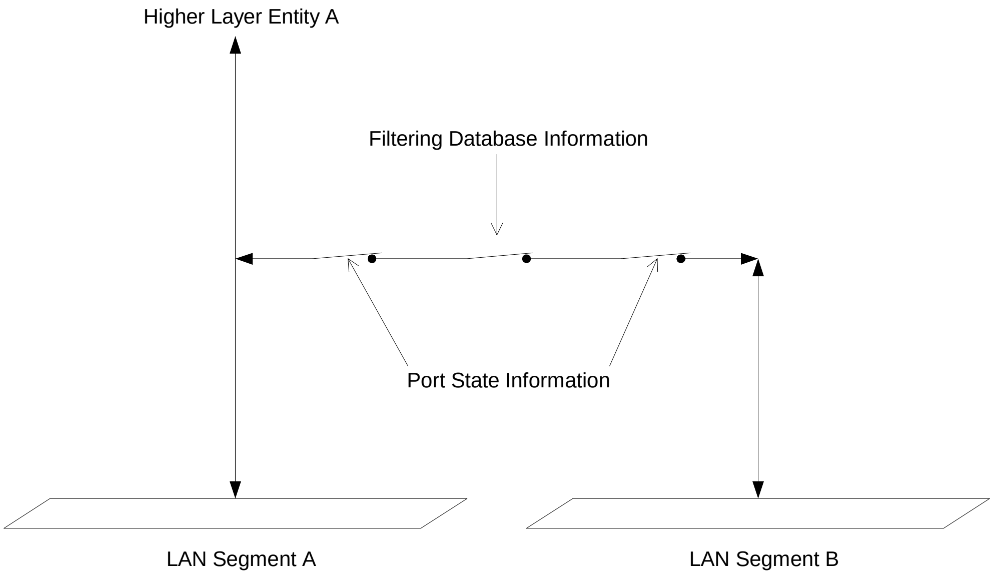


Figure 8-13—Single point of attachment—relay permitted

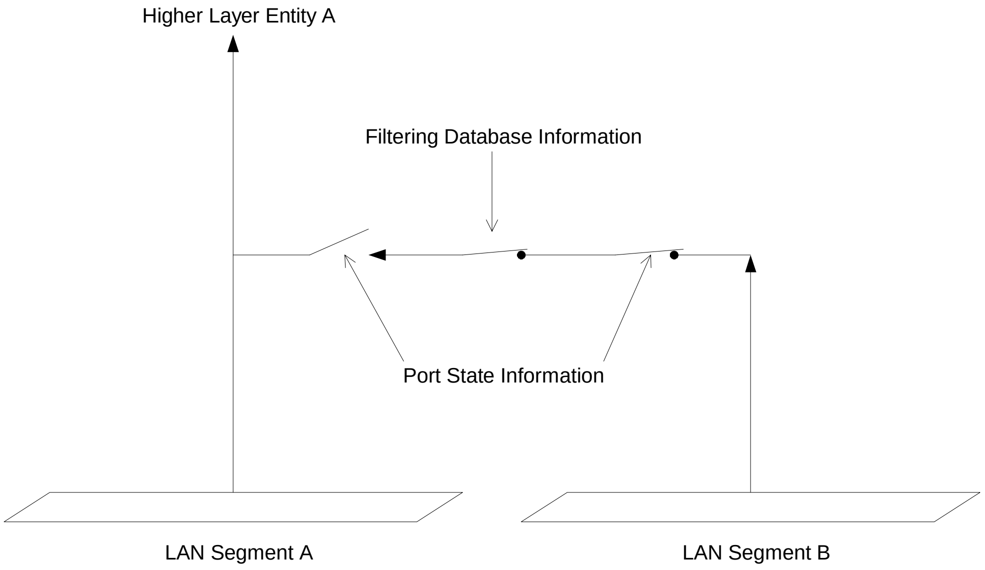


Figure 8-14—Single point of attachment—relay not permitted

NOTE 2—If the Port state shown in Figure 8-14 occurs as a result of the normal operation of the Spanning Tree (as opposed to being a result of equipment failure, or administrative control of Port state information), then such a path will exist, either via another Port of this Bridge (not shown in the diagram) connected to segment A, or via one or more Bridges providing a path between segments A and B. If there is no active Spanning Tree path from segment B to segment A, then the Bridged LAN has partitioned into two separate Bridged LANs, one on either side of this Port, and the Higher Layer Entity shown is only reachable via segment A.

In VLAN-aware Bridges, two more switches appear in the forwarding path, corresponding to the actions taken by the Forwarding Process (8.6.1 and 8.6.4) in applying the ingress and egress rules (8.6.1 and 8.6.4), as illustrated in Figure 8-15.

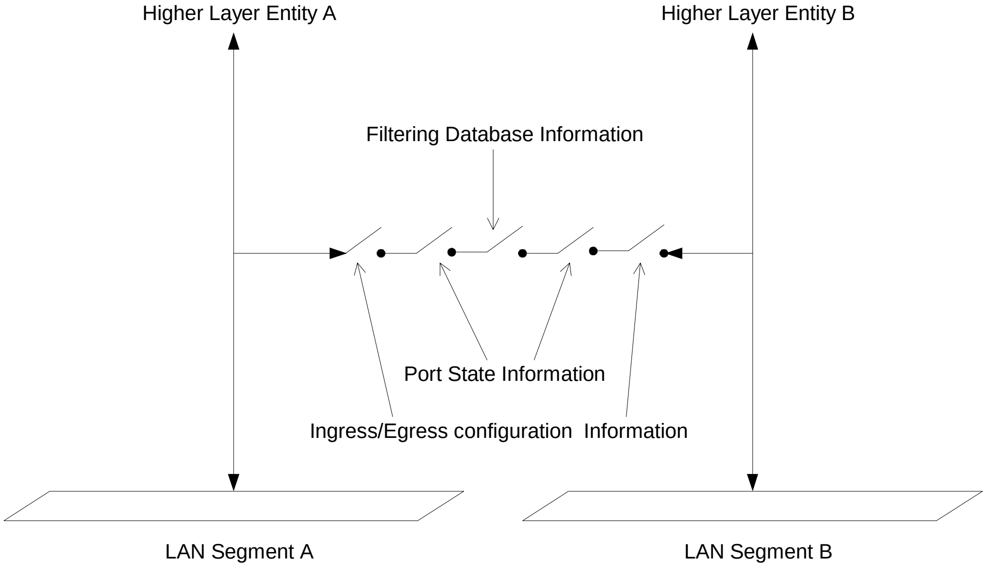


Figure 8-15—Ingress/egress control information in the forwarding path

As with Port state information, the configuration of the ingress and egress rules does not affect the reception of frames received on the same LAN segment as a Higher Layer Entity's point of attachment. For example, the reception of a frame by Higher Layer Entity A that was transmitted on LAN Segment A is unaffected by the ingress or egress configuration of either Port. However, for Higher Layer Entities that require only a single point of attachment, the ingress and egress configuration affects the forwarding path. For example, frames destined for Higher Layer Entity A that are transmitted on LAN Segment B would be subjected to the ingress rules that apply to Port B and the egress rules that apply to Port A.

The decision as to whether frames transmitted by Higher Layer Entities are VLAN-tagged or untagged depends upon the Higher Layer Entity concerned, and the connectivity that it requires

h) Spanning Tree BPDUs transmitted by the Spanning Tree Protocol Entity are not forwarded by Bridges, and must be visible to all other Spanning Tree Protocol Entities attached to the same LAN segment. Such frames shall be transmitted untagged;

NOTE 3—Any BPDUs or GVRP PDUs that carry a tag header are not recognized as well-formed BPDUs or GVRP PDUs and are not forwarded by the Bridge.

i) The definition of the GVRP application (11.2.3) calls for all GVRP frames to be transmitted untagged for similar reasons;
j) The definition of the GMRP application (Clause 10) calls for all GMRP frames originating from VLAN-aware devices to be transmitted VLAN-tagged, in order for the VID in the tag to be used to identify the VLAN context in which the registration applies;
k) It may be necessary for PDUs transmitted for Bridge Management (8.13) to be VLAN-tagged in order to achieve the necessary connectivity for management in a VLAN Bridged LAN. In order to access a Bridge Management entity located in a region of the network that is served only by a given set of VLANs, it may be necessary to communicate with that entity using frames VLAN-tagged with one of the VIDs concerned, unless one of those VIDs also happens to be the PVID (or a member of the VID Set that matches the appropriate Protocol) for the Port serving the management station.

This Amendment makes no changes to Clause 9.

10. Use of GMRP in VLANs

10.1 Definition of a VLAN context

Change the note at the end of the subclause as follows:

~~NOTE—For the purposes of this standard, a single spanning tree is used to support all VLANs; however, the above definition has been deliberately worded so as not to preclude its use in a context where a mapping exists between M instances of spanning tree and N VLANs.~~

NOTE—The above definition applies equally to SST and MST environments. It ensures that GMRP operates in either environment, without the GMRP implementations needing to be aware whether the VLAN contexts that apply are all supported by the same spanning tree, as in the SST environment, or are potentially distributed across two or more spanning trees, as in the MST environment.

11. VLAN topology management

11.2 GARP VLAN Registration Protocol (GVRP)

11.2.1 GVRP overview

Insert the following two items following item b) of the list in the first paragraph of 11.2.1, and relabel later list items appropriately.

c) In an SST environment, there is a single GVRP Participant per port, rather than one GVRP Participant per VLAN per port, and the GVRP Participants all operate in a single GIP context;

d) In an MST environment, there is again a single GVRP Participant per port, but each GVRP Participant operates in multiple GIP contexts.

Change the first paragraphs of 11.2.1.2 as follows:

VLAN-aware Bridges register and propagate VLAN memberships on all Bridge Ports that are part of the active topology of the underlying Spanning Tree(s). Incoming VID registration and de-registration information is used to update the Dynamic VLAN Registration Entries associated with each VLAN. Any changes in the state of registration of a given VID on a given Port are propagated on Ports that are part of the active topology of the underlying Spanning Tree, in order to ensure that other GVRP-aware devices in the Bridged LAN update their Filtering Databases appropriately. In Bridges that support multiple Spanning Tree instances, the MST Configuration Table (12.12, 13.7) is used to determine which spanning tree instance is to be used to propagate registration information for each supported VLAN.

11.2.3 Definition of the GVRP application

Change 11.2.3.3 by deleting the current text of the subclause and inserting the following two replacement subclauses:

11.2.3.3 GIP context for GVRP in SST environments

In an SST environment, GVRP operates in the Base Spanning Tree Context (12.3.4 of IEEE Std 802.1D, 1998 Edition); i.e. GVRP operates only on the CIST defined by IEEE Std 802.1D, 1998 Edition. Consequently, all GVRP PDUs sent and received by GVRP Participants in SST bridges are transmitted as untagged frames.

11.2.3.4 GIP contexts for GVRP in MST environments

In an MST environment, GVRP operates in multiple spanning-tree contexts, one for each of the spanning trees. Each spanning-tree context consists of the ports that are in the forwarding state for the corresponding spanning tree. The GIP context for the GVRP Participants associated with a given spanning tree is the same as the spanning-tree context. MST bridges can identify the GIP contexts using the mappings of VID values to MSTID values (see 8.11.2). All GVRP PDUs sent and received by GVRP Participants in MST bridges are transmitted as untagged frames.

11.3 Conformance to GVRP

11.3.1 Conformance to GVRP in MAC bridges

Change list item c) as follows:

~~c)~~ ~~Propagate registration information in accordance with the operation of GIP for the Base Spanning Tree Context, as defined in ISO/IEC 15802-3, 12.3.3 and 12.3.4;~~
c) propagate registration information
  1) in an SST bridge, in accordance with the operation of GIP for the Base Spanning Tree Context, as specified in 12.3.3 and 12.3.4 of IEEE Std 802.1D, 1998 Edition; or
  2) in an MST bridge, in accordance with the operation of GIP for multiple Spanning Tree contexts as specified in 11.2.3.4 of this standard.

12. VLAN bridge management

Delete the text of Clause 12 (as modified by IEEE Std 802.1u-2001 and IEEE Std 802.1v-2001), and insert new text for Clause 12 as indicated below:

This clause defines the set of managed objects, and their functionality, that allow administrative configuration of VLANs.

This clause

a) Introduces the functions of management to assist in the identification of the requirements placed on Bridges for the support of management facilities.
b) Establishes the correspondence between the Processes used to model the operation of the Bridge (8.3) and the managed objects of the Bridge.
c) Specifies the management operations supported by each managed object.

12.1 Management functions

Management functions relate to the users' needs for facilities that support the planning, organization, supervision, control, protection, and security of communications resources, and account for their use. These facilities may be categorized as supporting the functional areas of Configuration, Fault, Performance, Security, and Accounting Management. Each of these is summarized in 12.1.1 through 12.1.5, together with the facilities commonly required for the management of communication resources, and the particular facilities provided in that functional area by Bridge Management.

12.1.1 Configuration Management

Configuration Management provides for the identification of communications resources, initialization, reset and close-down, the supply of operational parameters, and the establishment and discovery of the relationship between resources. The facilities provided by Bridge Management in this functional area are

a) The identification of all Bridges that together make up the Bridged LAN and their respective locations and, as a consequence of that identification, the location of specific end stations to particular individual LANs.
b) The ability to remotely reset, i.e., reinitialize, specified Bridges.
c) The ability to control the priority with which a Bridge Port transmits frames.
d) The ability to force a specific configuration of a spanning tree.
e) The ability to control the propagation of frames with specific group MAC Addresses to certain parts of the configured Bridged LAN.
f) The ability to identify the VLANs in use, and through which Ports of the Bridge and for which Protocols frames destined for a given VLAN may be received and/or forwarded.

12.1.2 Fault Management

Fault Management provides for fault prevention, detection, diagnosis, and correction. The facilities provided by Bridge Management in this functional area are

a) The ability to identify and correct Bridge malfunctions, including error logging and reporting.

12.1.3 Performance Management

Performance Management provides for evaluation of the behavior of communications resources and of the effectiveness of communication activities. The facilities provided by Bridge Management in this functional area are

a) The ability to gather statistics relating to performance and traffic analysis. Specific metrics include network utilization, frame forward, and frame discard counts for individual Ports within a Bridge.

12.1.4 Security Management

Security Management provides for the protection of resources. Bridge Management does not provide any specific facilities in this functional area.

12.1.5 Accounting Management

Accounting Management provides for the identification and distribution of costs and the setting of charges. Bridge Management does not provide any specific facilities in this functional area.

12.2 Managed objects

Managed objects model the semantics of management operations. Operations upon an object supply information concerning, or facilitate control over, the Process or Entity associated with that object.

The managed resources of a MAC Bridge are those of the Processes and Entities established in 8.3 of this standard and 12.2 of IEEE Std 802.1D, 1998 Edition. Specifically,

a) The Bridge Management Entity (12.4 and 8.13).
b) The individual MAC Entities associated with each Bridge Port (12.5, 8.2, 8.5, and 8.9).

c) The Forwarding Process of the MAC Relay Entity (12.6, 8.2, and 8.7).
d) The Filtering Database of the MAC Relay Entity (12.7 and 8.11).
e) The Bridge Protocol Entity (12.8 and 8.12 of this standard; Clauses 8 and 17 of IEEE Std 802.1D, 1998 Edition).
f) GARP Participants (Clause 12 of IEEE Std 802.1D, 1998 Edition);
g) GVRP participants (12.10, Clause 11);
h) GMRP participants (12.11, Clause 10 of IEEE Std 802.1D, 1998 Edition);
i) The MST Configuration Table (12.12).

The management of each of these resources is described in terms of managed objects and operations below.

NOTE—The values specified in this clause, as inputs and outputs of management operations, are abstract information elements. Questions of formats or encodings are a matter for particular protocols that convey or otherwise represent this information.

12.3 Data types

This subclause specifies the semantics of operations independent of their encoding in management protocol. The data types of the parameters of operations are defined only as required for that specification.

The following data types are used:

a) Boolean.
b) Enumerated, for a collection of named values.
c) Unsigned, for all parameters specified as “the number of” some quantity, and for Spanning Tree priority values that are numerically compared. When comparing Spanning Tree priority values, the lower number represents the higher priority value.
d) MAC Address.
e) Latin1 String, as defined by ANSI X3.159, for all text strings.
f) Time Interval, an Unsigned value representing a positive integral number of seconds, for all Spanning Tree protocol timeout parameters;
g) Counter, for all parameters specified as a “count” of some quantity. A counter increments and wraps with a modulus of 2 to the power of 64.
h) GARP Time Interval, an Unsigned value representing a positive integral number of centiseconds, for all GARP protocol time-out parameters.
i) Port Number, an Unsigned value assigned to a Port as part of a Port Identifier. Valid Port Numbers are in the range 1 through 4095;
j) Port Priority, an Unsigned value used to represent the priority component of a Port Identifier. Valid Port Priorities are in the range 0 through 240, in steps of 16;
k) Bridge Priority, an Unsigned value used to represent the priority component of a Bridge Identifier. Valid Bridge Priorities are in the range 0 through 61440, in steps of 4096.

12.4 Bridge Management Entity

The Bridge Management Entity is described in 8.13.

The objects which comprise this managed resource are

a) The Bridge Configuration (12.4.1).
b) The Port Configuration for each Port (12.4.2).

12.4.1 Bridge Configuration

The Bridge Configuration object models the operations that modify, or enquire about, the configuration of the Bridge's resources. There is a single Bridge Configuration object per Bridge.

The management operations that can be performed on the Bridge Configuration are

a) Discover Bridge (12.4.1.1);
b) Read Bridge (12.4.1.2);
c) Set Bridge Name (12.4.1.3);
d) Reset Bridge (12.4.1.4).

12.4.1.1 Discover Bridge

12.4.1.1.1 Purpose

To solicit configuration information regarding the Bridge(s) in the Bridged LAN.

12.4.1.1.2 Inputs

a) Inclusion Range, a set of ordered pairs of specific MAC Addresses. Each pair specifies a range of MAC Addresses. A Bridge shall respond if and only if
   1) For one of the pairs, the numerical comparison of its Bridge Address with each MAC Address of the pair shows it to be greater than or equal to the first, and
   2) Less than or equal to the second, and
   3) Its Bridge Address does not appear in the Exclusion List parameter below.

The numerical comparison of one MAC Address with another, for the purpose of this operation, is achieved by deriving a number from the MAC Address according to the following procedure. The consecutive octets of the MAC Address are taken to represent a binary number; the first octet that would be transmitted on a LAN medium when the MAC Address is used in the source or destination fields of a MAC frame has the most significant value, the next octet the next most significant value. Within each octet the first bit of each octet is the least significant bit.

b) Exclusion List, a list of specific MAC Addresses.

12.4.1.1.3 Outputs

a) Bridge Address—the MAC Address for the Bridge from which the Bridge Identifiers used by the Spanning Tree Algorithm and Protocol, the Rapid Spanning Tree Protocol, and the Multiple Spanning Tree Protocol are derived (8.14.5, 13.23 of this standard; 8.5.1.3 and 17.17.2 of IEEE Std 802.1D, 1998 Edition).
b) Bridge Name—a text string of up to 32 characters, of locally determined significance.
c) Number of Ports—the number of Bridge Ports (MAC Entities).
d) Port Addresses—a list specifying the following for each Port:
   1) Port Number—the number of the Bridge Port (13.24 of this standard and 8.5.5.1 of IEEE Std 802.1D, 1998 Edition).
   2) Port Address—the specific MAC Address of the individual MAC Entity associated with the Port (8.14.2).
e) Uptime—count in seconds of the time elapsed since the Bridge was last reset or initialized (13.23.1 of this standard and 8.8.1 of IEEE Std 802.1D, 1998 Edition).

NOTE—Events that are considered to reset or initialize the Bridge include changing the MST Configuration Identifier.

12.4.1.2 Read Bridge

12.4.1.2.1 Purpose

To obtain general information regarding the Bridge.

12.4.1.2.2 Inputs

None.

12.4.1.2.3 Outputs

a) Bridge Address—the MAC Address for the Bridge from which the Bridge Identifiers used by the Spanning Tree Algorithm and Protocol and the Multiple Spanning Tree Protocol are derived (8.14.5, 13.23 of this standard, and 8.5.1.3 of IEEE Std 802.1D, 1998 Edition).
b) Bridge Name—a text string of up to 32 characters, of locally determined significance.
c) Number of Ports—the number of Bridge Ports (MAC Entities).
d) Port Addresses—a list specifying the following for each Port:
    1) Port Number (13.24 of this standard and 8.5.5.1 of IEEE Std 802.1D, 1998 Edition).
    2) Port Address—the specific MAC Address of the individual MAC Entity associated with the Port (8.14.2).
e) Uptime—count in seconds of the time elapsed since the Bridge was last reset or initialized (13.23.1 of this standard and 8.8.1 of IEEE Std 802.1D, 1998 Edition).

12.4.1.3 Set Bridge Name

12.4.1.3.1 Purpose

To associate a text string, readable by the Read Bridge operation, with a Bridge.

12.4.1.3.2 Inputs

a) Bridge Name—a text string of up to 32 characters.

12.4.1.3.3 Outputs

None.

12.4.1.4 Reset Bridge

12.4.1.4.1 Purpose

To reset the specified Bridge. The Filtering Database is cleared and initialized with the entries specified in the Permanent Database, and the Bridge Protocol Entity is initialized (13.23.1 of this standard and 8.8.1 of IEEE Std 802.1D, 1998 Edition).

12.4.1.4.2 Inputs

None.

12.4.1.4.3 Outputs

None.

12.4.2 Port configuration

The Port Configuration object models the operations that modify, or inquire about, the configuration of the Ports of a Bridge. There are a fixed set of Bridge Ports per Bridge (one for each MAC interface), and each is identified by a permanently allocated Port Number.

The allocated Port Numbers are not required to be consecutive. Also, some Port Numbers may be dummy entries, with no actual LAN Port (for example, to allow for expansion of the Bridge by addition of further MAC interfaces in the future). Such dummy Ports shall support the Port Configuration management operations, and other Port-related management operations in a manner consistent with the Port being permanently disabled.

The information provided by the Port Configuration consists of summary data indicating its name and type. Specific counter information pertaining to the number of packets forwarded, filtered, and in error is maintained by the Forwarding Process resource. The management operations supported by the Bridge Protocol Entity allow for controlling the states of each Port.

The management operations that can be performed on the Port Configuration are

a) Read Port (12.4.2.1);
b) Set Port Name (12.4.2.2).

12.4.2.1 Read Port

12.4.2.1.1 Purpose

To obtain general information regarding a specific Bridge Port.

12.4.2.1.2 Inputs

a) Port Number—the number of the Bridge Port (13.24 of this standard, 8.5.5.1 of IEEE Std 802.1D, 1998 Edition).

12.4.2.1.3 Outputs

a) Port Name—a text string of up to 32 characters, of locally determined significance.
b) Port Type—the MAC Entity type of the Port (IEEE Std 802.3; ISO/IEC 8802-4; ISO/IEC 8802-5; ISO/IEC 8802-6; ISO/IEC 8802-9; IEEE Std 802.9a-1995; ISO/IEC 8802-11; ISO/IEC 8802-12 (IEEE Std 802.3 format); ISO/IEC 8802-12 (ISO/IEC 8802-5 format); ISO 9314; other).

12.4.2.2 Set Port Name

12.4.2.2.1 Purpose

To associate a text string, readable by the Read Port operation, with a Bridge Port.

12.4.2.2.2 Inputs

a) Port Number (13.24 of this standard, 8.5.5.1 of IEEE Std 802.1D, 1998 Edition).
b) Port Name—a text string of up to 32 characters.

12.4.2.2.3 Outputs

None.

12.5 MAC entities

The Management Operations and Facilities provided by the MAC Entities are those specified in the Layer Management standards of the individual MACs. A MAC Entity is associated with each Bridge Port.

12.6 Forwarding process

The Forwarding Process contains information relating to the forwarding of frames. Counters are maintained that provide information on the number of frames forwarded, filtered, and dropped due to error. Configuration data, defining how frame priority is handled, is maintained by the Forwarding Process.

The objects that comprise this managed resource are

a) The Port Counters (12.6.1).
b) The Priority Handling objects for each Port (12.6.2).
c) The Traffic Class Table for each Port (12.6.3).

12.6.1 The Port Counters

The Port Counters object models the operations that can be performed on the Port counters of the Forwarding Process resource. There are multiple instances (one for each VLAN for each MAC Entity) of the Port Counters object per Bridge.

The management operation that can be performed on the Port Counters is Read Forwarding Port Counters (12.6.1.1).

12.6.1.1 Read forwarding port counters

12.6.1.1.1 Purpose

To read the forwarding counters associated with a specific Bridge Port.

12.6.1.1.2 Inputs

a) Port Number (13.24 of this standard, 8.5.5.1 of IEEE Std 802.1D, 1998 Edition);
b) Optionally, VLAN Identifier (9.3.2.3).

If the VLAN Identifier parameter is supported, then the forwarding Port counters are maintained per VLAN per Port. If the parameter is not supported, then the forwarding Port counters are maintained per Port only.

12.6.1.1.3 Outputs

a) Frames Received—count of all valid frames received (including BPDUs, frames addressed to the Bridge as an end station and frames that were submitted to the Forwarding Process, 8.5).
b) Optionally, Octets Received—count of the total number of octets in all valid frames received (including BPDUs, frames addressed to the Bridge as an end station, and frames that were submitted to the Forwarding Process).
c) Discard Inbound—count of valid frames received that were discarded by the Forwarding Process (8.7).
d) Forward Outbound—count of frames forwarded to the associated MAC Entity (8.9).
e) Discard Lack of Buffers—count of frames that were to be transmitted through the associated Port but were discarded due to lack of buffers (8.7.3).

f) Discard Transit Delay Exceeded—count of frames that were to be transmitted but were discarded due to the maximum bridge transit delay being exceeded (buffering may have been available, 8.7.3).
g) Discard on Error—count of frames that were to be forwarded on the associated MAC but could not be transmitted (e.g., frame would be too large, IEEE Std 802.1D, 6.3.8).
h) If Ingress Filtering is supported (8.4.5), Discard on Ingress Filtering—count of frames that were discarded as a result of Ingress Filtering being enabled.
i) Optionally, Discard on Error Details—a list of 16 elements, each containing the source address of a frame and the reason why the frame was discarded (frame too large). The list is maintained as a circular buffer. The reasons for discard on error, at present, are
    1) Transmissible service data unit size exceeded; or
    2) Discard due to Ingress Filtering. The VID associated with the last discarded frame is recorded.

12.6.2 Priority handling

The Priority Handling object models the operations that can be performed upon, or inquire about, the Default User Priority parameter, the User Priority Regeneration Table parameter, and the Outbound Access Priority Table parameter for each Port. The operations that can be performed on this object are

a) Read Port Default User Priority (12.6.2.1);
b) Set Port Default User Priority (12.6.2.2);
c) Read Port User Priority Regeneration Table (12.6.2.3);
d) Set Port User Priority Regeneration Table (12.6.2.4);
e) Read Outbound Access Priority Table (12.6.2.5).

12.6.2.1 Read Port Default User Priority

12.6.2.1.1 Purpose

To read the current state of the Default User Priority parameter (6.4 of IEEE Std 802.1D, 1998 Edition) for a specific Bridge Port.

12.6.2.1.2 Inputs

a) Port number.

12.6.2.1.3 Outputs

a) Default User Priority value—Integer in range 0–7.

12.6.2.2 Set Port Default User Priority

12.6.2.2.1 Purpose

To set the current state of the Default User Priority parameter (6.4 of IEEE Std 802.1D, 1998 Edition) for a specific Bridge Port.

12.6.2.2.2 Inputs

a) Port number;
b) Default User Priority value—Integer in range 0–7.

12.6.2.2.3 Outputs

None.

12.6.2.3 Read Port User Priority Regeneration Table

12.6.2.3.1 Purpose

To read the current state of the User Priority Regeneration Table parameter (8.5.1) for a specific Bridge Port.

12.6.2.3.2 Inputs

a) Port number.

12.6.2.3.3 Outputs

a) Regenerated User Priority value for Received User Priority 0—Integer in range 0–7.
b) Regenerated User Priority value for Received User Priority 1—Integer in range 0–7.
c) Regenerated User Priority value for Received User Priority 2—Integer in range 0–7.
d) Regenerated User Priority value for Received User Priority 3—Integer in range 0–7.
e) Regenerated User Priority value for Received User Priority 4—Integer in range 0–7.
f) Regenerated User Priority value for Received User Priority 5—Integer in range 0–7.
g) Regenerated User Priority value for Received User Priority 6—Integer in range 0–7.
h) Regenerated User Priority value for Received User Priority 7—Integer in range 0–7.

12.6.2.4 Set Port User Priority Regeneration Table

12.6.2.4.1 Purpose

To set the current state of the User Priority Regeneration Table parameter (8.5.1) for a specific Bridge Port.

12.6.2.4.2 Inputs

a) Port number;
b) Regenerated User Priority value for Received User Priority 0—Integer in range 0–7.
c) Regenerated User Priority value for Received User Priority 1—Integer in range 0–7.
d) Regenerated User Priority value for Received User Priority 2—Integer in range 0–7.
e) Regenerated User Priority value for Received User Priority 3—Integer in range 0–7.
f) Regenerated User Priority value for Received User Priority 4—Integer in range 0–7.
g) Regenerated User Priority value for Received User Priority 5—Integer in range 0–7.
h) Regenerated User Priority value for Received User Priority 6—Integer in range 0–7.
i) Regenerated User Priority value for Received User Priority 7—Integer in range 0–7.

12.6.2.4.3 Outputs

None.

12.6.2.5 Read Outbound Access Priority Table

12.6.2.5.1 Purpose

To read the state of the Outbound Access Priority Table parameter (Table 8-3) for a specific Bridge Port.

12.6.2.5.2 Inputs

a) Port number.

12.6.2.5.3 Outputs

a) Access Priority value for User Priority 0—Integer in range 0–7.
b) Access Priority value for User Priority 1—Integer in range 0–7.
c) Access Priority value for User Priority 2—Integer in range 0–7.
d) Access Priority value for User Priority 3—Integer in range 0–7.
e) Access Priority value for User Priority 4—Integer in range 0–7.
f) Access Priority value for User Priority 5—Integer in range 0–7.
g) Access Priority value for User Priority 6—Integer in range 0–7.
h) Access Priority value for User Priority 7—Integer in range 0–7.

12.6.3 Traffic Class Table

The Traffic Class Table object models the operations that can be performed upon, or inquire about, the current contents of the Traffic Class Table (8.7.3) for a given Port. The operations that can be performed on this object are Read Port Traffic Class Table and Set Port Traffic Class Table.

12.6.3.1 Read Port Traffic Class Table

12.6.3.1.1 Purpose

To read the contents of the Traffic Class Table (8.7.3) for a given Port.

12.6.3.1.2 Inputs

a) Port Number.

12.6.3.1.3 Outputs

a) The number of Traffic Classes, in the range 1 through 8, supported on the Port;
b) For each value of Traffic Class supported on the Port, the value of the Traffic Class in the range 0 through 7, and the set of user_priority values assigned to that Traffic Class.

12.6.3.2 Set Port Traffic Class Table

12.6.3.2.1 Purpose

To set the contents of the Traffic Class Table (8.7.3) for a given Port.

12.6.3.2.2 Inputs

a) Port number;
b) For each value of Traffic Class supported on the Port, the value of the Traffic Class in the range 0 through 7, and the set of user_priority values assigned to that Traffic Class.

NOTE—If a Traffic Class value greater than the largest Traffic Class available on the Port is specified, then the value applied to the Traffic Class Table is the largest available Traffic Class.

12.6.3.2.3 Outputs

None.

12.7 Filtering Database

The Filtering Database is described in 8.11. It contains filtering information used by the Forwarding Process (8.7) in deciding through which Ports of the Bridge frames should be forwarded.

The objects that comprise this managed resource are

a) The Filtering Database (12.7.1);
b) The Static Filtering Entries (12.7.2);
c) The Dynamic Filtering Entries (12.7.3);
d) The Group Registration Entries (12.7.4);
e) The Static VLAN Registration Entries (12.7.5);
f) The Dynamic VLAN Registration Entries (12.7.5);
g) The Permanent Database (12.7.6).

12.7.1 The Filtering Database

The Filtering Database object models the operations that can be performed on, or affect, the Filtering Database as a whole. There is a single Filtering Database object per Bridge.

The management operations that can be performed on the Database are:

a) Read Filtering Database (12.7.1.1);
b) Set Filtering Database Ageing Time (12.7.1.2);
c) Read Permanent Database (12.7.6.1);
d) Create Filtering Entry (12.7.7.1);
e) Delete Filtering Entry (12.7.7.2);
f) Read Filtering Entry (12.7.7.3);
g) Read Filtering Entry Range (12.7.7.4).

12.7.1.1 Read Filtering Database

12.7.1.1.1 Purpose

To obtain general information regarding the Bridge’s Filtering Database.

12.7.1.1.2 Inputs

None.

12.7.1.1.3 Outputs

a) Filtering Database Size—the maximum number of entries that can be held in the Filtering Database.
b) Number of Static Filtering Entries—the number of Static Filtering Entries (8.11.1) currently in the Filtering Database;
c) Number of Dynamic Filtering Entries—the number of Dynamic Filtering Entries (8.11.3) currently in the Filtering Database;
d) Number of Static VLAN Registration Entries—the number of Static VLAN Registration Entries (8.11.2) currently in the Filtering Database;
e) Number of Dynamic VLAN Registration Entries—the number of Dynamic VLAN Registration Entries (8.11.5) currently in the Filtering Database.
f) Ageing Time—for ageing out Dynamic Filtering Entries when the Port associated with the entry is in the Forwarding state (8.11.3).
g) If Extended Filtering Services are supported, Number of Group Registration Entries—the number of Group Registration Entries (8.11.4) currently in the Filtering Database;

12.7.1.2 Set Filtering Database Ageing Time

12.7.1.2.1 Purpose

To set the ageing time for Dynamic Filtering Entries (8.11.3).

12.7.1.2.2 Inputs

a) Ageing Time.

12.7.1.2.3 Outputs

None.

12.7.2 A Static Filtering Entry

A Static Filtering Entry object models the operations that can be performed on a single Static Filtering Entry in the Filtering Database. The set of Static Filtering Entry objects within the Filtering Database changes only under management control.

A Static Filtering Entry object supports the following operations:

a) Create Filtering Entry (12.7.7.1);
b) Delete Filtering Entry (12.7.7.2);
c) Read Filtering Entry (12.7.7.3);
d) Read Filtering Entry Range (12.7.7.4).

12.7.3 A Dynamic Filtering Entry

A Dynamic Filtering Entry object models the operations that can be performed on a single Dynamic Filtering Entry (i.e., one that is created by the Learning Process as a result of the observation of network traffic) in the Filtering Database.

A Dynamic Filtering Entry object supports the following operations:

a) Delete Filtering Entry (12.7.7.2);
b) Read Filtering Entry (12.7.7.3);
c) Read Filtering Entry Range (12.7.7.4).

12.7.4 A Group Registration Entry

A Group Registration Entry object models the operations that can be performed on a single Group Registration Entry in the Filtering Database. The set of Group Registration Entry objects within the Filtering Database changes only as a result of GARP protocol exchanges.

A Group Registration Entry object supports the following operations:

a) Read Filtering Entry (12.7.7.3);
b) Read Filtering Entry Range (12.7.7.4).

12.7.5 A VLAN Registration Entry

A VLAN Registration Entry object models the operations that can be performed on a single VLAN Registration Entry in the Filtering Database. The set of VLAN Registration Entry objects within the Filtering Database changes under management control and also as a result of GARP protocol exchanges.

12.7.5.1 Static VLAN Registration Entry object

A Static VLAN Registration Entry object supports the following operations:

a) Create Filtering Entry (12.7.7.1);
b) Delete Filtering Entry (12.7.7.2);
c) Read Filtering Entry (12.7.7.3);
d) Read Filtering Entry Range (12.7.7.4).

12.7.5.2 Dynamic VLAN Registration Entry object

A Dynamic VLAN Registration Entry object supports the following operations:

a) Read Filtering Entry (12.7.7.3);
b) Read Filtering Entry Range (12.7.7.4).

12.7.6 Permanent Database

The Permanent Database object models the operations that can be performed on, or affect, the Permanent Database. There is a single Permanent Database per Filtering Database.

The management operations that can be performed on the Permanent Database are

a) Read Permanent Database (12.7.6.1);
b) Create Filtering Entry (12.7.7.1);
c) Delete Filtering Entry (12.7.7.2);
d) Read Filtering Entry (12.7.7.3);
e) Read Filtering Entry Range (12.7.7.4).

12.7.6.1 Read Permanent Database

12.7.6.1.1 Purpose

To obtain general information regarding the Permanent Database (8.11.10).

12.7.6.1.2 Inputs

None.

12.7.6.1.3 Outputs

a) Permanent Database Size—maximum number of entries that can be held in the Permanent Database.
b) Number of Static Filtering Entries—number of Static Filtering Entries (8.11.1) currently in the Permanent Database;
c) Number of Static VLAN Registration Entries—number of Static VLAN Registration Entries (8.11.2) currently in the Permanent Database.

12.7.7 General Filtering Database operations

In these operations on the Filtering Database, the operation parameters make use of VID values, even when operating upon a Dynamic Filtering Entry (8.11.3) whose structure carries an FID rather than a VID. In this case, the value used in the VID parameter can be any VID that has been allocated to the FID concerned (8.11.7).

12.7.7.1 Create Filtering Entry

12.7.7.1.1 Purpose

To create or update a Static Filtering Entry (8.11.1) or Static VLAN Registration Entry (8.11.2) in the Filtering Database or Permanent Database. Only static entries may be created in the Filtering Database or Permanent Database.

12.7.7.1.2 Inputs

a) Identifier—Filtering Database or Permanent Database.
b) Address—MAC Address of the entry (not present in VLAN Registration Entries).
c) VID—VLAN Identifier of the entry.
d) Port Map—a set of control indicators, one for each Port, as specified in 8.11.1 and 8.11.2.

12.7.7.1.3 Outputs

None.

12.7.7.2 Delete Filtering Entry

12.7.7.2.1 Purpose

To delete a Filtering Entry or VLAN Registration Entry from the Filtering Database or Permanent Database.

12.7.7.2.2 Inputs

a) Identifier—Filtering Database or Permanent Database.
b) Address—MAC Address of the desired entry (not present in VLAN Registration Entries).
c) VID—VLAN Identifier of the entry.

12.7.7.2.3 Outputs

None.

12.7.7.3 Read Filtering Entry

12.7.7.3.1 Purpose

To read a Filtering Entry, Group Registration Entry, or VLAN Registration Entry from the Filtering or Permanent Databases.

12.7.7.3.2 Inputs

a) Identifier—Filtering Database or Permanent Database.
b) Address—MAC Address of the desired entry (not present in VLAN Registration Entries).
c) VID—VLAN Identifier of the entry.
d) Type—Static or Dynamic entry.

12.7.7.3.3 Outputs

a) Address—MAC Address of the desired entry (not present in VLAN Registration Entries).
b) VID—VLAN Identifier of the entry.
c) Type—Static or Dynamic entry.
d) Port Map—a set of control indicators as appropriate for the entry, as specified in 8.11.1 through 8.11.5.

12.7.7.4 Read Filtering Entry range

12.7.7.4.1 Purpose

To read a range of Filtering Database entries (of any type) from the Filtering or Permanent Databases.

Since the number of values to be returned in the requested range may have exceeded the capacity of the service data unit conveying the management response, the returned entry range is identified. The indices that define the range take on values from zero up to Filtering Database Size minus one.

12.7.7.4.2 Inputs

a) Identifier—Filtering Database or Permanent Database.
b) Start Index—inclusive starting index of the desired entry range.
c) Stop Index—inclusive ending index of the desired range.

12.7.7.4.3 Outputs

a) Start Index—inclusive starting index of the returned entry range.
b) Stop Index—inclusive ending index of the returned entry range.
c) For each index returned:
    1) Address—MAC Address of the desired entry (not present in VLAN Registration Entries).
    2) VID—VLAN Identifier of the entry.
    3) Type—Static or Dynamic entry.
    4) Port Map—a set of control indicators as appropriate for the entry, as specified in 8.11.1 through 8.11.5.

12.8 Bridge Protocol Entity

The Bridge Protocol Entity is described in 8.12 and Clause 13 of this standard, and Clauses 8 and 17 of IEEE Std 802.1D, 1998 Edition.

The objects that comprise this managed resource are

a) The Protocol Entity itself.
b) The Ports under its control.

12.8.1 The Protocol Entity

The Protocol Entity object models the operations that can be performed upon, or inquire about, the operation of the Spanning Tree Algorithm and Protocol. There is a single Protocol Entity per Bridge; it can, therefore, be identified as a single fixed component of the Protocol Entity resource.

The management operations that can be performed on the Protocol Entity are

a) Read CIST Bridge Protocol Parameters (12.8.1.1);
b) Read MSTI Bridge Protocol Parameters (12.8.1.2);
c) Set CIST Bridge Protocol Parameters (12.8.1.3).
d) Set MSTI Bridge Protocol Parameters (12.8.1.4).

12.8.1.1 Read CIST Bridge Protocol Parameters

12.8.1.1.1 Purpose

To obtain information regarding the Bridge’s Bridge Protocol Entity for the CIST.

12.8.1.1.2 Inputs

None.

12.8.1.1.3 Outputs

a) Bridge Identifier—as defined in 8.5.3 of IEEE Std 802.1D, 1998 Edition. The Bridge Identifier for the CIST.
b) Time Since Topology Change—in an STP Bridge, the count in seconds of the time elapsed since the Topology Change flag parameter for the Bridge (8.5.3.12 of IEEE Std 802.1D, 1998 Edition) was last True, or in an RSTP or MSTP Bridge, the count in seconds since tcWhile timer (13.21 of this standard or 17.15.7 of IEEE Std 802.1D, 1998 Edition) for any Port was non-zero.
c) Topology Change Count—in an STP Bridge, the count of the times the Topology Change flag parameter for the Bridge has been set (i.e., transitioned from False to True) since the Bridge was powered on or initialized, or in an RSTP or MSTP Bridge, the count of times that there has been at least one non-zero tcWhile timer (13.21 of this standard or 17.15.7 of IEEE Std 802.1D, 1998 Edition).
d) Topology Change—in an STP Bridge, the value of the Topolgy Change parameter (8.5.3.12 of IEEE Std 802.1D, 1998 Edition), or in an RSTP or MSTP Bridge, asserted if the tcWhile timer for any Port for the CIST (13.21 of this standard or 17.15.7 of IEEE Std 802.1D, 1998 Edition) is non-zero.
e) Designated Root (13.23.3 of this standard, 8.5.3.1 and 17.18.7 of IEEE Std 802.1D, 1998 Edition).
f) Root Path Cost (13.23.3 of this standard, 8.5.3.1 and 17.18.7 of IEEE Std 802.1D, 1998 Edition).
g) Root Port (13.23.5 of this standard, 8.5.3.3 and 17.17.5 of IEEE Std 802.1D, 1998 Edition).
h) Max Age (13.23.7 of this standard, 8.5.3.4 and 17.18.18 of IEEE Std 802.1D, 1998 Edition).
i) Forward Delay (13.23.7 of this standard, 8.5.3.6 and 17.16.2 of IEEE Std 802.1D, 1998 Edition).
j) Bridge Max Age (13.23.4 of this standard, 8.5.3.7 and 17.17.4 of IEEE Std 802.1D, 1998 Edition).
k) Bridge Hello Time (13.23.4 of this standard, 8.5.3.9 and 17.17.4 of IEEE Std 802.1D, 1998 Edition). This parameter is present only if the Bridge supports STP or RSTP.
l) Bridge Forward Delay (13.23.4 of this standard, 8.5.3.10 and 17.17.4 of IEEE Std 802.1D, 1998 Edition).
m) Hold Time (8.5.3.14 of IEEE Std 802.1D, 1998 Edition) or Transmission Limit (TxHoldCount in 13.22 of this standard and 17.16.6 of IEEE Std 802.1D, 1998 Edition).

The following parameter is present only if the Bridge supports RSTP or MSTP:

n) forceVersion—the value of the Force Protocol Version parameter for the Bridge (13.6.2 of this standard and 17.16.1 of IEEE Std 802.1D, 1998 Edition)

The following additional parameters are present only if the Bridge supports MSTP:

o) CIST Regional Root Identifier (13.16.4). The Bridge Identifier of the current CIST Regional Root.
p) CIST Path Cost. The CIST path cost from the transmitting Bridge to the CIST Regional Root.

12.8.1.2 Read MSTI Bridge Protocol Parameters

12.8.1.2.1 Purpose

In an MST Bridge, to obtain information regarding the Bridge's Bridge Protocol Entity for the specified Spanning Tree instance.

12.8.1.2.2 Inputs

a) MSTID—Identifies the set of parameters that will be returned. For Bridges that support MSTP, this parameter is the identifier of the spanning tree for which the operation is being performed. This parameter takes a value in the range 1 through 4094.

12.8.1.2.3 Outputs

a) MSTID—Identifies the set of parameters that are being returned. This parameter is the identifier of the MST Instance for which the operation is being performed.
b) Bridge Identifier—as defined in 13.23.2. The Bridge Identifier for the spanning tree instance identified by the MSTID.
c) Time Since Topology Change—count in seconds of the time elapsed since tcWhile (13.21) was last non-zero for any Port for the given MSTI.
d) Topology Change Count—count of the times tcWhile (13.21) has been non-zero for any Port for the given MSTI since the Bridge was powered on or initialized.
e) Topology Change (tcWhile, 13.21). True if tcWhile is non-zero for any Port for the given MST.
f) Designated Root (13.23.9). The Bridge Identifier of the Root Bridge for the spanning tree instance identified by the MSTID.
g) Root Path Cost (13.23.9). The path cost from the transmitting Bridge to the Root Bridge for the spanning tree instance identified by the MSTID.
h) Root Port (13.23.11). The Root Port for the spanning tree instance identified by the MSTID.

12.8.1.3 Set CIST Bridge Protocol Parameters

12.8.1.3.1 Purpose

To modify parameters in the Bridge's Bridge Protocol Entity for the CIST, in order to force a configuration of the spanning tree and/or tune the reconfiguration time to suit a specific topology. In RSTP and MSTP implementations, this operation causes these values to be set for all Ports of the Bridge.

12.8.1.3.2 Inputs

a) Bridge Max Age—the new value (13.23.4 of this standard, 8.5.3.8 and 17.17.4 of IEEE Std 802.1D, 1998 Edition).
b) Bridge Hello Time—the new value (13.23.4 of this standard, 8.5.3.9 and 17.17.4 of IEEE Std 802.1D, 1998 Edition) This parameter is present only if the Bridge supports STP or RSTP.
c) Bridge Forward Delay—the new value (13.23.4 of this standard, 8.5.3.10 and 17.17.4 of IEEE Std 802.1D, 1998 Edition).
d) Bridge Priority—the new value of the priority part of the Bridge Identifier (13.23.2 of this standard, 8.5.3.7 of IEEE Std 802.1D, 1998 Edition) for the CIST.

The following parameter is present only if the Bridge supports RSTP or MSTP:

e) forceVersion—the new value of the Force Protocol Version parameter for the Bridge (13.6.2 of this standard and 17.16.1 of IEEE Std 802.1D, 1998 Edition).

12.8.1.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to invalid Bridge Priority value (12.3); or
   2) Operation rejected due to the specified Max Age, Hello Time, or Forward Delay values being outside the range specified by IEEE Std 802.1D (see 12.8.1.3.4); or
   3) Operation rejected due to the specified Max Age, Hello Time, or Forward Delay values not being in compliance with the requirements of IEEE Std 802.1D (see 12.8.1.3.4); or
   4) Operation accepted.

12.8.1.3.4 Procedure

In the following description, the references to Bridge Hello Time apply only to Bridges that support STP or RSTP.

The input parameter values are checked for compliance with 8.10.2 of IEEE Std 802.1D, 1998 Edition (STP Bridges), 17.28 of IEEE Std 802.1D, 1998 Edition (RSTP Bridges), or their definitions in Clause 13. If they do not comply, or the value of Bridge Max Age or Bridge Forward Delay is less than the lower limit of the range specified in Table 8-3 of IEEE Std 802.1D, 1998 Edition (STP Bridges), or Table 17-5 of IEEE Std 802.1D, 1998 Edition (RSTP and MSTP Bridges), then no action shall be taken for any of the supplied parameters. If the value of any of Bridge Max Age, Bridge Forward Delay, or Bridge Hello Time is outside the range specified in Table 8-3 of IEEE Std 802.1D, 1998 Edition (STP Bridges), or Table 17-5 of IEEE Std 802.1D, 1998 Edition (RSTP and MSTP Bridges), then the Bridge need not take action.

Otherwise:

a) The Bridge's Bridge Max Age, Bridge Hello Time, and Bridge Forward Delay parameters are set to the supplied values.
b) In STP Bridges, the Set Bridge Priority procedure (8.8.4 of IEEE Std 802.1D, 1998 Edition) is used to set the priority part of the Bridge Identifier to the supplied value.
c) In RSTP and MSTP Bridges, the priority component of the Bridge Identifier (13.23.4 of this standard, 17.17.3 of IEEE Std 802.1D, 1998 Edition) is updated using the supplied value. For all Ports of the Bridge, the reselect for the CIST parameter (13.24 of this standard, 17.18.29 of IEEE Std 802.1D, 1998 Edition) is set TRUE, and the selected parameter for the CIST (13.24 of this standard, 17.18.31 of IEEE Std 802.1D, 1998 Edition) is set FALSE.

12.8.1.4 Set MSTI Bridge Protocol Parameters

12.8.1.4.1 Purpose

To modify parameters in the Bridge's Bridge Protocol Entity for the specified Spanning Tree instance, in order to force a configuration of the spanning tree and/or tune the reconfiguration time to suit a specific topology.

12.8.1.4.2 Inputs

a) MSTID—Identifies the set of parameters upon which the operation will be performed.
b) Bridge Priority—the new value of the priority part of the Bridge Identifier (13.23.2) for the Spanning Tree instance identified by the MSTID.

12.8.1.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to invalid Bridge Priority value (12.3); or

2) Operation rejected due to invalid MSTID (i.e, there is currently no MST Instance with that value of MSTID supported by the Bridge); or
3) Operation accepted.

12.8.1.4.4 Procedure

The Bridge Priority parameter value is checked for compliance with its definition in Clause 13. If it does not comply, then no action shall be taken.

Otherwise, the priority part of the Bridge Identifier is set to the supplied value for the specified Spanning Tree instance.

12.8.2 Bridge Port

A Bridge Port object models the operations related to an individual Bridge Port in relation to the operation of the Spanning Tree Algorithm and Protocol. There are a fixed set of Bridge Ports per Bridge; each can, therefore, be identified by a permanently allocated Port Number, as a fixed component of the Protocol Entity resource.

The management operations that can be performed on a Bridge Port are

a) Read CIST Port Parameters (12.8.2.1);
b) Read MSTI Port Parameters (12.8.2.2);
c) Force CIST Port State (12.8.2.3);
d) Force MSTI Port State (12.8.2.4);
e) Set CIST Port Parameters (12.8.2.5);
f) Set MSTI Port Parameters (12.8.2.6);
g) Force BPDU Migration Check (12.8.2.7).

12.8.2.1 Read CIST Port Parameters

12.8.2.1.1 Purpose

To obtain information regarding a specific Port within the Bridge’s Bridge Protocol Entity, for the CIST.

12.8.2.1.2 Inputs

a) Port Number—the number of the Bridge Port.

12.8.2.1.3 Outputs

a) Uptime—count in seconds of the time elapsed since the Port was last reset or initialized (BEGIN, 13.23).
b) State—the current state of the Port (i.e., Disabled, Listening, Learning, Forwarding, or Blocking) (8.4, 13.34 of this standard, 8.4, 8.5.5.2, and 17.5 of IEEE Std 802.1D, 1998 Edition).
c) Port Identifier—the unique Port identifier comprising two parts, the Port Number and the Port Priority field (13.24.8 of this standard, 8.5.5.1 and 17.18.16 of IEEE Std 802.1D, 1998 Edition).
d) Path Cost (8.5.5.3 and 17.16.5 of IEEE Std 802.1D, 1998 Edition).
e) Designated Root (13.24.8 of this standard, 8.5.5.4 and 17.18.17 of IEEE Std 802.1D, 1998 Edition).
f) Designated Cost (13.24.8 of this standard, 8.5.5.5 and 17.18.17 of IEEE Std 802.1D, 1998 Edition).
g) Designated Bridge (13.24.8 of this standard, 8.5.5.6 and 17.18.17 of IEEE Std 802.1D, 1998 Edition).
h) Designated Port (13.24.8 of this standard, 8.5.5.7 and 17.18.17 of IEEE Std 802.1D, 1998 Edition).
i) Topology Change Acknowledge (8.5.5.8 and 17.18.37 of IEEE Std 802.1D, 1998 Edition).

j) Hello Time (13.24.9 of this standard, 8.5.3.5 and 17.18.18 of IEEE Std 802.1D, 1998 Edition).
k) adminEdgePort (18.3.3 of IEEE Std 802.1D, 1998 Edition). Present in implementations that support the identification of edge ports.
l) operEdgePort (18.3.4 of IEEE Std 802.1D, 1998 Edition). Present in implementations that support the identification of edge ports.
m) MAC Enabled - the current state of the MAC Enabled parameter (6.4.2 of IEEE Std 802.1D, 1998 Edition). Present if the implementation supports the MAC Enabled parameter.
n) MAC Operational - the current state of the MAC Operational parameter (6.4.2 of IEEE Std 802.1D, 1998 Edition). Present if the implementation supports the MAC Operational parameter.
o) adminPointToPointMAC - the current state of the adminPointToPointMAC parameter (6.4.3 of IEEE Std 802.1D, 1998 Edition). Present if the implementation supports the adminPointToPointMAC parameter.
p) operPointToPointMAC - the current state of the operPointToPointMAC parameter (6.4.3 of IEEE Std 802.1D, 1998 Edition). Present if the implementation supports the operPointToPointMAC parameter.

The following additional parameters are present only if the Bridge supports MSTP:

q) CIST Regional Root Identifier (13.16.4). The Bridge Identifier of the current CIST Regional Root.
r) CIST Path Cost. The CIST path cost from the transmitting Bridge to the CIST Regional Root.
s) Port Hello Time. The administrative value of Hello Time for the Port (13.22).

12.8.2.2 Read MSTI Port Parameters

12.8.2.2.1 Purpose

To obtain information regarding a specific Port within the Bridge's Bridge Protocol Entity, for a given MSTI.

12.8.2.2.2 Inputs

a) Port Number—the number of the Bridge Port.
b) MSTID—Identifies the set of parameters that will be returned, in the range 1 through 4094.

12.8.2.2.3 Outputs

a) MSTID—Identifies the set of parameters that are being returned. This parameter is the identifier of the spanning tree for which the operation is being performed.
b) Uptime—count in seconds of the time elapsed since the Port was last reset or initialized (BEGIN, 13.23).
c) State—the current state of the Port (i.e., Disabled, Listening, Learning, Forwarding, or Blocking) (8.4, 13.34).
d) Port Identifier—the unique Port identifier comprising two parts, the Port Number and the Port Priority field (13.24.17).
e) Path Cost (13.36.1).
f) Designated Root (13.24.17).
g) Designated Cost (13.24.17).
h) Designated Bridge (13.24.17).
i) Designated Port (13.24.17).

12.8.2.3 Force CIST port state

12.8.2.3.1 Purpose

To set the Administrative Bridge Port State (see 17.5 of IEEE Std 802.1D, 1998 Edition) for the specified Port to Disabled or Enabled, for the CIST.

12.8.2.3.2 Inputs

a) Port Number—the number of the Bridge Port.
b) State—either Disabled or Enabled.

12.8.2.3.3 Outputs

None.

12.8.2.3.4 Procedure

In Bridges that support STP, if the selected state is Disabled, the Disable Port procedure (8.8.3 of IEEE Std 802.1D, 1998 Edition) is used for the specified Port for the specified Spanning Tree instance. If the selected state is Enabled, the Enable Port procedure (8.8.2 of IEEE Std 802.1D, 1998 Edition) is used.

In Bridges that support RSTP or MSTP, the effect of changing this parameter is as defined in 17.5 of IEEE Std 802.1D, 1998 Edition.

12.8.2.4 Force MSTI port state

12.8.2.4.1 Purpose

To set the Administrative Bridge Port State (see 17.5 of IEEE Std 802.1D, 1998 Edition) for the specified Port to Disabled or Enabled, for the specified Spanning Tree instance.

12.8.2.4.2 Inputs

a) MSTID—Identifies the set of parameters upon which the operation will be performed. The identifier of the spanning tree for which the operation is being performed. The parameter can take a value in the range 1 through 4094.
b) Port Number—the number of the Bridge Port.
c) State—either Disabled or Enabled.

12.8.2.4.3 Outputs

None.

12.8.2.4.4 Procedure

The effect of changing this parameter is as defined in 17.5 of IEEE Std 802.1D, 1998 Edition.

12.8.2.5 Set CIST port parameters

12.8.2.5.1 Purpose

To modify parameters for a Port in the Bridge’s Bridge Protocol Entity in order to force a configuration of the spanning tree for the CIST.

12.8.2.5.2 Inputs

a) Port Number—the number of the Bridge Port.
b) Path Cost—the new value (13.36.1 of this standard, 8.5.5.3 and 17.16.5 of IEEE Std 802.1D, 1998 Edition).
c) Port Priority—the new value of the priority field for the Port Identifier (13.24.8 of this standard, 8.5.5.1 and 17.18.7 of IEEE Std 802.1D, 1998 Edition).
d) adminEdgePort—the new value of the adminEdgePort parameter (18.3.3 of IEEE Std 802.1D, 1998 Edition). Present in implementations that support the identification of edge ports.
e) MAC Enabled - the new value of the MAC Enabled parameter (6.4.2 of IEEE Std 802.1D, 1998 Edition). May be present if the implementation supports the MAC Enabled parameter.
f) adminPointToPointMAC - the new value of the adminPointToPointMAC parameter (6.4.3 of IEEE Std 802.1D, 1998 Edition). May be present if the implementation supports the adminPointToPointMAC parameter.

12.8.2.5.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to invalid Port Priority value (12.3); or
   2) Operation accepted.

12.8.2.5.4 Procedure

In STP Bridges, the Set Path Cost procedure (8.8.6 of IEEE Std 802.1D, 1998 Edition) is used to set the Path Cost parameter for the specified Port for the specified spanning tree instance. The Set Port Priority procedure (8.8.5 of IEEE Std 802.1D, 1998 Edition) is used to set the priority part of the Port Identifier (8.5.5.1 of IEEE Std 802.1D, 1998 Edition) for the CIST to the supplied value.

In RSTP and MSTP Bridges, the Path Cost (13.36.1 of this standard, 17.16.5 of IEEE Std 802.1D, 1998 Edition) and Port Priority (17.18.7 of IEEE Std 802.1D, 1998 Edition) parameters for the Port are updated using the supplied values. The reselect parameter value for the CIST for the Port (13.24 of this standard, 17.18.29 of IEEE Std 802.1D, 1998 Edition) is set TRUE, and the selected parameter for the CIST for the Port (13.24 of this standard, 17.18.31 of IEEE Std 802.1D, 1998 Edition) is set FALSE.

12.8.2.6 Set MSTI port parameters

12.8.2.6.1 Purpose

To modify parameters for a Port in the Bridge’s Bridge Protocol Entity in order to force a configuration of the spanning tree for the specified Spanning Tree instance.

12.8.2.6.2 Inputs

a) MSTID—Identifies the set of parameters upon which the operation will be performed. This parameter is the identifier of the spanning tree for which the operation is being performed.
b) Port Number—the number of the Bridge Port.
c) Path Cost—the new value (13.36.1).
d) Port Priority—the new value of the priority field for the Port Identifier (13.24.17).

12.8.2.6.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to invalid Port Priority value (12.3); or

2) Operation rejected due to invalid MSTID (i.e, there is currently no spanning tree instance with that value of MSTID supported by the Bridge); or
3) Operation accepted.

12.8.2.6.4 Procedure

The Path Cost (13.36.1 of this standard, 17.16.5 of IEEE Std 802.1D, 1998 Edition) and Port Priority (17.18.7 of IEEE Std 802.1D, 1998 Edition) parameters for the specified MSTI and Port are updated using the supplied values. The reselect parameter value for the MSTI for the Port (13.24) is set TRUE, and the selected parameter for the MSTI for the Port () is set FALSE.

12.8.2.7 Force BPDU Migration Check

This operation is available only in Bridges that support RSTP or MSTP, as specified in Clause 13 of this standard or Clause 17 of IEEE Std 802.1D, 1998 Edition.

12.8.2.7.1 Purpose

To force the specified Port to transmit RST or MST BPDUs (see 13.29 of this standard and 17.26 of IEEE Std 802.1D, 1998 Edition).

12.8.2.7.2 Inputs

a) Port Number—the number of the Bridge Port.

12.8.2.7.3 Outputs

None.

12.8.2.7.4 Procedure

The mcheck variable (17.18.10 of IEEE Std 802.1D, 1998 Edition) for the specified Port is set to the value TRUE if the value of the forceVersion variable (13.6.2 of this standard, 17.16.1 of IEEE Std 802.1D, 1998 Edition) is greater than or equal to 2.

12.9 GARP Entities

The operation of GARP is described in Clause 12 of IEEE Std 802.1D, 1998 Edition.

The objects that comprise this managed resource are

a) The GARP Timer objects (12.9.1);
b) The GARP Attribute Type objects (12.9.2);
c) The GARP State Machine objects (12.9.3).

12.9.1 The GARP Timer object

The GARP Timer object models the operations that can be performed upon, or inquire about, the current settings of the timers used by the GARP protocol on a given Port. The management operations that can be performed on the GARP Participant are

a) Read GARP Timers (12.9.1.1);
b) Set GARP Timers (12.9.1.2).

NOTE—The GARP timer values modeled by this object are the values used to initialize timer instances that are used within the GARP state machines, not the timer instances themselves. Hence, there is a single GARP Timer object per Port, regardless of whether the Bridge supports single or multiple spanning trees.

12.9.1.1 Read GARP Timers

12.9.1.1.1 Purpose

To read the current GARP Timers for a given Port.

12.9.1.1.2 Inputs

a) The Port identifier.

12.9.1.1.3 Outputs

a) Current value of JoinTime—Centiseconds (12.10.2.1 and 12.12.1 of IEEE Std 802.1D, 1998 Edition);
b) Current value of LeaveTime—Centiseconds (12.10.2.2 and 12.12.1 of IEEE Std 802.1D, 1998 Edition);
c) Current value of LeaveAllTime—Centiseconds (12.10.2.3 and 12.12.1 of IEEE Std 802.1D, 1998 Edition).

12.9.1.2 Set GARP Timers

12.9.1.2.1 Purpose

To set new values for the GARP Timers for a given Port.

12.9.1.2.2 Inputs

a) The Port identifier;
b) New value of JoinTime—Centiseconds (12.10.2.1 and 12.12.1 of IEEE Std 802.1D, 1998 Edition);
c) New value of LeaveTime—Centiseconds (12.10.2.2 and 12.12.1 of IEEE Std 802.1D, 1998 Edition);
d) New value of LeaveAllTime—Centiseconds (12.10.2.3 and 12.12.1 of IEEE Std 802.1D, 1998 Edition).

12.9.1.2.3 Outputs

None.

12.9.2 The GARP Attribute Type object

The GARP Attribute Type object models the operations that can be performed upon, or inquire about, the operation of GARP for a given Attribute Type (12.11.2.2 of IEEE Std 802.1D, 1998 Edition). The management operations that can be performed on a GARP Attribute Type are

a) Read GARP Applicant Controls (12.9.2.1);
b) Set GARP Applicant Controls (12.9.2.2).

12.9.2.1 Read GARP Applicant Controls

12.9.2.1.1 Purpose

To read the current values of the GARP Applicant Administrative control parameters (12.9.2 of IEEE Std 802.1D, 1998 Edition) associated with all GARP Participants for a given Port, GARP Application and Attribute Type.

12.9.2.1.2 Inputs

a) The Port identifier;
b) The GARP Application address (Table 12-1 of IEEE Std 802.1D, 1998 Edition);
c) The Attribute Type (12.11.2.5 of IEEE Std 802.1D, 1998 Edition).

12.9.2.1.3 Outputs

a) The current Applicant Administrative Control Value (12.9.2 of IEEE Std 802.1D, 1998 Edition);
b) Failed Registrations—Count of the number of times that this GARP Application has failed to register an attribute of this type due to lack of space in the Filtering Database (12.10.1.6).

12.9.2.2 Set GARP Applicant Controls

12.9.2.2.1 Purpose

To set new values for the GARP Applicant Administrative control parameters (12.9.2 of IEEE Std 802.1D, 1998 Edition) associated with all GARP Participants for a given Port, GARP Application and Attribute Type.

12.9.2.2.2 Inputs

a) The Port identifier;
b) The GARP Application address (Table 12-1 of IEEE Std 802.1D, 1998 Edition);
c) The Attribute Type (12.11.2.5 of IEEE Std 802.1D, 1998 Edition) associated with the state machine;
d) The desired Applicant Administrative Control Value (12.9.2 of IEEE Std 802.1D, 1998 Edition).

12.9.2.2.3 Outputs

None.

12.9.3 The GARP State Machine object

The GARP State Machine object models the operations that can be performed upon, or inquire about, the operation of GARP for a given State Machine.

The management operation that can be performed on a GARP State Machine is Read GARP State.

12.9.3.1 Read GARP State

12.9.3.1.1 Purpose

To read the current value of an instance of a GARP state machine.

12.9.3.1.2 Inputs

a) The Port identifier;

b) The GARP Application address (Table 12-1 of IEEE Std 802.1D, 1998 Edition);
c) The GIP Context (12.3.4 of IEEE Std 802.1D, 1998 Edition);
d) The Attribute Type (12.11.2.2 of IEEE Std 802.1D, 1998 Edition) associated with the state machine;
e) The Attribute Value (12.11.2.6 of IEEE Std 802.1D, 1998 Edition) associated with the state machine.

12.9.3.1.3 Outputs

a) The current value of the combined Applicant and Registrar state machine for the attribute (Table 12-6 of IEEE Std 802.1D, 1998 Edition);
b) Optionally, Originator address—the MAC Address of the originator of the most recent GARP PDU that was responsible for causing a state change in this state machine (12.9.1 of IEEE Std 802.1D, 1998 Edition).

12.10 Bridge VLAN managed objects

The following managed objects define the semantics of the management operations that can be performed upon the VLAN aspects of a Bridge:

a) The Bridge VLAN Configuration managed object (12.10.1);
b) The VLAN Configuration managed object (12.10.2);
c) The VLAN Learning Constraints managed object (12.10.3).

12.10.1 Bridge VLAN Configuration managed object

The Bridge VLAN Configuration managed object models operations that modify, or enquire about, the overall configuration of the Bridge's VLAN resources. There is a single Bridge VLAN Configuration managed object per Bridge.

The management operations that can be performed on the Bridge VLAN Configuration managed object are

a) Read Bridge VLAN Configuration (12.10.1.1);
b) Configure PVID and VID Set values (12.10.1.2);
c) Configure Acceptable Frame Types parameters (12.10.1.3);
d) Configure Enable Ingress Filtering parameters (12.10.1.4);
e) Reset VLAN Bridge (12.10.1.5);
f) Notify VLAN registration failure (12.10.1.6);
g) Configure Restricted_VLAN_Registration parameters (12.10.1.3);
h) Configure Protocol Group Database (12.10.1.8);
i) Configure VLAN Learning Constraints (12.10.3).

12.10.1.1 Read Bridge VLAN Configuration

12.10.1.1.1 Purpose

To obtain general VLAN information from a Bridge.

12.10.1.1.2 Inputs

None.

12.10.1.1.3 Outputs

a) The 802.1Q VLAN Version number. Reported as “1” by VLAN Bridges that support only SST operation, and reported as “2” by VLAN Bridges that support MST operation;

NOTE—No 802.1Q VLAN version numbers other than 1 and 2 are currently specified.

b) The optional VLAN features supported by the implementation:
   1) The maximum number of VLANs supported;
   2) Whether the implementation supports the ability to override the default PVID setting, and its egress status (VLAN-tagged or untagged) on each Port;
   3) For a Bridge that supports Port-and-Protocol-based VLAN classification, which of the Protocol Template formats (8.6.2) are supported by the implementation.
   4) For MST Bridges, the maximum number of MSTIs supported within an MST Region (i.e., the number of Spanning Tree instances that can be supported in addition to the CIST). For SST Bridges, this parameter may either be omitted or reported as “0”.

c) For each Port:
   1) the Port number;
   2) the PVID value (8.4.4) currently assigned to that Port;
   3) For a Bridge that supports Port-and-Protocol-based VLAN classification, whether the implementation supports Port-and-Protocol-based VLAN classification on that Port;
   4) For a Bridge that supports Port-and-Protocol-based VLAN classification on that Port, the maximum number of entries supported in the VID Set on that Port; the VID value and Protocol Group Identifier currently assigned to each entry in the VID Set (8.4.4) on that Port;
   5) the state of the Acceptable Frame Types parameter (8.4.3). The permissible values for this parameter are:
      i) Admit only VLAN-tagged frames;
      ii) Admit all frames.
   3) the state of the Enable Ingress Filtering parameter (8.4.5); Enabled or Disabled;
   4) the state of the Restricted_VLAN_Registration parameter (11.2.3.2.3), TRUE or FALSE.

d) For a Bridge that supports Port-and-Protocol-based VLAN classification: the contents of the Protocol Group Database comprising a set of {Protocol Template, Protocol Group Identifier} bindings (8.6.1, 8.6.3, and 8.6.4); the maximum number of entries supported in the Protocol Group Database.

12.10.1.2 Configure PVID and VID Set values

12.10.1.2.1 Purpose

To configure the PVID and VID Set value(s) (8.4.4) associated with one or more Ports.

12.10.1.2.2 Inputs

a) For each Port to be configured, a Port number and the PVID value to be associated with that Port
b) In addition, for a Bridge that supports Port-and-Protocol-based VLAN classification: for each Port to be configured, a Port number, a Protocol Group Identifier, and a VID value for the member of the Port’s VID Set that is to be configured.

12.10.1.2.3 Outputs

a) Operation status for each Port to be configured. This takes one of the following values:
   1) Operation rejected due to there being no spare VID Set entries on this Port; or
   2) Operation rejected due to the PVID or VID being out of the supported range for this Port; or
   3) Operation accepted.

12.10.1.3 Configure Acceptable Frame Types parameters

12.10.1.3.1 Purpose

To configure the Acceptable Frame Types parameter (8.4.3) associated with one or more Ports.

12.10.1.3.2 Inputs

a) For each Port to be configured, a Port number and the value of the Acceptable Frame Types parameter to be associated with that Port. The permissible values of this parameter are (as defined in 8.4.3):
   1) Admit only VLAN-tagged frames;
   2) Admit all frames.

12.10.1.3.3 Outputs

None.

12.10.1.4 Configure Enable Ingress Filtering parameters

12.10.1.4.1 Purpose

To configure the Enable Ingress Filtering parameter(s) (8.4.5) associated with one or more Ports.

12.10.1.4.2 Inputs

a) For each Port to be configured, a Port number and the value of the Enable Ingress Filtering parameter to be associated with that Port. The permissible values for the parameter are
   1) Enabled;
   2) Disabled.

12.10.1.4.3 Outputs

None.

12.10.1.5 Reset VLAN Bridge

12.10.1.5.1 Purpose

To reset all statically configured VLAN-related information in the Bridge to its default state. This operation

a) Deletes all VLAN Configuration managed objects;
b) Resets the PVID associated with each Bridge Port to the Default PVID value (Table 9-2);
c) Removes all entries in the Protocol Group Database and removes all members of the VID Set on each port, for a Bridge that supports Port-and-Protocol-based VLAN classification;
d) Resets the Acceptable Frame Types parameter value associated with each Port to the default value (8.4.3).

12.10.1.5.2 Inputs

None.

12.10.1.5.3 Outputs

None.

12.10.1.6 Notify VLAN registration failure

12.10.1.6.1 Purpose

To notify a manager that GVRP (11.2.3) has failed to register a given VLAN owing to lack of resources in the Filtering Database for the creation of a Dynamic VLAN Registration Entry (8.11.5), or owing to the Restricted_VLAN_Registration parameter being set to TRUE.

12.10.1.6.2 Inputs

None.

12.10.1.6.3 Outputs

a) The VID of the VLAN that GVRP failed to register;
b) The Port number of the Port on which the registration request was received;
c) The reason for the failure:
   1) Lack of Resources; or
   2) Registration Restricted; or
   3) Unsupported VID value.

12.10.1.7 Configure Restricted_VLAN_Registration parameters

12.10.1.7.1 Purpose

To configure the Restricted_VLAN_Registration parameter (11.2.3.2.3) associated with one or more Ports.

12.10.1.7.2 Inputs

a) For each Port to be configured, a Port number and the value of the Restricted_VLAN_Registration parameter. The permissible values of this parameter are (as defined in 11.2.3.2.3) as follows:
   1) TRUE;
   2) FALSE.

12.10.1.7.3 Outputs

None.

12.10.1.8 Configure Protocol Group Database

To configure a Protocol Group Database (8.6.4) entry. This operation is not applicable to a Bridge that does not support Port-and-Protocol-based VLAN classification.

NOTE—Implementation of the Configure Protocol Group Database operation is not mandatory; conformant implementations may implement a fixed set of Protocol Group Database entries.

12.10.1.8.1 Inputs

a) A value representing the frame format to be matched: Ethernet, RFC_1042, SNAP_8021H, SNAP_Other or LLC_Other (8.6.1);
b) One of
   1) An IEEE 802.3 Type value, for matching frame formats of Ethernet, RFC_1042, or SNAP_8021H;
   2) A 40-bit Protocol ID (PID), for matching frame formats of SNAP_Other;

   3) A pair of IEEE 802.2 DSAP and SSAP address field values, for matching frame formats of LLC_Other;

c) A Protocol Group Identifier (8.6.3).

12.10.1.8.2 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to there being no spare Protocol Group Database entries; or
   2) Operation rejected due to an unsupported frame format; or
   3) Operation rejected due to an unsupported value for an IEEE 802.3 Type value, PID, DSAP, or SSAP; or
   4) Operation accepted.

12.10.2 VLAN Configuration managed object

The VLAN Configuration object models operations that modify, or enquire about, the configuration of a particular VLAN within a Bridge. There are multiple VLAN Configuration objects per Bridge; only one such object can exist for a given VLAN ID.

The management operations that can be performed on the VLAN Configuration are:

a) Read VLAN Configuration (12.10.2.1);
b) Create VLAN Configuration (12.10.2.2);
c) Delete VLAN Configuration (12.10.2.3);

12.10.2.1 Read VLAN Configuration

12.10.2.1.1 Purpose

To obtain general information regarding a specific VLAN Configuration.

12.10.2.1.2 Inputs

a) VLAN Identifier: a 12-bit VID.

12.10.2.1.3 Outputs

a) VLAN Name: A text string of up to 32 characters of locally determined significance;
b) List of Untagged Ports: The set of Port numbers for which this VLAN ID is a member of the Untagged set (8.11.9) for that Port;
c) List of Egress Ports: The set of Port numbers for which this VLAN ID is a member of the Member set (8.11.9) for that Port.

NOTE—The values of the Member set and the Untagged set are determined by the values held in VLAN Registration Entries in the Filtering Database (8.11.2, 8.11.5, and 8.11.9).

12.10.2.2 Create VLAN Configuration

12.10.2.2.1 Purpose

To create or update a VLAN Configuration managed object.

12.10.2.2.2 Inputs

a) VLAN Identifier: a 12-bit VID;
b) VLAN Name: A text string of up to 32 characters of locally determined significance.

NOTE—Static configuration of the Member set and the Untagged set is achieved by means of the management operations for manipulation of VLAN Registration Entries (12.7.5).

12.10.2.2.3 Outputs

None.

12.10.2.3 Delete VLAN Configuration

12.10.2.3.1 Purpose

To delete a VLAN Configuration managed object.

12.10.2.3.2 Inputs

a) VLAN Identifier: a 12-bit VID;

12.10.2.3.3 Outputs

None.

12.10.3 The VLAN Learning Constraints managed object

The VLAN Learning Constraints managed object models operations that modify, or enquire about, the set of VLAN Learning Constraints (8.11.7.2) and VID to FID allocations (8.11.7.1) that apply to the operation of the Learning Process and the Filtering Database. There is a single VLAN Learning Constraints managed object per Bridge. The object is modeled as a pair of fixed-length tables, as follows:

a) A Learning Constraint table in which each table entry either defines a single Learning Constraint or is undefined. For some of the operations that can be performed upon the table, an *entry index* is used; this identifies the number of the entry in the table, where index number 1 is the first, and N is the last (where the table contains N entries).

NOTE—The number of Learning Constraint table entries supported is an implementation option. This standard does not provide any distribution mechanism to ensure that the same set of constraints is configured in all Bridges; individual Bridges can be configured by use of the management operations defined in this subclause (for example, via the use of SNMP operating upon a VLAN Bridge MIB), but there is no in-built consistency checking to ensure that all Bridges have been provided with the same constraint information. Hence, any such consistency checking is the responsibility of the network administrator and the management applications employed in the LAN.

b) A VID to FID allocation table (8.11.7.1) with an entry per VID supported by the implementation. Each table entry indicates, for that VID, that there is currently
   1) No allocation defined; or
   2) A fixed allocation to FID X; or
   3) A dynamic allocation to FID X.

The management operations that can be performed on the VLAN Learning Constraints managed object are

c) Read VLAN Learning Constraints (12.10.3.1);
d) Read VLAN Learning Constraints for VID (12.10.3.2);

e) Set VLAN Learning Constraint (12.10.3.3);
f) Delete VLAN Learning Constraint (12.10.3.4);
g) Read VID to FID allocations (12.10.3.5);
h) Read FID allocation for VID (12.10.3.6);
i) Read VIDs allocated to FID (12.10.3.7);
j) Set VID to FID allocation (12.10.3.8);
k) Delete VID to FID allocation (12.10.3.9);
l) Notify Learning Constraint Violation (12.10.3.10).

12.10.3.1 Read VLAN Learning Constraints

12.10.3.1.1 Purpose

To read the contents of a range of one or more entries in the VLAN Learning Constraints table.

12.10.3.1.2 Inputs

a) First Entry—Entry Index of first entry to be read;
b) Last Entry—Entry Index of last entry to be read.

12.10.3.1.3 Outputs

a) List of Entries—for each entry that was read:
    1) The Entry Index;
    2) The type of the Learning Constraint: Undefined, S or I;
    3) The value of the Learning Constraint, which is one of:
        i) Undefined, indicating an empty element in the table;
        ii) An S Constraint value, consisting of a pair of VIDs;
        iii) An I Constraint value, consisting of a VID and an Independent Set Identifier.

NOTE—Where this operation is implemented using a remote management protocol, PDU size constraints may restrict the number of entries that are actually read to fewer than was requested in the input parameters. In such cases, retrieving the remainder of the desired entry range can be achieved by repeating the operation with a modified entry range specification.

12.10.3.2 Read VLAN Learning Constraints for VID

12.10.3.2.1 Purpose

To read all the VLAN Learning Constraints for a given VID.

12.10.3.2.2 Inputs

a) VID—The VLAN Identifier to which the read operation applies.

12.10.3.2.3 Outputs

a) All learning constraint values that identify the VID requested. Each value returned is either
    1) An S Constraint value, consisting of a pair of VIDs; or
    2) An I Constraint value, consisting of a VID and an Independent Set Identifier.

12.10.3.3 Set VLAN Learning Constraint

12.10.3.3.1 Purpose

To modify the contents of one of the entries in the VLAN Learning Constraints table.

12.10.3.3.2 Inputs

a) Entry Index—Entry index of the entry to be set;
b) The type of the Learning Constraint: S or I;
c) The value of the Learning Constraint, which is either:
   1) An S Constraint value, consisting of a pair of VIDs; or
   2) An I Constraint value, consisting of a VID and an Independent Set Identifier.

12.10.3.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to inconsistent learning constraint specification (8.11.7.3)—The Set operation requested setting a constraint that is inconsistent with another constraint already defined in the constraint table. The operation returns the value of the constraint concerned; or
   2) Operation rejected due to inconsistent fixed VID to FID allocation (8.11.7.3)—The Set operation requested setting a constraint that is inconsistent with a fixed VID to FID allocation already defined in the allocation table. The operation returns the value of the fixed allocation concerned; or
   3) Operation rejected due to entry index exceeding the maximum index supported by the constraint table; or
   4) Operation rejected due to conflict with FID to MSTID allocations (12.12.2)—The Set operation requested setting a constraint that cannot be reconciled with the current FID to MSTID allocations represented by the FID to MSTID Allocation Table; or

NOTE—It is not possible to specify a shared VLAN learning constraint for VLANs that do not share the same Spanning Tree instance.

   5) Operation accepted.

12.10.3.3.4 Procedure

In MST Bridges, the Configuration Digest element of the MST Configuration Identifier is re-calculated, in accordance with the definition in 13.7, following any change in the VLAN Learning Constraints that results in a change in the allocation of VIDs to spanning trees.

12.10.3.4 Delete VLAN Learning Constraint

12.10.3.4.1 Purpose

To remove one of the entries in the VLAN Learning Constraints table. This operation has the effect of setting the value of the specified table entry to “Undefined.”

12.10.3.4.2 Inputs

a) Entry Index—Entry index of the entry to be deleted.

12.10.3.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to entry index exceeding the maximum index supported by the constraint table; or
   2) Operation accepted.

12.10.3.4.4 Procedure

In MST Bridges, the Configuration Digest element of the MST Configuration Identifier is re-calculated, in accordance with the definition in 13.7, following any change in the VLAN Learning Constraints that results in a change in the allocation of VIDs to spanning trees.

12.10.3.5 Read VID to FID allocations

12.10.3.5.1 Purpose

To read the contents of a range of one or more entries in the VID to FID allocation table.

12.10.3.5.2 Inputs

a) First Entry—VID of first entry to be read;
b) Last Entry—VID of last entry to be read.

12.10.3.5.3 Outputs

a) List of Entries—For each entry that was read:
   1) VID—The VLAN Identifier for this entry;
   2) Allocation Type—The type of the allocation: Undefined, Fixed or Dynamic;
   3) FID—The FID to which the VID is allocated (if not of type Undefined).

NOTE—Where this operation is implemented using a remote management protocol, PDU size constraints may restrict the number of entries that are actually read to fewer than was requested in the input parameters. In such cases, retrieving the remainder of the desired entry range can be achieved by repeating the operation with a modified entry range specification.

12.10.3.6 Read FID allocation for VID

12.10.3.6.1 Purpose

To read the FID to which a specified VID is currently allocated.

12.10.3.6.2 Inputs

a) VID—The VLAN Identifier to which the read operation applies.

12.10.3.6.3 Outputs

a) VID—the VLAN Identifier to which the read operation applies;
b) Allocation Type—the type of the allocation: Undefined, Fixed or Dynamic;
c) FID—the FID to which the VID is allocated (if not of type Undefined).

12.10.3.7 Read VIDs allocated to FID

12.10.3.7.1 Purpose

To read all the VIDs currently allocated to a given FID.

12.10.3.7.2 Inputs

a) FID—the Filtering Identifier to which the read operation applies.

12.10.3.7.3 Outputs

a) FID—the Filtering Identifier to which the read operation applies
b) Allocation List—a list of allocations for this FID. For each element in the list:
   1) Allocation Type—the type of the allocation: Fixed or Dynamic;
   2) VID—the VID that is allocated.

12.10.3.8 Set VID to FID allocation

12.10.3.8.1 Purpose

To establish a fixed allocation of a VID to an FID.

12.10.3.8.2 Inputs

a) VID—the VID of the entry to be set;
b) FID—the FID to which the VID is to be allocated.

12.10.3.8.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to inconsistent learning constraint specification (8.11.7.3)—The Set operation requested setting a fixed allocation that is inconsistent with a VLAN Learning Constraint. The operation returns the value of the VLAN Learning Constraint concerned; or
   2) Operation rejected due to VID exceeding the maximum VID supported by the allocation table; or
   3) Operation rejected due to FID exceeding the maximum ID supported by the implementation; or
   4) Operation accepted.

12.10.3.8.4 Procedure

In MST Bridges, the Configuration Digest element of the MST Configuration Identifier is recalculated, in accordance with the definition in 13.7, following any change in the allocation of VIDs to FIDs that results in a change in the allocation of VIDs to spanning trees.

12.10.3.9 Delete VID to FID allocation

12.10.3.9.1 Purpose

To remove a fixed VID to FID allocation from the VID to FID allocation table. This operation has the effect of setting the value of the specified table entry to “Undefined.”

NOTE—If the VID concerned represents a currently active VLAN, then removal of a fixed allocation may result in the “Undefined” value in the table immediately being replaced by a dynamic allocation to an FID.

12.10.3.9.2 Inputs

a) VID—VID of the allocation to be deleted.

12.10.3.9.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to VID exceeding the maximum value supported by the allocation table; or
   2) Operation accepted.

12.10.3.9.4 Procedure

In MST Bridges, the Configuration Digest element of the MST Configuration Identifier is re-calculated, in accordance with the definition in 13.7, and the MSTP state machine variables are reinitialized by asserting BEGIN, following any change in the allocation of VIDs to FIDs that results in a change in the allocation of VIDs to spanning trees.

12.10.3.10 Notify Learning Constraint Violation

12.10.3.10.1 Purpose

To alert the Manager to the existence of a Learning Constraint violation (8.11.7.3). This is an unsolicited notification from the management entity of the Bridge, issued upon detection of the constraint violation.

NOTE—As indicated in 8.11.7.3, a single change in configuration, such as the registration of a new VID by GVRP or the addition of a new learning constraint, can give rise to more than one violation being notified, depending upon the set of learning constraints currently configured in the Bridge.

12.10.3.10.2 Inputs

a) None.

12.10.3.10.3 Outputs

a) Violation Type/Argument—one of
   1) Shared VLAN Learning not supported. The argument returned indicates the VIDs of a pair of active VLANs for which an S constraint exists.
   2) Independent VLAN Learning not supported. The argument returned indicates the VIDs of a pair of active VLANs for which I constraints exist that contain the same independent set identifier.
   3) Required FID range not supported. The argument returned indicates
      i) The VID that the Bridge is unable to allocate to an FID;
      ii) The maximum number of FIDs supported by the Bridge.

The violation type *Required FID range not supported* is detected only by IVL or IVL/SVL Bridges that support fewer than 4094 FIDs.

12.11 GMRP entities

The following managed objects define the semantics of the management operations that can be performed upon the operation of GMRP in a Bridge:

a) The GMRP Configuration managed object (12.10.1).

12.11.1 GMRP Configuration managed object

The GMRP Configuration managed object models operations that modify, or enquire about, the overall configuration of the operation of GMRP. There is a single GMRP Configuration managed object per Bridge.

The management operations that can be performed on the GMRP Configuration managed object are as follows:

a) Read GMRP Configuration (12.10.1.1);
b) Notify Group registration failure (12.10.1.6);
c) Configure Restricted_Group_Registration parameters (12.11.1.3).

12.11.1.1 Read GMRP Configuration

12.11.1.1.1 Purpose

To obtain general GMRP configuration information from a Bridge.

12.11.1.1.2 Inputs

None.

12.11.1.1.3 Outputs

a) For each Port:
   1) The Port number;
   2) The state of the Restricted_Group_Registration parameter (10.3.2.3 in IEEE Std 802.1D, 1998 Edition), TRUE or FALSE.

12.11.1.2 Notify Group registration failure

12.11.1.2.1 Purpose

To notify a manager that GMRP has failed to register a given Group owing to lack of resources in the Filtering Database for the creation of a Group Registration Entry (8.11.4).

12.11.1.2.2 Inputs

None.

12.11.1.2.3 Outputs

a) The MAC address of the Group that GMRP failed to register;
b) The Port number of the Port on which the registration request was received.
c) The reason for the failure:
   1) Lack of Resources; or
   2) Registration Restricted.

12.11.1.3 Configure Restricted_Group_Registration parameters

12.11.1.3.1 Purpose

To configure the Restricted_Group_Registration parameter (10.3.2.3 in IEEE Std 802.1D, 1998 Edition) associated with one or more Ports.

12.11.1.3.2 Inputs

a) For each Port to be configured, a Port number and the value of the Restricted_Group_Registration parameter. The permissible values of this parameter are (as defined in 10.3.2.3 of IEEE Std 802.1D, 1998 Edition) as follows:
   1) TRUE;
   2) FALSE.

12.11.1.3.3 Outputs

None.

12.12 MST configuration entities

The following managed objects define the semantics of the management operations that can be performed upon the MST configuration in a Bridge:

a) The MSTI List object (12.12.1);
b) The FID to MSTID Allocation Table object (12.12.2);
c) The MST Configuration Table object (12.12.3).

12.12.1 The MSTI List

For MST Bridges, the MSTI List object models the operations that modify, or enquire about, the list of MST spanning tree instances supported by the Bridge. The object is modelled as a list of MSTIDs corresponding to the MSTIs supported by the Bridge.

The MSTID List object supports the following operations:

a) Read MSTI List (12.12.1.1);
b) Create MSTI (12.12.1.2);
c) Delete MSTI (12.12.1.3).

12.12.1.1 Read MSTI List

12.12.1.1.1 Purpose

To read the list of MSTIDs that are currently supported by the Bridge.

12.12.1.1.2 Inputs

None.

12.12.1.1.3 Outputs

a) MSTID list. The list of MSTID values that are currently supported by the Bridge.

12.12.1.2 Create MSTI

12.12.1.2.1 Purpose

To create a new MSTI and its associated state machines and parameters, and to add its MSTID to the MSTI List.

12.12.1.2.2 Inputs

a) The MSTID of the MSTI to be created.

12.12.1.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to the number of MSTIs currently supported by the Bridge being equal to the maximum number of MSTIs that the Bridge is able to support.
   2) Operation rejected as the MSTID value supplied in the input parameters is already present in the MSTI List.
   3) Operation accepted.

12.12.1.3 Delete MSTI

12.12.1.3.1 Purpose

To delete an existing MSTI and its associated state machines and parameters, and to remove its MSTID from the MSTI List.

12.12.1.3.2 Inputs

a) The MSTID of the MSTI to be deleted.

12.12.1.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected as the MSTID value supplied in the input parameters is not present in the MSTI List.
   2) Operation rejected as the MSTID value supplied in the input parameter currently has one or more FIDs allocated to it in the FID to MSTID Allocation Table.
   3) Operation accepted.

12.12.2 The FID to MSTID Allocation Table

For MST Bridges, the FID to MSTID Allocation Table object models the operations that modify, or enquire about, the assignment of FIDs to spanning tree instances currently supported by the Bridge (8.11.3). The object is modelled as a fixed-length table in which each entry in the table corresponds to a FID, and the value of the entry specifies the MSTID of the spanning tree to which the set of VLANs supported by that FID are assigned. A value of zero in an entry specifies that the set of VLANs supported by that FID are assigned to the CST.

The MSTID Allocation Table object supports the following operations:

a) Read FID to MSTID allocations (12.12.2.1);
b) Set FID to MSTID allocation (12.12.2.2).

12.12.2.1 Read FID to MSTID allocations

12.12.2.1.1 Purpose

To read a range of one or more entries in the FID to MSTID Allocation Table.

12.12.2.1.2 Inputs

a) First FID—The FID of the first entry to be read;
b) Last FID—The FID of the last entry to be read.

If the value of Last FID is numerically equal to, or smaller than, the value of First FID, then a single table entry is read, corresponding to the value of First FID.

12.12.2.1.3 Outputs

a) List of entries—For each entry that was read:
   1) The FID of the entry: and
   2) The MSTID to which that FID is allocated.

12.12.2.2 Set FID to MSTID allocation

12.12.2.2.1 Purpose

To change the contents of an entry in the FID to MSTID Allocation Table.

12.12.2.2.2 Inputs

a) FID—The FID of the entry to be changed;
b) MSTID—The MSTID to which the FID is to be allocated.

12.12.2.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected as the MSTID value supplied in the input parameters is not present in the MSTI List.
   2) Operation rejected as the FID value supplied in the input parameters is invalid or is not supported.
   3) Operation accepted.

12.12.2.2.4 Procedure

The Configuration Digest element of the MST Configuration Identifier is re-calculated, in accordance with the definition in 13.7, following any change in the allocations of FIDs to MSTIDs.

12.12.3 The MST Configuration Table

The MST Configuration Table managed object models the operations that can be performed on the MST Configuration Table for the Bridge (3.26, 8.11.1, and 13.7). Associated with the table is the MST Configuration Identifier for the Bridge (8.11.2, 13.7).

The MST Configuration Table is a read-only table, its elements derived from other configuration information held by the Bridge; specifically, the current state of the VID to FID allocation table (8.10.7.1, 12.10.3), and the FID to MSTID allocation table (8.11.3, 12.12.2). Hence, changes made to either of these tables can in turn affect the contents of the MST Configuration Table, and also affect the value of the “digest” element of the MST Configuration Identifier. The MST Configuration Table is modelled as a fixed table of 4096 elements, as described in 13.7.

The MST Configuration Table managed object supports the following operations:

a) Read MST Configuration Table Element (12.12.3.1);
b) Read VIDs assigned to MSTID (12.12.3.2);
c) Read MST Configuration Identifier (12.12.3.3);
d) Set MST Configuration Identifier Elements (12.12.3.4).

12.12.3.1 Read MST Configuration Table Element

12.12.3.1.1 Purpose

To read a single element of the current MST Configuration Table for the Bridge (13.7).

12.12.3.1.2 Inputs

a) A VID value, in the range 0 through 4094.

12.12.3.1.3 Outputs

a) A VID value, in the range 0 through 4094;
b) The MSTID value corresponding to that VID.

12.12.3.2 Read VIDs assigned to MSTID

12.12.3.2.1 Purpose

To read the list of VIDs that are currently assigned to a given MSTID in the MST Configuration Table for the Bridge (13.7).

12.12.3.2.2 Inputs

a) An MSTID value, in the range 0 through 4094.

12.12.3.2.3 Outputs

a) A MSTID value, in the range 0 through 4094;
b) A 4096-bit vector in which bit N is set TRUE if VID N is assigned to the given MSTID, and is otherwise set FALSE.

12.12.3.3 Read MST Configuration Identifier

12.12.3.3.1 Purpose

To read the current value of the MST Configuration Identifier for the Bridge (13.7).

12.12.3.3.2 Inputs

None.

12.12.3.3.3 Outputs

a) The MST Configuration Identifier (13.7), consisting of:
    1) The Configuration Identifier Format Selector in use by the Bridge. This has a value of 0 to indicate the format specified in this Standard.

2) The Configuration Name;
3) The Revision Level;
4) The Configuration Digest.

12.12.3.4 Set MST Configuration Identifier Elements

12.12.3.4.1 Purpose

To change the current values of the modifiable elements of the MST Configuration Identifier for the Bridge (13.7).

NOTE—The Configuration Digest element of the MST Configuration Identifier is read-only; its value is re-calculated whenever configuration changes occur that result in a change in the allocation of VIDs to MSTIs.

12.12.3.4.2 Inputs

a) The MST Configuration Identifier (13.7) Format Selector in use by the Bridge. This has a value of 0 to indicate the format specified in this Standard.
b) The Configuration Name;
c) The Revision Level.

12.12.3.4.3 Outputs

a) Operation Status. This can take the following values:
    1) Operation rejected due to unsupported Configuration Identifier Format Selector value.
    2) Operation accepted.

Insert a new Clause 13 as follows:

13. The Multiple Spanning Tree Protocol (MSTP)

The MSTP algorithm and protocol provides simple and full connectivity for frames assigned to any given VLAN throughout a Bridged Local Area Network comprising arbitrarily interconnected Bridges, each operating MSTP, STP (Clause 8 of IEEE Std 802.1D, 1998 Edition), or RSTP (Clause 17 of IEEE Std 802.1D, 1998 Edition). MSTP allows frames assigned to different VLANs to follow separate paths, each based on an independent Multiple Spanning Tree Instance (MSTI), within Multiple Spanning Tree (MST) Regions composed of LANs and or MST Bridges. These Regions and the other Bridges and LANs are connected into a single Common Spanning Tree (CST).

NOTE 1—The specification of RSTP is contained in IEEE Std 802.1w-2001, which is an amendment to IEEE Std 802.1D, 1998 Edition. References to IEEE Std 802.1D, 1998 Edition in this standard assume that this amendment, along with IEEE Std 802.1t-2001 (which documents technical and editorial corrections to IEEE Std 802.1D, 1998 Edition), have been applied to the base text of IEEE Std 802.1D, 1998 Edition.

MSTP connects all Bridges and LANs with a single Common and Internal Spanning Tree (CIST). The CIST supports the automatic determination of each MST Region, choosing its maximum possible extent. The connectivity calculated for the CIST provides the CST for interconnecting these Regions, and an Internal Spanning Tree (IST) within each Region. MSTP ensures that frames with a given VID are assigned to one and only one of the MSTIs or the IST within the Region, that the assignment is consistent amongst all the Bridges within the region, and that the stable connectivity of each MSTI and the IST at the boundary of the Region matches that of the CST. The stable active topology of the Bridged Local Area Network with respect to frames consistently classified as belonging to any given VLAN thus simply and fully connects all LANs and Bridges throughout the network, though frames belonging to different VLANs can take different paths within any MST Region.

NOTE 1—Readers of this specification are urged to begin by familiarizing themselves with the referenced specification of RSTP.

NOTE 2—Although the active topology determined by STP, RSTP, and MSTP fully connects the components of a Bridged Local Area Network, filtering (GVRP etc.) can restrict frames to a subset of the active topology where some VLANs are not present throughout.

13.1 Protocol Design Requirements

The Spanning Tree Algorithm and its associated Bridge Protocol operate in Bridged Local Area Networks of arbitrary physical topology comprising MSTP, RSTP, or STP Bridges connecting shared media or point to point LANs, so as to support, preserve, and maintain the quality of the MAC Service in all its aspects as specified by Clause 7. In order to do this the algorithm meets the following requirements:

a) It will configure the active topology into a single spanning tree for any given VLAN, such that there is at most one data route between any two end stations for frames consistently allocated to a given VID by Bridges conforming to this standard, eliminating data loops.
b) It will provide for fault tolerance by automatic reconfiguration of the spanning tree topology as a result of Bridge failure or a breakdown in a data path, within the confines of the available Bridged Local Area Network components, and for the automatic accommodation of any Bridge or Bridge Port added to the network without the formation of transient data loops.
c) The active topology will, with a high probability, stabilize within a short, known bounded interval in order to minimize the time for which the service is unavailable for communication between any pair of end stations.
d) The active topology will be predictable and reproducible, and may be selected by management of the parameters of the algorithm, thus allowing the application of Configuration Management, following traffic analysis, to meet the goals of Performance Management.
e) It will operate transparently to the end stations, such that they are unaware of their attachment to a single LAN or a Bridged LAN when using the MAC Service.
f) The communications bandwidth consumed by the Bridges in establishing and maintaining a spanning tree on any particular LAN will be a small percentage of the total available bandwidth and independent of the total traffic supported by the Bridged LAN regardless of the total number of Bridges or LANs.
g) It allows frames assigned to different VLANs to follow different data routes within administratively established regions of the network.
h) It will, with a high probability, continue to provide simple and full connectivity for frames even in the presence of administrative errors in the allocation of VLANs to spanning trees.

Additionally, the algorithm and protocol meet the following goals, which limit the complexity of Bridges and their configuration:

i) The memory requirements associated with each Bridge Port are independent of the number of Bridges and LANs in the Bridged LAN.
j) Bridges do not have to be individually configured before being added to the Bridged LAN, other than having their MAC Addresses assigned through normal procedures.

13.2 Protocol Support Requirements

MSTP does not require any additional configuration mechanisms beyond those specified in 17.1 of IEEE Std 802.1D, 1998 Edition in order to support the MAC Service. However to realize the improved throughput and associated frame loss and transit delay performance improvements made possible by the use of multiple spanning trees the following are required:

a) A means of consistently assigning VIDs to MSTIDs within each potential MST Region.
b) Administrative agreement on the Configuration Name and Revision Level used to represent the assignments of VIDs to MSTIDs.
c) A means of assessing the probable distribution of traffic between sets of communicating end stations.
d) A choice of performance goals or the establishment of goals that the quality of service characteristics of some set of communications shall be independent of some other sets.
e) Choices of configuration parameters for the spanning trees that support these goals given the available physical components.

13.3 MSTP Overview

The Multiple Spanning Tree Protocol specifies:

a) An MST Configuration Identifier (13.7). This allows each Bridge to advertise its configuration for allocating frames with given VIDs to any of a number of distinct, fully and simply connected Multiple Spanning Tree Instances (MSTIs).
b) A priority vector (13.9) that comprises bridge identifier and path cost information for constructing a deterministic and manageable single spanning tree active topology, the CIST, that:
    1) Fully and simply connects all the Bridges and LANs in a Bridged Local Area Network.
    2) Permits the construction and identification of Regions of Bridges and LANs that are guaranteed fully connected by the Bridges and LANs within each Region.
    3) Ensures that paths within each Region are always preferred to paths outside the Region.
c) An MSTI priority vector (13.9), comprising information for constructing a deterministic and independently manageable active topology for any given MSTI within each Region.
d) Comparisons and calculations performed by each Bridge in support of the distributed spanning tree algorithm (13.10). These select a CIST priority vector for each Port, based on the priority vectors and MST Configuration Identifiers received from other Bridges and on an incremental Path Cost associated with each receiving Port. The resulting priority vectors are such that in a stable network:
    1) One Bridge is selected to be the CIST Root of the Bridged Local Area Network as a whole.
    2) A minimum cost path to the CIST Root is selected for each Bridge and LAN, thus preventing loops while ensuring full connectivity.
    3) The one Bridge in each Region whose minimum cost path to the Root is not through another Bridge using the same MST Configuration Identifier is identified as its Region's CIST Regional Root.
    4) Conversely, each Bridge whose minimum cost path to the Root is through a Bridge using the same MST Configuration Identifier is identified as being in the same MST Region as that Bridge.
e) Priority vector comparisons and calculations performed by each Bridge for each MSTI (13.11). In a stable network:
    1) One Bridge is independently selected for each MSTI to be the MSTI Regional Root.
    2) A minimum cost path to the MSTI Regional Root that lies wholly within the Region is selected for each Bridge and LAN.
f) CIST Port Roles (13.12) that identify the role in the CIST active topology played by each Port on a Bridge.
    1) The Root Port provides the minimum cost path from the Bridge to the CIST Root (if the Bridge is not the CIST Root) through the Regional Root (if the Bridge is not a Regional Root).
    2) A Designated Port provides the least cost path from the attached LAN through the Bridge to the CIST Root.
    3) Alternate or Backup Ports provide connectivity if other Bridges, Bridge Ports, or LANs fail or are removed.

g) MSTI Port Roles (13.12) that identify the role played by each Port on a Bridge for each MSTI's active topology within and at the boundaries of a Region.
   1) The Root Port provides the minimum cost path from the Bridge to the MSTI Regional Root (if the Bridge is not the Regional Root for this MSTI).
   2) A Designated Port provides the least cost path from the attached LAN though the Bridge to the Regional Root.
   3) A Master Port provides connectivity from the Region to a CIST Root that lies outside the Region. The Bridge Port that is the CIST Root Port for the CIST Regional Root is the Master Port for all MSTIs.
   4) Alternate or Backup Ports provide connectivity if other Bridges, Bridge Ports, or LANs fail or are removed.

h) State machines and state variables associated with each spanning tree (CIST or MSTI), port, and port role, to select and change the Port State (8.4, 13.19 of this standard, 17.5 of IEEE Std 802.1D, 1998 Edition) that controls the processing and forwarding of frames allocated to that tree by a MAC Relay Entity (7.3).

13.3.1 Example Topologies

The examples shown in this clause make use of the diagrammatic conventions shown in Figure 13-1._

Figure 13-3 is an example Bridged Local Area Network, chosen to illustrate MSTP calculations rather than as an example of a common or desirable physical topology. Figure 13-3 is the same network showing Bridges and LANs with better CIST spanning tree priorities higher on the page, and including CIST priority vectors, port roles, and MST Regions. In this example:

a) Bridge 0.42 has been chosen as the CIST Root because it has the best (numerically the lowest) Bridge Identifier of all the bridges in the network.

b) Bridges 0.57 and 2.83 are in the same MST Region (1) as 0.42, because they have the same MST Configuration Identifier as the latter. Because they are in the same MST Region as the CIST Root, their External Root Path Cost is 0, and their CIST Regional Root is the CIST Root.

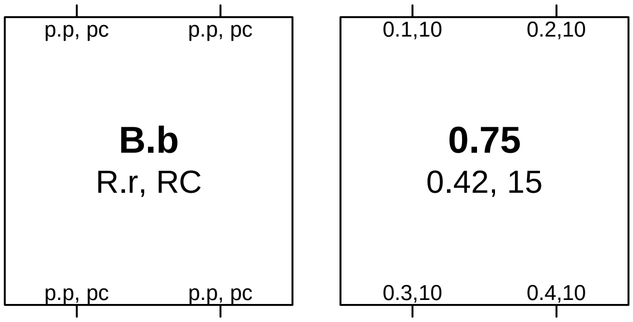
c) LANs A, B, C, and D are in Region 1 because a Region 1 MST Bridge is the CIST Designated Bridge for those LANs and there are no attached STP Bridges. LAN E is not in a Region (or is in a Region by itself, which is an equivalent view) because it is attached to Bridge 0.53, which is not an MST Bridge.

d) Bridges 0.77, 0.65, 0.97, 0.86, 3.84, and 3.72 are in the same MST Region (2) because they all have the same MST Configuration Identifier, and are all interconnected by LANs for which one of them is the CIST Designated Bridge.

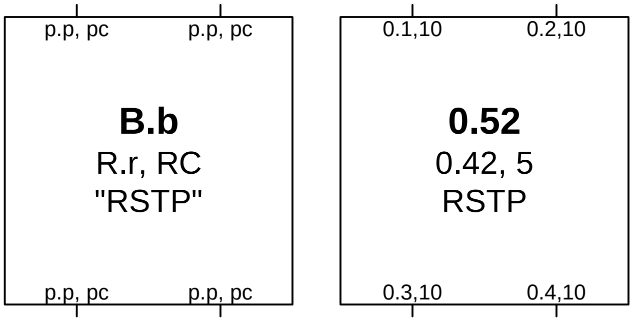
e) Bridge 0.86 is the CIST Regional Root for Region 2 because it is has the lowest External Root Path Cost through a Boundary Port.

f) LAN N is in Region 2 because its CIST Designated Bridge is in Region 2. Frames assigned to different MSTIDs may reach N from Bridge 0.86 (for example) by either Bridge 0.65 or Bridge 3.72, even though Bridges 0.94 and 0.69 with MST Configuration Identifiers that differ from those for the Bridges in Region 2 are attached to this shared LAN.

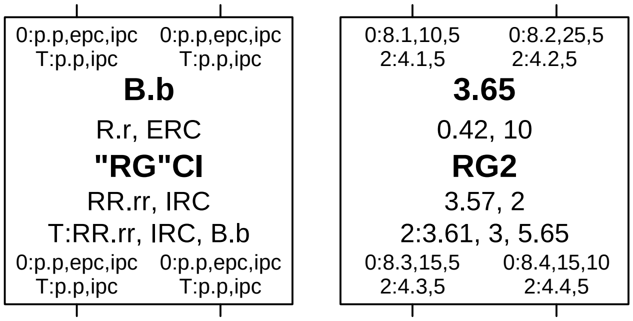
g) Bridges 0.94 and 0.69 are in different Regions, even though they have the same MST Configuration Identifier, because the LAN that connects them (N) is in a different Region.



A template for and example of an STP Bridge. **B.b** is the Bridge Identifier (including the manageable priority component **B.**). **R.r** and **RC** are the Root Identifier, Root Path Cost, and the Designated Bridge Identifier, for the Root Port. **p.p, pc** are the Port Identifier (with manageable priority **p.**) and the Port Path Cost for a Bridge Port.



A template for and example of an RSTP Bridge.



A template for and an example of an MSTP Bridge. **B.b** is the CIST Bridge Identifier. **R.r**, **ERC**, **RR.rr** are the CIST Root Identifier, External Root Path Cost, and Regional Root Identifier. **CI** identifies the Configuration Identifier for the Bridge. **RR.rr, IRC** the CIST Regional Root Identifier and the Internal Root Path Cost. **T:RR.rr, IRC, B.b**, is the Regional Root Identifier, Internal Root Path Cost IRC, and Bridge Identifier for the MSTI with MSTID **T**.

-**p.p, epc, ipc** are the CIST Port Identifier, External Port Path Cost, and Internal Port Path Cost for a Bridge Port. **T:p.p, ipc** are the Port Identifiers and their Regional Costs for MSTI **T**.

Any of the above information may be selectively omitted if deemed irrelevant for the purposes of a diagram.

A LAN

Connections between Bridges and LANs indicate the Port Role and Port State by means of their end point symbols, and in some examples, may show the transmission of BPDUs from a Port onto a LAN by means of arrowheads, as shown in the following table.

Port Role	Port State	Legend
Designated	Discarding Learning Forwarding	●┼┼—— ●┼—— ●——
& operEdge	Forwarding	●◇——
Root Port or Master Port	Discarding Learning Forwarding	○┼┼—— ○┼—— ○——
Alternate	Discarding Learning Forwarding	┼┼—— ┼—— ——
Backup	Discarding Learning Forwarding	┼┼┼—— >┼—— >——
Disabled	-	⟍——
Transmitted Bpdus		
Designated Designated Proposal Root Root Agreement		——▶ ——▶▶ ——▷ ——▷▷

NOTE—These diagrammatic conventions allow the representation of Alternate and Backup Ports that are in Learning or Forwarding states; this can happen as a transitory condition due to implementation-dependent delays in switching off Learning and/or Forwarding on a Port that changes role from Designated or Root to Alternate or Backup.

○┼——

Figure 13-1—Diagrammatic conventions

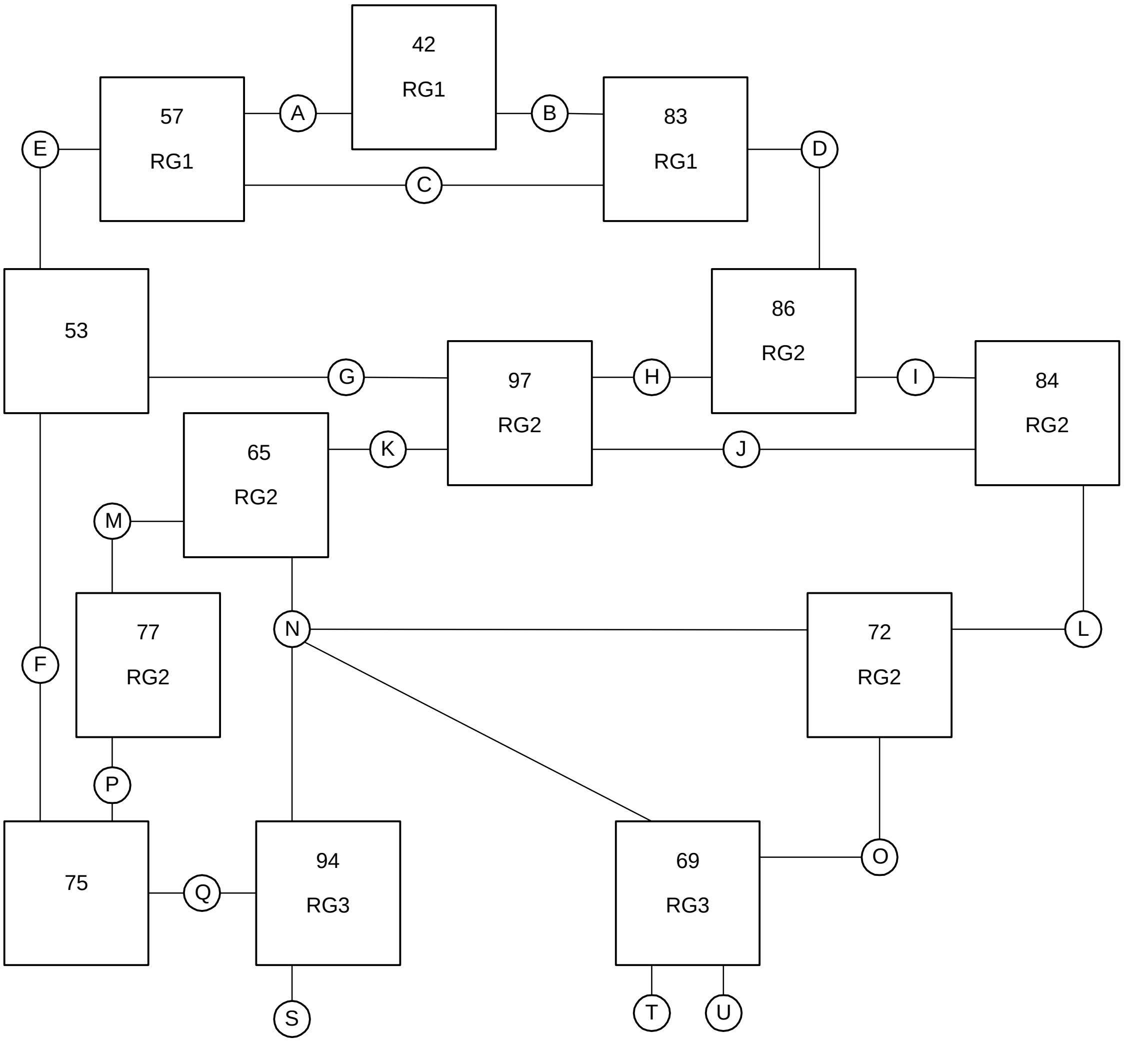


Figure 13-2—An Example Network

Figure 13-4 shows a possible active topology of MSTI 2 within Region 2.

h) Bridge 0.65 has been chosen as the MSTI Regional Root because it has the best (numerically the lowest) Bridge Identifier of all the bridges in the Region for this MSTI.
i) The connectivity between the whole of Region 2 and Region 1 is provided through a single Bridge Port, the Master Port on Bridge 0.86. This port was selected for this role because it is the CIST Root Port on the CIST Regional Root for the Region (see Figure 13-3).
j) The connectivity between the whole of Region 2 and LANs and Bridges outside the Region for the MSTI is the same as that for the CIST. This connectivity is similar to that which might result by replacing the entire Region by a single SST Bridge. The Region has a single Root Port (this port is the Master Port for each MSTI) and a number of Designated Ports.

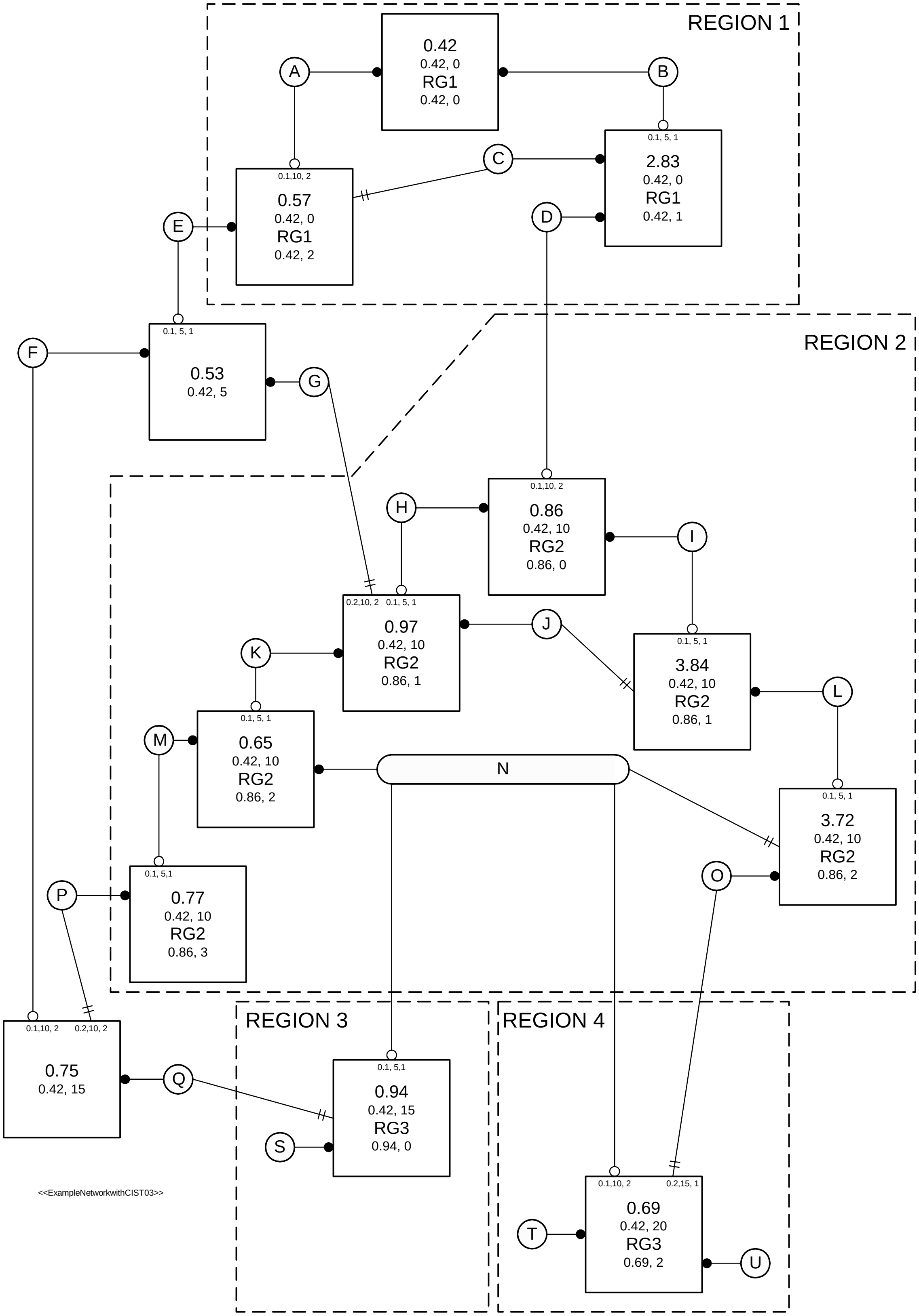


Figure 13-3—Example Network with CIST Priority Vectors, Port Roles, and MST Regions

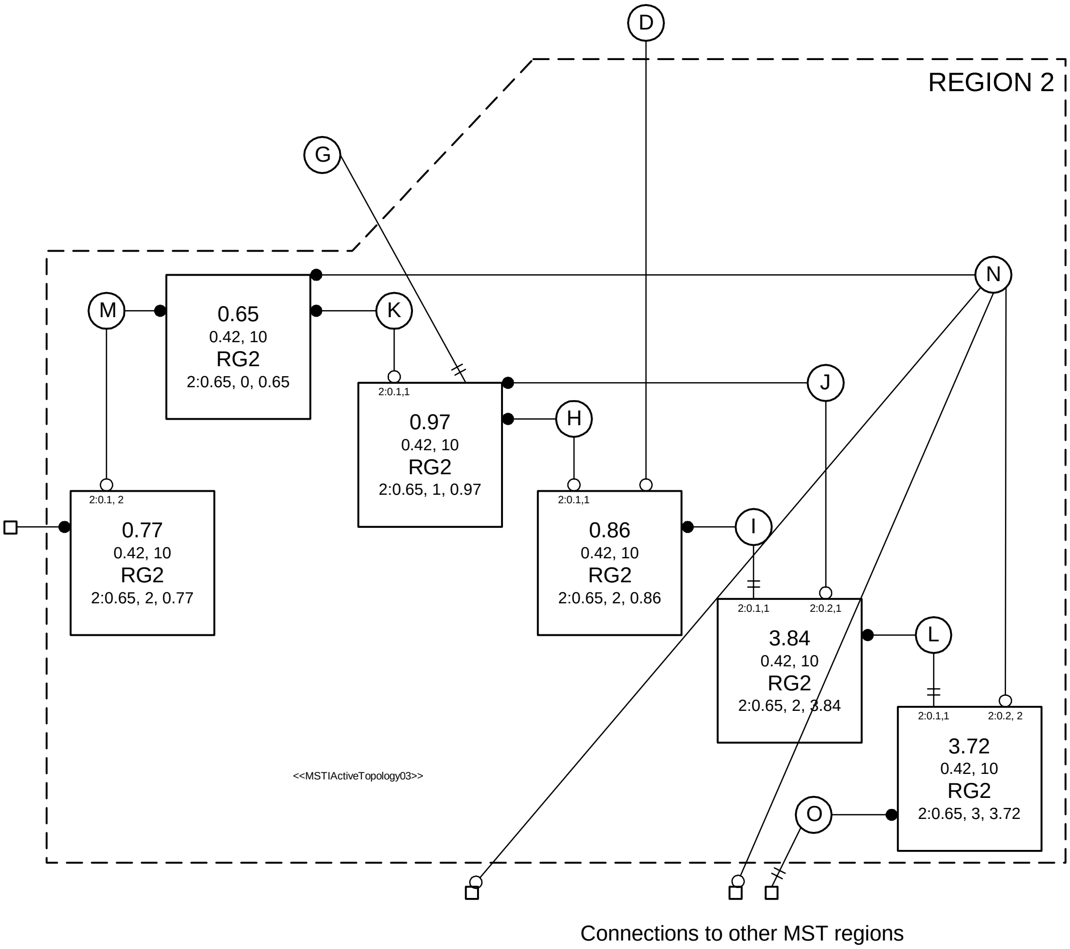


Figure 13-4—MSTI Active Topology in Region 2 of the example network

13.4 Relationship of MSTP to RSTP

The design of the Multiple Spanning Tree Protocol is based on that of the Rapid Spanning Tree Protocol (Clause 17 of IEEE Std 802.1D, 1998 Edition) extended to provide the capability for frames assigned to different VLANs to be transmitted along different paths within MST Regions.

a) The selection of the CIST Root Bridge and the computation of port roles for the CIST uses the same fundamental algorithm (17.4.1 of IEEE Std 802.1D, 1998 Edition) but extended priority vector components and calculations (13.9, 13.10) within MST Regions as compared to RSTP (17.4.2 of IEEE Std 802.1D, 1998 Edition). The effect of these extensions is to cause each region to resemble a single bridge from the point of view of the CST as calculated by STP or RSTP.
b) MST Configuration Identification is specific to MSTP.
c) The selection of the MSTI Regional Root Bridge and computation of port roles for each MSTI also uses the same fundamental spanning tree algorithm but modified priority vector components (13.11).
d) Different Bridges may be selected as the Regional Root for different MSTIs by modifying the manageable priority component of the Bridge Identifier differently for the MSTIs.
e) The port roles used by the CIST (Root, Designated, Alternate, Backup or Disabled Port) are the same as those of STP and RSTP (17.4 of IEEE Std 802.1D, 1998 Edition). The MSTIs use the additional port role Master Port. The Port States associated with each spanning tree and bridge port are the same as those of RSTP (17.5 of IEEE Std 802.1D, 1998 Edition).
f) The state variables associated with each port for each spanning tree and for the tree itself are those specified for RSTP as per bridge port and per bridge (17.13, 17.15, 17.17, 17.18 of IEEE Std 802.1D, 1998 Edition) with few exceptions, additions, and enhancements.
g) The state machine performance parameters specified for RSTP (17.6 of IEEE Std 802.1D, 1998 Edition) apply equally to the CIST. A simplified set of performance parameters apply to the MSTIs.
h) The state machine procedures of RSTP are used (17.9 of IEEE Std 802.1D, 1998 Edition) with detailed changes.

MSTP, like RSTP:

i) Cannot protect against temporary loops caused by the inter-connection of two LAN segments by devices other than Bridges (e.g., LAN repeaters) that operate invisibly with respect to support of the Bridges’ MAC Internal Sublayer Service.
j) Provides for rapid recovery of connectivity following the failure of a Bridge, Bridge Port, or a LAN. The timers used define worst case delays, only used to backup the normal operation of the protocol.
k) Provides a Force Protocol Version parameter, controlled by management and applicable to all Ports and trees supported by an MST bridge, to instruct MSTP to emulate aspects of early versions of spanning tree protocol. In particular the Force Protocol Version parameter allows rapid transitions to be disabled. This reduces the risk of an increase, as compared to STP, in the rates of frame duplication and misordering in the Bridged LAN, as discussed in F.2.4 of IEEE Std 802.1D, 1998 Edition.
l) Allows Bridge Ports to be configured such that they can transition directly to the Forwarding Port State on re-initialization of the Bridge. This may be appropriate where a specific Bridge Port is known to be connected to a LAN segment that is not connected to further Bridges. The per port operational control, operEdge, that supports this behavior applies equally to all the spanning trees of an MST Bridge.

13.5 Modelling an MST Region as a single RSTP Bridge

The specification of MSTP is such that the nominal replacement of an entire MST Region by a single RSTP Bridge leads to little change in the behavior of the remainder of the bridged local area network. This design is intended to assist those familiar with the STP and RSTP specifications to comprehend and verify MSTP, and to administer bridged local area networks using the MSTP specification.

In a network comprising STP Bridges, RSTP Bridges, and multiple MST Regions, treating the MST Regions as single Bridges provides the network administrator with a natural hierarchy. The internal management of MST Regions can be largely separated from the management of the active topology of the bridge local area network as a whole.

The portion of the active topology of the network that connects any two bridges in the same MST Region traverses only MST Bridges and LANs in that region, and never Bridges of any kind outside the region, in other words connectivity within the region is independent of external connectivity. This is because the protocol parameters that determine the active topology of the network as a whole, the Root Identifier and Root Path Cost (known in the MSTP specification as the CIST Root Identifier and CIST External Root Path Cost) are carried unchanged throughout and across the MST Region, so bridges within the region will always prefer spanning tree information that has been propagated within the region to information that has exited the region and is attempting to re-enter it.

NOTE 1—No LAN can be in more than one Region at a time, so two Bridges (0.11 and 0.22 say) that would otherwise be in the same MST Region by virtue of having the same MST Configuration and of being directly connected by a LAN, may be in distinct regions if that is a shared LAN with other Bridges attached (having a different MST Configuration) and no other connectivity between 0.11 and 0.22 and lying wholly within their Region is available. The Region that the shared LAN belongs to may be dynamically determined. No such dynamic partitioning concerns arise with single Bridges. Obviously the sharing of LANs between administrative regions militates against the partitioning of concerns, and should only be done following careful analysis.

The Port Path Cost (MSTP's External Port Path Cost) is added to the Root Path Cost just once at the Root Port of the CIST Regional Root, the closest Bridge in the Region to the Root Bridge of the entire network. The Message Age used by STP and RSTP is also only incremented at this Port. If the CIST Root is within an MST Region it also acts as the Regional Root, and the Root Path Cost and Message Age advertised are zero, just as for a single Bridge.

Within an MST Region, each MSTI operates in much the same way as an independent instance of RSTP with dedicated Regional Root Identifier, Internal Root Path Cost, and Internal Port Path Cost parameters. Moreover the overall spanning tree (the CIST) includes a fragment (the IST) within each MST Region that can be viewed as operating in the same way as an MSTI with the Regional Root as its root.

NOTE 2—Since an MST Region behaves like a single Bridge and does not partition (except in the unusual configuration involving shared LANs noted above) it has a single Root Port in the CST active topology. Partitioning a network into two or more Regions can therefore force non-optimal blocking of Bridge Ports at the boundaries rather than internal to those Regions.

13.6 STP and RSTP compatibility

MSTP is designed to be STP and RSTP compatible and interoperable without additional operational management practice.

13.6.1 Designated Port Selection

Correct operation of the spanning tree protocols requires that all Bridge Ports attached to any given LAN agree on a single CIST Designated Port after a short interval sufficient for any Bridge Port to receive a configuration message from that Designated Port.

A unique spanning tree priority (13.9) is required for each Bridge Port for STP, which has no other way of communicating port roles. Since port numbers on different bridges are not guaranteed to be unique, this necessitates the inclusion of the transmitting Bridge's Bridge Identifier in the STP BPDU. RSTP and MSTP's Port Protocol Migration state machines (13.29) ensure that all Bridges attached to any LAN with an attached STP Bridge send and receive STP BPDUs exclusively.

NOTE1 —This behavior satisfies the requirement for unique, agreed Designated Port for LANs with attached STP Bridges, but means that an MST Region cannot completely emulate a single Bridge since the transmitted Designated Bridge Identifier can differ on Bridge Ports at the Region's boundary.

MSTP transmits and receives the Regional Root Identifier and not the Designated Bridge Identifier in the BPDU fields recognized by RSTP (14.6) to allow both the MSTP and RSTP Bridges potentially connected to a single LAN to perform comparisons (13.9, 13.10) between all the spanning tree priority vectors transmitted that yield a single conclusion as to which RSTP Bridge or MST Region includes the Designated Port. MST and RST BPDUs convey the transmitting port's CIST Port Role. This is checked on receipt by RSTP when receiving messages from a Designated Bridge (17.19.8 of IEEE Std 802.1D, 1998 Edition), thus ensuring that an RSTP Bridge does not incorrectly identify one MST Bridge Port as being Designated rather than another, even while omitting the competing Bridge Ports' Designated Bridge Identifiers from comparisons.

NOTE 2—This ability of MSTP Bridges to communicate the full set of MSTP information on shared LANs to which RSTP Bridges are attached avoids the need for the Port Protocol Migration machines to detect RSTP Bridges. Two or more MSTP and one or more RSTP Bridges may be connected to a shared LAN, with full MSTP operation. This includes the possibility of different MSTI Designated Ports (see 13.3.1).

13.6.2 Force Protocol Version

A Force Protocol Version parameter, controlled by management, instructs MSTP to emulate additional aspects of the behavior of earlier versions of spanning tree protocol that are not strictly required for interoperability. The value of this parameter applies to all Ports of the Bridge.

a) ST BPDUs, rather than MST BPDUs, are transmitted if Force Protocol Version is 0. RST BPDUs omit the MST Configuration Identifier and all MSTI Information.
b) RST BPDUs, rather than MST BPDUs, are transmitted if Force Protocol Version is 2. RST BPDUs omit the MST Configuration Identifier and all MSTI Information.
c) All received BPDUs are treated as being from a different MST Region if Force Protocol Version is 0 or 2.
d) The MSTP state machines disable rapid transitions if Force Protocol Version is 0. This allow MSTP Bridges to support applications and protocols that may be sensitive to the increased rates of frame duplication and misordering that can arise under some circumstances, as discussed in IEEE Std 802.1D F.2.4
e) The MSTP state machines allow full MSTP behavior if Force Protocol Version is 3 or more.

NOTE 1—Allowing for the case of a Force Protocol Version parameter value greater than 3 can simplify management of Bridges with different protocol versions.

NOTE 2—The Force Protocol Version parameter does not support multiple spanning trees with rapid transitions disabled.

13.7 MST Configuration Identification

It is essential that all Bridges within an MST Region agree on the allocation of VIDs to specific spanning trees. If the allocation differs, frames for some VIDs may be duplicated or not delivered to some LANs at all. MST Bridges check that they are allocating VIDs to the same spanning trees as their neighboring MST Bridges in the same Region by transmitting and receiving MST Configuration Identifiers along with the spanning tree information. These MST Configuration Identifiers, while compact, are designed so that two matching identifiers have a very high probability of denoting the same configuration even in the absence of any supporting management practice for identifier allocation.

NOTE 1—Suitable management practices for the deployment of equipment and the choice of Configuration Names and Revision Levels (see below) can be used to guarantee that the MST Configuration Identifiers will differ if the VID to spanning tree allocation differs within a single administrative domain.

Each MST Configuration Identifier contains the following components:

1) A Configuration Identifier Format Selector, the value 0 encoded in a fixed field of one octet to indicate the use of the following components as specified in this Standard.
2) The Configuration Name, a variable length text string encoded within a fixed field of 32 octets, conforming to RFC 2271's definition of SnmpAdminString.
3) The Revision Level, an unsigned integer encoded within a fixed field of 2 octets.
4) The Configuration Digest, a 16 octet signature of type HMAC-MD5 (see IETF RFC 2104) created from the MST Configuration Table (3.26, 8.11). For the purposes of calculating the Configuration Digest, the MST Configuration Table is considered to contain 4096 consecutive two octet elements, where each element of the table (with the exception of the first and last) contains an MSTID value encoded as a binary number, with the first octet being most significant. The first element of the table contains the value 0, the second element the MSTID value corresponding to VID 1, the third element the MSTID value corresponding to VID 2, and so on, with the next to last element of the table containing the MSTID value corresponding to VID 4094, and the last element containing the value 0. The key used to generate the signature consists of the 16 octet string specified in Table .

Table 13-1—Configuration Digest Signature Key

Parameter	Mandatory value
Configuration Digest Signature Key	0x13AC06A62E47FD51F95D2BA243CD0346

NOTE 2—The formulation of the signature as described above does not imply that a separate VID to MSTID translation table has to be maintained by the implementation; rather that it should be possible for the implementation to derive the logical contents of such a table, and the signature value as specified above, from the other configuration information maintained by the implementation, as described in Clause 12.

The Configuration Digests of some VID to MSTID translations are shown in Table 13-2 to help verify implementations of this specification.

Table 13-2—Sample Configuration Digest Signature Keys

VID to MSTID translation	Configuration Digest
All VIDs map to the CIST, no VID mapped to any MSTI	0xAC36177F50283CD4B83821D8AB26DE62
All VIDs map to MSTID 1	0xE13A80F11ED0856ACD4EE3476941C73B
Every VID maps to the MSTID equal to (VID modulo 32) + 1	0x9D145C267DBE9FB5D893441BE3BA08CE

It is recommended that MST Bridge implementations provide an easily selectable or default configuration comprising a Configuration Name of the Bridge Address as a text string using the Hexadecimal Representation specified in IEEE Std 802-2001, a Revision Level of 0, and a Configuration Digest representing a VID to MSTID translation table containing the value 0 for every element. Such a table represents the mapping of all VLANs to the CIST. Since the Bridge Address is unique to each MST Bridge, no two MST Bridges using this default configuration will be identified as belonging to the same MST Region.

13.8 MST Regions

An MST Region comprises one or more MST Bridges with the same MST Configuration Identifiers, using the same MSTIs, interconnected by and including LANs for which one of those Bridges is the Designated Bridge for the CIST and which have no Bridges attached that cannot receive and transmit RSTP BPDUs.

13.9 Spanning Tree Priority Vectors

All Bridges, whether they use STP, RSTP, or MSTP, send information to each other, in Configuration Messages (13.14 of this standard, 17.7 of IEEE Std 802.1D, 1998 Edition) to assign Port roles that determine each Port's participation in a fully and simply connected active topology based on one or more spanning trees. The information communicated is known as a *spanning tree priority vector.* Spanning tree priority vectors provide the basis for a concise specification of each protocol's computation of the active topology, in terms of both the entire Bridged LAN and the operation of individual Bridges in support of the distributed algorithm.

CIST priority vectors comprise the following components:

a) CIST Root Identifier, the Bridge Identifier of the CIST Root;
b) CIST External Root Path Cost, the path cost between MST Regions from the transmitting Bridge to the CIST Root;
c) CIST Regional Root Identifier, the Bridge Identifier of the single bridge in a Region whose CIST Root Port is a Boundary Port, or the Bridge Identifier of the CIST Root if that is within the Region;
d) CIST Internal Root Path Cost, the path cost to the CIST Regional Root;
e) CIST Designated Bridge Identifier, the Bridge Identifier for the transmitting bridge for the CIST;
f) CIST Designated Port Identifier, the Port Identifier for the transmitting port for the CIST;
g) CIST Receiving Port Identifier (not conveyed in Configuration Messages, used as tie-breaker between otherwise equal priority vectors within a receiving Bridge).

The CIST External Root Path Cost is significant throughout the Bridged LAN. It is propagated along each path from the CIST Root, and is added to at Bridge Ports that receive the priority vector from a Bridge in a different MST Region. The External Path Cost transmitted by a Bridge thus represents costs accumulated at the Root Ports of Bridges that are either not MST Bridges or are CIST Regional Roots, and is constant within a Region. The CIST Internal Root Path Cost is only significant and explicitly defined within a Region.

NOTE 1—The path to the CIST Root from a bridge with a CIST Root Port within a region always goes to or through the CIST Regional Root.

NOTE 2—The STP and RSTP specifications refer to the CIST Root Identifier and CIST External Root Path Cost simply as the Root Bridge Identifier and Root Path Cost respectively and omit the CIST Internal Root Path Cost. MSTP encodes the CIST Regional Root Identifier in the (External Designated) Bridge Identifier BPDU field used by RSTP to convey the Designated Bridge Identifier (14.3.3), so an entire MST Region appears to an RSTP capable Bridge as a single Bridge. However, this is not possible for STP, as the latter lacks the fields necessary for MST Bridges to communicate the Designated Bridge Identifier to resolve a potential priority vector tie, and MSTP BPDUs are not sent on a LAN to which an STP Bridge is attached.

MSTI priority vectors comprise the following components:

h) MSTI Regional Root Identifier, the Bridge Identifier of the MSTI Regional Root for this particular MSTI in this MST Region;
i) MSTI Internal Root Path Cost, the path cost to the MSTI Regional Root for this particular MSTI in this MST Region;
j) MSTI Designated Bridge Identifier, the Bridge Identifier for the transmitting bridge for this MSTI;
k) MSTI Designated Port Identifier, the Port Identifier for the transmitting port for this MSTI;
l) MSTI Receiving Port Identifier (not conveyed in Configuration Messages).

The set of priority vectors for a given MSTI is only defined within an MST Region. Within each Region they are totally and uniquely ordered. A CIST Root Identifier, CIST External Root Path Cost, and CIST Regional Root Identifier tuple defines the connection of the Region to the external CST and is required to be associated with the source of the MSTI priority vector information when assessing the agreement of information for rapid transitions to forwarding, but plays no part in priority vector calculations.

As each Bridge and Bridge Port receives priority vector information from other Bridges and Ports closer to the Root, priority vector calculations and comparisons are made to decide which priority information to record, and what information to be passed on. Decisions about a given Port's role are made by comparing the priority vector components that could be transmitted with that received by the Port. For all components a lesser numerical value is better, and earlier components in the above lists are more significant. As each Bridge Port receives priority vector information from Ports closer to the Root, additions are made to one or more priority vector components to yield a worse priority vector for potential transmission through other ports of the same Bridge.

NOTE 3—The consistent use of lower numerical values to indicate better information is deliberate as the Designated Port that is closest to the Root Bridge, i.e. has a numerically lowest path cost component, is selected from amongst potential alternatives for any given LAN (13.9). Adopting the conventions that lower numerical values indicate better information, that where possible more significant priority components are encoded earlier in the octet sequence of a BPDU (14.3), and that earlier octets in the encoding of individual components are more significant (14.2) allow concatenated octets that compose a priority vector to be compared as if they were a multiple octet encoding of a single number, without regard to the boundaries between the encoded components. To reduce the confusion that naturally arises from having the lesser of two numerical values represent the better of the two, i.e. the one to be chosen all other factors being equal, this clause uses the following consistent terminology. Relative numeric values are described as “least”, “lesser”, “equal”, and “greater”, and their comparisons as “less than”, “equal to”, or “greater than”, while relative Spanning Tree priorities are described as “best”, “better”, “the same”, “different”, and “worse” and their comparisons as “better than”, “the same as”, “different from”, and “worse than”. The operators “<” and “=” represent less than and equal to respectively. The terms “superior” and “inferior” are used for comparisons that are not simply based on priority but include the fact that a priority vector can replace an earlier vector transmitted by the same Bridge Port. All these terms are defined for priority vectors in terms of the numeric comparison of components below (13.10, 13.11).

NOTE 4—To ensure that the CIST and each MSTI's view of the boundaries of each MST region remain in synchronization at all times, each BPDU carries priority vector information for the CIST as well as for MSTIs. Associating the CIST Root Identifier, External Path Cost, and Regional Root Identifier with the priority vector information for each MSTI does not therefore raise a requirement to transmit these components separately. A single bit per MSTI vector, the Agreement flag, satisfies the requirement to indicate that the vector beginning with the MSTI Regional Root Identifier for that specific MSTI has always been associated with the single CIST Root Identifier etc. transmitted in the BPDU.

To allow the active topology to be managed for each tree through adjusting the relative priority of different Bridges and Bridge Ports for selection as the CIST Root, a CSTI or MSTI Regional Root, Designated Bridge, or Designated Port, the priority component of the Bridge's Bridge Identifier can be independently chosen for the CIST and for each MSTI. The priority component used by the CIST for its CIST Regional Root Identifier can also be chosen independently of that used for the CIST Root Identifier. Independent configuration of Port Path Cost and Port Priority values for the CIST and for each MSTI can also be used to control selection of the various roles for the CIST and for each MSTI.

13.10 CIST Priority Vector Calculations

The *port priority vector* is the priority vector held for the port when the reception of BPDUs and any pending update of information has been completed:

port priority vector = *{RootID : ExtRootPathCost :*
RRootID : IntRootPathCost :
DesignatedBridgeID : DesignatedPortID : RcvPortID}

The *message priority vector* is the priority vector conveyed in a received Configuration Message. For a Bridge with Bridge Identifier B receiving a Configuration Message on a Port P_B from a Designated Port P_D on Bridge D claiming a CIST Root Identifier of $R_{D,}$ a CIST External Root Path Cost of ERC$_D$, a CIST Regional Root Identifier of $RR_{D,}$ and a CIST Internal Root Path Cost of IRC_D:

$$\textit{message priority vector} = \{R_D : ERC_D : RR_D : IRC_D : D : P_D : P_B\}$$

If B is not in the same MST Region as D, the Internal Root Path Cost is decoded as 0, as it has no meaning to B.

NOTE—If a Configuration Message is received in an RSTP or STP BPDU, both the Regional Root Identifier and the Designated Bridge Identifier are decoded from the single BPDU field used for the Designated Bridge Parameter (the MST BPDU field in this position encodes the CIST Regional Root Identifier). An STP or RSTP Bridge is always treated by MSTP as being in an MST Region of its own, so the Internal Root Path Cost is decoded as zero, and the tests below become the familiar checks used by STP and RSTP.

The received CIST message priority vector is the same as B’s port priority vector if:

$$\begin{aligned}&(R_D == RootID)\ \&\&\ (ERC_D == ExtRootPathCost)\ \&\&\ (RR_D == RRootID)\ \&\&\\&(IRC_D == IntRootPathCost)\ \&\&\ (D == DesignatedBridgeID)\ \&\&\ (P_D == DesignatedPortID)\end{aligned}$$

and is better if:

$$\begin{aligned}&((R_D < RootID))\ ||\\&((R_D == RootID)\ \&\&\ (ERC_D\ \ < ExtRootPathCost))\ ||\\&((R_D == RootID)\ \&\&\ (ERC_D == ExtRootPathCost)\ \&\&\ (RR_D < RRootID))\ ||\\&((R_D == RootID)\ \&\&\ (ERC_D == ExtRootPathCost)\ \&\&\ (RR_D == RRootID)\\&\qquad \&\&\ (IRC_D < IntRootPathCost))\ ||\\&((R_D == RootID)\ \&\&\ (ERC_D == ExtRootPathCost)\ \&\&\ (RR_D == RRootID)\\&\qquad \&\&\ (IRC_D == IntRootPathCost)\ \&\&\ (D < DesignatedBridgeID))\ ||\\&((R_D == RootID)\ \&\&\ (ERC_D == ExtRootPathCost)\ \&\&\ (RR_D == RRootID)\\&\qquad \&\&\ (IRC_D == IntRootPathCost)\ \&\&\ (D == DesignatedBridgeID)\\&\qquad \&\&\ (P_D < DesignatedPortID))\end{aligned}$$

A received CIST message priority vector is superior to the port priority vector if, and only if, the message priority vector is better than the port priority vector, or the Designated Bridge Identifier and Designated Port Identifier components are the same in which case the message has been transmitted from the same Designated Port as a previously received superior message, i.e. if:

$$\begin{aligned}&(\{R_D\ : ERC_D : RR_D : IRC_D : D : P_D : P_B\}\\&\qquad \textit{is better than}\\&\ \{RootID : ExtRootPathCost : RRootID : IntRootPathCost :\\&\qquad DesignatedBridgeID : DesignatedPortID : RcvPortID\}\\&)||\ ((D == DesignatedBridgeID)\ \&\&\ (P_D == DesignatedPortID))\end{aligned}$$

If the message priority vector received in a Configuration Message from a Designated Port is superior it will replace the current port priority vector.

A *root path priority vector* for a Port can be calculated from a port priority vector that contains information from a message priority vector, as follows.

If the port priority vector was received from a bridge in a different MST Region (13.26.5), the External Port Path Cost EPC_{PB} is added to the External Root Path Cost component, and the Regional Root Identifier is set to the value of the Bridge Identifier for the receiving Bridge. The Internal Root Path Cost component will have been set to zero on reception.

root path priority vector = $\{R_D : ERC_D + EPC_{PB} : B : 0 : D : P_D : P_B)$

If the port priority vector was received from a bridge in the same MST Region (13.26.5), the Internal Port Path Cost IPC_{PB} is added to the Internal Root Path Cost component.

root path priority vector = $\{R_D : ERC_D : RR_D : IRC_D + IPC_{PB} : D : P_D : P_B)$

The *bridge priority vector* for a Bridge *B* is the priority vector that would, with the Designated Port Identifier set equal to the transmitting Port Identifier, be used as the message priority vector in Configuration Messages transmitted on Bridge *B's* Designated Ports if *B* was selected as the Root Bridge of the CIST.

bridge priority vector = $\{B : 0 : B : 0 : B : 0 : 0\}$

The *root priority vector* for Bridge *B* is the best priority vector of the set of priority vectors comprising the bridge priority vector plus all root path priority vectors whose Designated Bridge Identifier *D* is not equal to *B*. If the bridge priority vector is the best of this set of priority vectors, Bridge *B* has been selected as the Root of the tree.

The *designated priority vector* for a port *Q* on Bridge *B* is the root priority vector with *B's* Bridge Identifier *B* substituted for the *DesignatedBridgeID* and *Q's* Port Identifier Q_B substituted for the *DesignatedPortID* and *RcvPortID* components. If *Q* is attached to a LAN which has one or more STP Bridges attached (as determined by the Port Protocol Migration state machine), *B's* Bridge Identifier *B* is also substituted for the the *RRootID* component.

If the designated priority vector is better than the port priority vector, the Port will be the Designated Port for the attached LAN and the current port priority vector will be updated. The message priority vector in Configuration Messages transmitted by a Port always comprises the components of the port priority vector of the Port, even if the Port is a Root Port.

13.11 MST Priority Vector Calculations

The *port priority vector* is the priority vector held for the port when the reception of BPDUs and any pending update of information has been completed:

port priority vector = *{RRootID : IntRootPathCost :
DesignatedBridgeID : DesignatedPortID : RcvPortID}*

The *message priority vector* is the priority vector conveyed in a received Configuration Message. For a Bridge with Bridge Identifier *B* receiving a Configuration Message on a Regional Port P_B from a Designated Port P_D on Bridge *D* belonging to the same MST Region and claiming an Internal Root Path Cost of IRC_D:

message priority vector = $\{RR_D : IRC_D : D : P_D : P_B\}$

An MSTI message priority vector received from a Bridge that does not belong to the same MST Region is discarded.

An MSTI message priority vector received from a bridge port internal to the region is the same as the port priority vector if:

$$((RR_D == RRootID) \mathbin{\&\&} (IRC_D == IntRootPathCost) \mathbin{\&\&} (D == DesignatedBridgeID)$$
$$\mathbin{\&\&} (P_D == DesignatedPortID))$$

and is better if:

$$
\begin{aligned}
&((RR_D < RRootID)) \,||\\
&((RR_D == RRootID) \,\&\&\, (IRC_D < IntRootPathCost)) \,||\\
&((RR_D == RRootID) \,\&\&\, (IRC_D == IntRootPathCost) \,\&\&\, (D < DesignatedBridgeID)) \,||\\
&((RR_D == RRootID) \,\&\&\, (IRC_D == IntRootPathCost) \,\&\&\, (D == DesignatedBridgeID)\\
&\qquad \&\& \,(P_D < DesignatedPortID))
\end{aligned}
$$

An MSTI message priority vector is superior to the port priority vector if, and only if, the message priority vector is better than the port priority vector, or the Designated Bridge Identifier and Designated Port Identifier components are the same in which case the message has been transmitted from the same Designated Port as a previously received superior message, i.e. if:

$$
\begin{aligned}
&(\{RR_D : IRC_D : D : P_D : P_B\}\\
&\qquad \textit{is better than}\\
&\{RRootID : IntRootPathCost : DesignatedBridgeID : DesignatedPortID : RcvPortID\}\\
&) \,||\, ((D == DesignatedBridgeID) \,\&\&\, (P_D == DesignatedPortID))
\end{aligned}
$$

If the message priority vector received in a Configuration Message from a Designated Port for the MSTI is superior it will replace the current port priority vector.

NOTE 1—the agreed flag (13.24.2) for the Port and this MSTI will be cleared if the CIST Root Identifier, CIST External Root Path Cost, and CIST Regional Root Identifier) in the received BPDU are not the same as those for the CIST designated priority vector for the port following processing of the received BPDU.

A *root path priority vector* for a given MSTI can be calculated for a Port that has received a port priority vector from a bridge in the same region by adding the Internal Port Path Cost IPC_{PB} to the Internal Root Path Cost component.

$$\textit{root path priority vector} = \{RR_D : IRC_D + IPC_{PB} : D : P_D : P_B)$$

NOTE 2—Internal Port Path Costs are independently manageable for each MSTI, as are the priority components of the Bridge and Port Identifiers. This permits topology management of each MSTI independent of other MSTIs. The ability to independently manage MSTIs in this way without explicitly transmitting individual Port Path Costs is a key reason for retaining the use of a Distance Vector protocol for constructing MSTIs. A simple Link State Protocol requires transmission (or apriori sharing) of all Port Costs for all links.

The *bridge priority vector* for a Bridge *B* is the priority vector that would, with the Designated Port Identifier set equal to the transmitting Port Identifier, be used as the message priority vector in Configuration Messages transmitted on Bridge *B's* Designated Ports if *B* was selected as the Root Bridge of a given tree.

$$\textit{bridge priority vector} = \{B : 0 : B : 0\}$$

The *root priority vector* for Bridge *B* is the best priority vector of the set of priority vectors comprising the bridge priority vector plus all root path priority vectors whose Designated Bridge Identifier *D* is not equal to *B*. If the bridge priority vector is the best of this set of priority vectors, Bridge *B* has been selected as the Root of the tree.

The *designated priority vector* for a port *Q* on Bridge *B* is the root priority vector with *B's* Bridge Identifier *B* substituted for the *DesignatedBridgeID* and *Q's* Port Identifier Q_B substituted for the *DesignatedPortID* and *RcvPortID* components.

If the designated priority vector is better than the port priority vector, the Port will be the Designated Port for the attached LAN and the current port priority vector will be updated. The message priority vector in MSTP BPDUs transmitted by a Port always comprises the components of the port priority vector of the Port, even if the Port is a Root Port.

Figure 13-4 shows the priority vectors and the active topology calculated for an MSTI in a Region of the example network of Figure 13-3.

13.12 Port Role Assignments

Port Role assignments for Bridge Ports that are enabled are determined by each bridge in the Bridged Local Area Network (13.12) according to the source and relative priority of the spanning tree port priority vectors (13.9) selected for each Port following priority vector calculations (13.10, 13.11).

Each MST Bridge Port that is enabled is assigned a Port Role for each spanning tree. First one of the following roles: Root Port, Designated Port, Alternate Port, or Backup Port, is assigned for the CIST.

a) If the Bridge is not the CIST Root, the Port that is the source of the root priority vector is the CIST Root Port.
b) Each Port whose port priority vector is the designated priority vector derived from the root priority vector is a CIST Designated Port.
c) Each Port, other than the Root Port, that has a port priority vector that has been received from another Bridge is a CIST Alternate Port.
d) Each Port that has a port priority vector that has been received from another Port on this Bridge is a CIST Backup Port.

Then one of these roles, or the additional role of Master Port, is assigned for each MSTI.

e) If the Port is the CIST Root Port and the CIST port priority vector was received from a Bridge in another MST Region, the Port is the MSTI Master Port.
f) If the Bridge is not the MSTI Regional Root, the Port that is the source of the MSTI root priority vector is the MSTI Root Port.
g) Each Port whose port priority vector is the designated priority vector derived from the root priority vector is a MSTI Designated Port.
h) Each Port, other than a Master Port or Root Port, that has a port priority vector that has been received from another Bridge or has a CIST port priority vector that has been received from a Bridge in a different region, is an MSTI Alternate Port.
i) Each Port that has a port priority vector that has been received from another Port on this Bridge is an MSTI Backup Port.

If the Port is not enabled, it is assigned the Disabled Port role for the CIST and all MSTIs, to identify it as having no part in the operation of any of the spanning trees or the active topology of the network.

13.13 Stable Connectivity

This clause provides an analysis to show that MSTP meets its goal of providing full and simple connectivity for frames allocated to any given VLAN in a stable network, i.e. where the physical topology has remained constant for long enough that the spanning tree information communicated and processed by Bridges is not changing on any Bridge Port.

Each MST Region independently can allocate such frames to the IST or any given MSTI. Root Ports, Designated Ports, and Master Ports forward data frames, and Alternate, Backup, and Disabled Ports do not.

NOTE—The term Common Spanning Tree (CST) refers to the CIST connectivity between Regions, and the term Internal Spanning Tree (IST) to the CIST connectivity within each Region.

The CIST interconnects both individual LANs and Bridges, and complete MST Regions into a single spanning tree, each Region being part of the CIST as a whole. Frames with VIDs consistently allocated to the CIST within every MST Region follow an active topology determined by the minimum path costs to each Bridge and LAN provided by that single tree throughout the network, and thus enjoy full and simple connectivity.

Frames otherwise allocated follow the CIST outside and an MSTI within an MST Region. Simple and, in the absence of continual changes in physical connectivity, full connectivity of this composite active topology is ensured as follows:

a) Each Bridge or LAN is in one and only one Region.
(SST Bridges, LANs connected to STP Bridges, and LANs whose Designated Bridge is an SST Bridge, are all conveniently regarded as being in a Region of their own.)
b) Each and every frame is associated with one and only one VID.
c) Frames with any given VID are allocated either to the IST or to a given MSTI within any given Region, i.e. all frames are allocated to some tree and no frames are allocated to more than one tree.
d) The IST and each MSTI provides full and simple connectivity between all LANs and Bridges in an MST Region for frames allocated to the IST or that MSTI.

Hence full and simple connectivity is provided for all frames from any Bridge or LAN within an MST Region to any other within the Region.

Further:

e) All Bridges within an MST Region with ports connected to a given LAN reach a consistent agreement as to whether each of those ports is or is not a Boundary Port (i.e. attaches a Bridge to a LAN that is not in the same Region) prior to forwarding frames.
(MST Bridges make the determination on the basis of the CIST Designated Port for the LAN or the selection of the protocol by the Protocol Migration machines, both are necessarily complete prior to frame forwarding. SST Bridges being unaware of MST Regions behave as if each LAN is in a different Region to the Bridge.)
f) At a Boundary Port frames allocated to the CIST and all MSTIs are forwarded or not forwarded alike. This is because Port Role assignments are such that if the CIST Port Role is Root Port the MSTI Port Role will be Master Port, and if the CIST Port Role is Designated Port, Alternate Port, Backup Port, or Disabled Port, each MSTI’s Port Role will be the same.
g) The CIST provides full and simple connectivity between all LANs and Bridges in the network, including the LANs and Bridges attached to the Boundary Ports of any MST Region.

Hence full and simple connectivity is provided for all frames between Bridges and LANs outside the MST Region since those frames will be carried across the MST Region if necessary, just as if they were allocated to the CIST whichever tree they are allocated to within the Region.

Similarly full and simple connectivity is provided for all frames between a Bridge or LAN inside the Region and a Bridge or LAN outside the region since the connectivity provided from within the Region by an MSTI to that outer Bridge or LAN is the same as that provided by the CIST.

Figure 13-5 illustrates the above connectivity with the simple example of Region 1 from the example network of Figure 13-3 and Figure 13-3. Bridge 0.42 has been selected as the CIST Root and Regional Root, Bridge 0.57 as the Regional Root for MSTI 1, and Bridge 2.83 for MSTI 2 by management of the per MSTI Bridge Identifier priority component. The potential loop through the three bridges in the Region is blocked at different Bridge Ports for the CIST, and each MSTI, but the connectivity across the Region and from each LAN and Bridge in the region through the boundaries of the Region is the same in all cases.

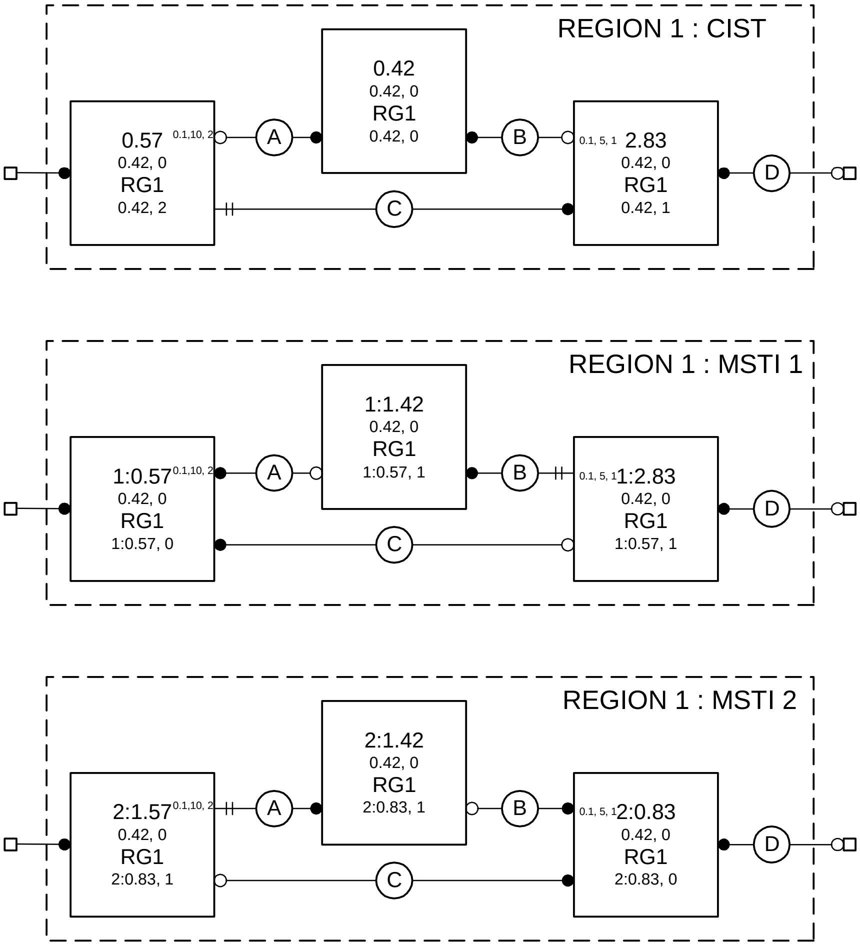


Figure 13-5—CIST and MSTI active topologies in Region 1 of the example network

13.14 Communicating Spanning Tree Information

Bridges transmit and receive MAC frames, each containing a Bridge Protocol Data Unit (BPDU) (Clauses 9 and 14 of IEEE Std 802.1D, 1998 Edition), to communicate Spanning Tree messages. A MAC frame conveying a BPDU carries the Bridge Group Address in the destination address field and is received by all the Bridges connected to the LAN on which the frame is transmitted. The Bridge Group Address is one of a small number of addresses that identify frames that are not directly forwarded by Bridges (7.12.6), but the information contained in the BPDU can be used by a Bridge in calculating its own BPDUs to transmit, and can stimulate that transmission.

BPDUs are used to convey three types of Spanning Tree message:

a) Configuration Messages;
b) Topology Change Notification (TCN) Messages;
c) MST Configuration Identifiers.

A Configuration Message for the CIST can be encoded and transmitted in an STP Configuration BPDU (9.3.1), an RST BPDU (9.3.3), or an MST BPDU (14). A TCN Message for the CIST can be encoded in an STP Topology Change Notification BPDU (9.3.2), an RST BPDU with the TC flag set, or an MST BPDU. Configuration and TCN Messages for the CIST and for all MSTIs in an MST Region are encoded in a single MST BPDU, as is the MST Configuration Identifier. No more than 64 MSTI Configuration Messages may be encoded in an MST BPDU, and no more than 64 MSTIs may be supported by an MST Bridge.

Configuration and Topology Change Notification BPDUs are distinguished from each other and from RST and MST BPDUs by their BPDU Type (Clause 9 of IEEE Std 802.1D, 1998 Edition). RST and MST BPDUs share the same BPDU Type and are distinguished by their version identifiers. Bridges implementing STP (Clause 8 of IEEE Std 802.1D, 1998 Edition) transmit and decode Configuration and Topology Change Notification BPDUs, and ignore RST and MST BPDUs on receipt. This ensures that connection of a Bridge Port of such a Bridge to a LAN that is also attached to by a Bridge implementing RSTP or MSTP is detected, as transmission of RSTP or MSTP BPDUs does not suppress regular transmissions by the STP Bridge. This functionality is provided by the Port Protocol Migration state machine for RSTP (17.26 of IEEE Std 802.1D, 1998 Edition) and MSTP (17.26). The Port Protocol Migration state machines selects the BPDU types used to encode Spanning Tree messages so that all Bridges attached to the same LAN participate in a spanning tree protocol, while maximizing the available functionality. If one or more attached Bridges only implement STP, only Configuration and Topology Change Notification BPDUs will be used and the functionality provided by the protocol will be constrained.

Each Configuration Message contains, among other parameters, a message priority vector (13.4.2, 13.4.3). This allows a receiving Bridge to determine the Port Role (13.4.4) including that of Designated Port. Configuration Messages are transmitted if the information to be transmitted by a Designated Port changes, or if a Root Port has an Agreement to convey. In addition Designated Ports transmit Configuration Messages at regular intervals to guard against loss and to assist in the detection of failed components (LANs, Bridges, or Bridge Ports). In both cases, message transmission is subject to a maximum transmission rate (see Transmission Limit in 13.28.2).

13.15 Changing Spanning Tree Information

Addition, removal, failure, or management of the parameters of Bridges and LAN connectivity can change spanning tree information and require Port Role changes in all or part of the network (for the CIST) or all or part of an MST Region (for an MSTI). Received information for a spanning tree is considered superior to, and will replace, that recorded in the receiving Port’s port priority vector if its message priority vector is better, or if it was transmitted by the same Designated Bridge and Designated Port and the message priority vector, timer, or hop count information differ from those recorded.

The new information will be propagated rapidly from Bridge to Bridge, superseding prior information and stimulating further transmissions until it reaches either Designated Ports that have already received the new information through redundant paths in the network or the leaves of the Spanning Tree, as defined by the new configuration. Configuration Message transmissions will then once more occur at regular intervals from Ports selected as Designated Ports.

To ensure that old information does not endlessly circulate through redundant paths in the network, preventing the effective propagation of the new information, MSTP associates a hop count with the information for each spanning tree. The hop count is assigned by the CIST Regional Root or the MSTI Regional Root and decremented by each receiving Port. Received information is discarded and the Port made a Designated Port if the hop count reaches zero.

If a Bridge Port’s MAC_Operational parameter becomes FALSE, the Port becomes a Disabled Port and received spanning tree information is immediately discarded. Spanning tree information for the tree can be recomputed, the Bridge’s Port Roles changed, and new spanning tree information transmitted if necessary.

Not all component failure conditions can be detected in this way, so each Designated Port transmits spanning tree information at regular intervals and a receiving Port will discard information and become a Designated Port if two transmissions are missed.

The Spanning Tree Protocol (STP, Clause 8 of IEEE Std 802.1D, 1998 Edition) and the Rapid Spanning Tree Protocol (RSTP, Clause 17 of IEEE Std 802.1D, 1998 Edition) do not use a hop count and detect both circulating aged information and loss of connectivity to a neighboring bridge by means of Message Age and Max Age (maximum message age) parameters. To ensure compatibility MSTP increments Message Age for information received at the boundary of an MST Region, discarding the information if necessary.

NOTE 1—MSTP's use of a separate hop count and message loss detection timer provides superior reconfiguration performance compared to STP and RSTP's use of Message Age and Max Age. Detection of loss of connectivity to a neighboring Bridge is not compromised by the need to allow for the overall diameter of the network, nor does the time allowed extend the number of hops permitted to aged recirculating information. Management calculation of the necessary parameters for custom topologies is also facilitated, as no allowance needs to be made for relative timer jitter and accuracy in different Bridges.

NOTE 2—The hop count applies to the spanning tree information for each tree. Message loss detection applies to all information transmitted by a given Bridge. The separate hop count can be more compactly encoded than the Message Age and Max Age timer values, and thus provides some per tree encoding efficiency in MST BPDUs.

13.16 Changing Port States

The Port State for each Bridge Port and spanning tree (CIST and MSTIs) is controlled by state machines whose goal is to maximize connectivity without introducing temporary data loops in the network. Root Ports, Master Ports, and Designated Ports are transitioned to the Forwarding Port State, and Alternate Ports and Backup Ports to the Discarding Port State, as rapidly as possible.

Transitions to the Discarding Port State can be simply effected without the risk of data loops. This clause describes the analysis used to determine the conditions for transitioning the Port State for a given spanning tree to Forwarding.

Starting with the assumption that any connected fragment of a network is composed of Bridges, Bridge Ports, and connected LANs that form a subtree of a spanning tree, this clause derives the conditions for transitioning ports with Root Port, Master Port, or Designated Port roles, such that the newly enlarged fragment continues to form either a subtree or the whole of the spanning tree. Since these conditions are applied every time a fragment is enlarged it is possible to trace the growth of a fragment from a single Bridge, which is clearly a consistent, if small, subtree of a spanning tree, to any sized fragment—thus justifying the initial assumption.

The requirement for consistent Port States in two subtrees, each bounded by Ports that either are not forwarding or are attached to LANs not attached to any other Bridge Port, can be met by waiting sufficient time for the priority vector information used to assign the Port Roles to reach all Bridges in the network. This ensures that these fragments of the potential active topology are not and are not about to be joined by other Forwarding Ports. However it can be shown that a newly selected Root Port can forward frames just as soon as prior recent root ports on the same bridge cease to do so, without further communication from other bridges. Rapid transitions of Designated Ports and Master Ports do require an explicit signal from the bridges and bridge ports in the connected subtrees. The Agreement mechanism is described, together with a Proposal mechanism that forces satisfaction of the conditions if they have not already been met by blocking Designated Ports connecting lower subtrees that are not yet in agreement. The same agreement mechanism is then used to transition the newly blocked ports back to forwarding, advancing the temporary cut in the active topology towards the edge of the network.

13.16.1 Subtree connectivity and priority vectors

Any given Bridge *B*, the LANs connected through its Forwarding Designated Ports, the further Bridges connected to those LANs through their Root Ports, the LANs connected to their Forwarding Designated Ports, and so on recursively, comprise a subtree S_B. Any LAN *L* that is part of S_B will be connected to B through a Forwarding Designated Port P_{CL} on a Bridge *C* also in S_B. *L* cannot be directly connected to any Port P_B on Bridge B unless B and C are one and the same, since the message priority vector for P_B is better than that of any Port of any other Bridge in $\mathrm{S_B}$, and prior to Forwarding P_{CL} will have advertised its spanning port priority vector for long enough for it to receive any better message priority vector (within the design probabilities of protocol failure due to repeated BPDU loss) or will have engaged in an explicit confirmed exchange (see below) with all other Bridge Ports attached to that LAN.

13.16.2 Root Port transition to Forwarding

It follows from the above that *B*'s Root Port can be transitioned to Forwarding immediately whether it is attached to a LAN in S_B or in the rest of the network, provided that all prior recent Root Ports on *B* (that might be similarly arbitrarily attached) have been transitioned to Discarding and the Root Port was not a Backup Port recently (*B* and *C* the same above).

13.16.3 Designated Port transition to Forwarding

On any given Bridge *A*, the Designated Port P_{AM} connected to a LAN *M* can be transitioned to Forwarding immediately provided that the message priority advertised by the Designated Port P_{CL} on any LAN *L* in any subtree S_{M1}, S_{M2},etc. connected to *M* is worse than that advertised by P_{AM}, that any bridge *D* attached to *L* has agreed that P_{CL} is the Designated Port, and only the Root Port and Designated Ports on *D* are Forwarding. A sufficient condition for P_{AM} to transition to Forwarding is that *M* is a point-to-point link attached to the Root Port P_{BM} of a Bridge *B*, that the port priority of P_{BM} is same as or worse than that of P_{AM}, and any port P_{BN} on B is Discarding or similarly attached to a Bridge *C*. P_{BM} signals this condition to P_{AM} by setting the Agreement flag in a Configuration Message carrying P_{BM}'s port priority and Port Role.

Figure 13-6 illustrates the generation of an Agreement at a Bridge's Root Port from an Agreement received or a Port State of Discarding at each of its Designated Ports, and a Port State of Discarding at each of its Alternate and Backup Ports. To solicit an Agreement each Designated Port that has been set to discard frames sends a Proposal. A Bridge receiving a Proposal transitions any Designated Port not already synchronized to Discarding, and solicits an Agreement by sending a Proposal in its turn.

NOTE 1—Agreements can be generated without prior receipt of a Proposal as soon as the conditions for the Agreement have been met. In that case subsequent receipt of a Proposal serves to elicit a further Agreement.

NOTE 2—If all Designated Ports have already been synchronized and the spanning priority vector received with the proposal does not convey worse information the synchronization is maintained and there is no need to transition Designated Ports to Discarding once more, or to transmit further Proposals.

13.16.4 Master Port transition to Forwarding

While the connectivity of the CIST from the CIST Regional Root through the Region to the rest of the CIST comprises a subtree rooted in the CIST Regional Root, the connectivity of the MSTI from the Master Port includes both a subtree below the CIST Regional Root and a subtree rooted in the MSTI Regional Root and connected to the CIST Regional Root by an MSTI Root Port. Figure 13-7 illustrates this connectivity for both part of the CIST and an MSTI through a Region in the example network of Figure 13-3. (In the example this latter subtree provides connectivity from the Master Port through LAN N to the subtree of the CIST outside the Region). Prior to the Master Port's transition to Forwarding it is possible that either MSTI subtree is providing connectivity to a prior Master Port. Before the Master Port can transition the connectivity of both subtrees has to agree with the new CIST Regional Root.

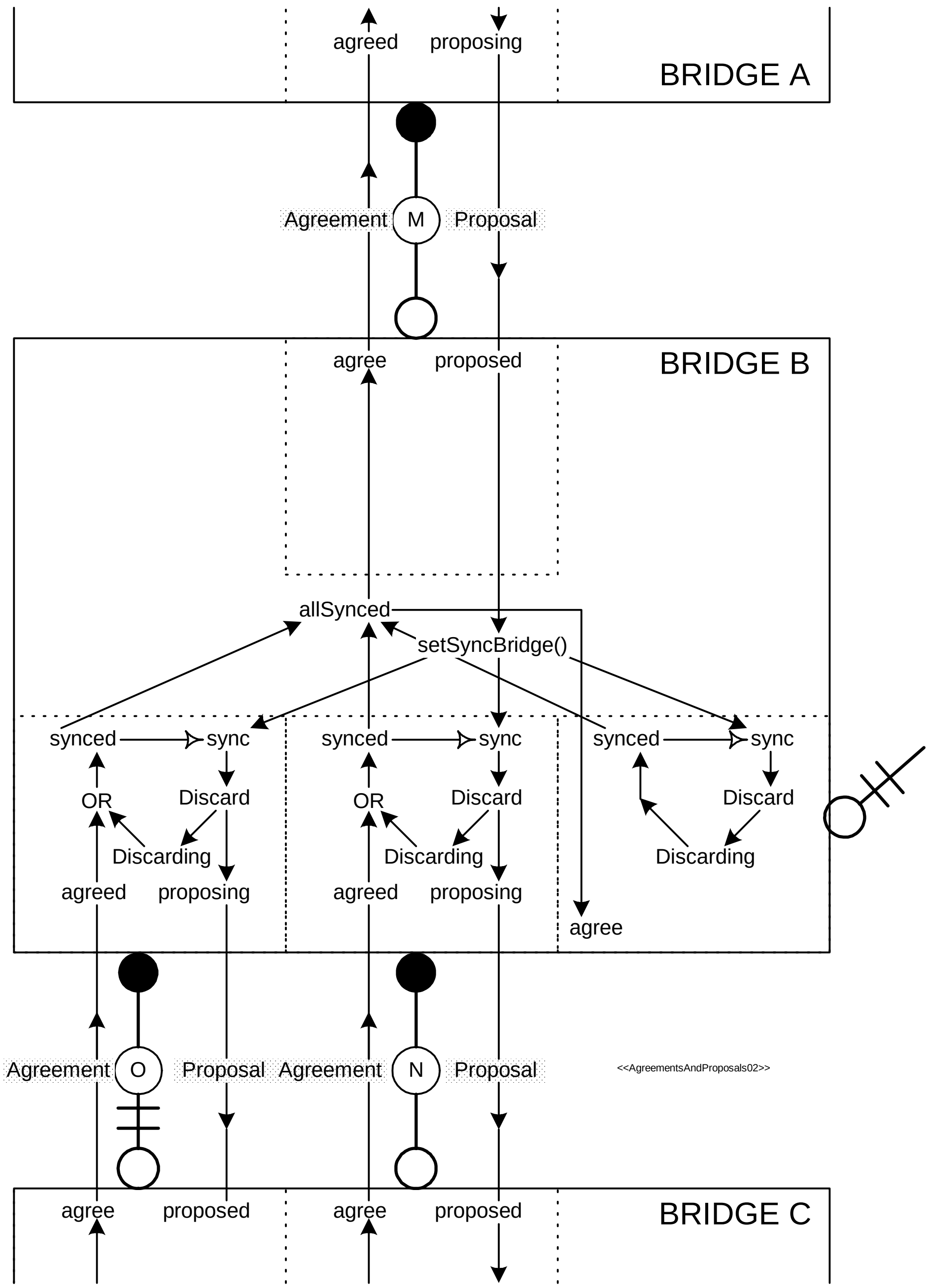
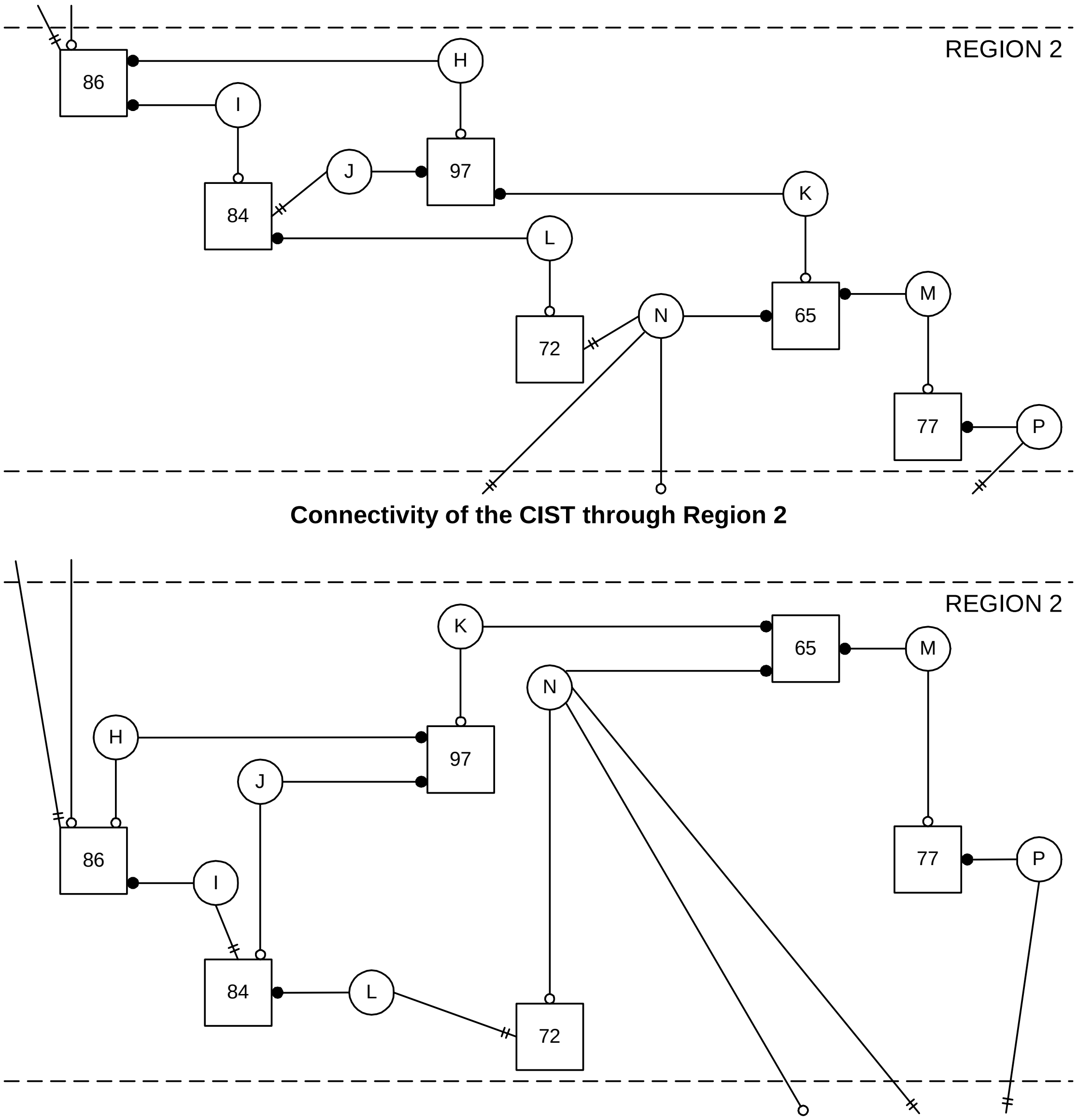


Figure 13-6—Agreements and Proposals

NOTE 1—The physical layout shown in the two halves of Figure 13-7 differs in order to reflect the different priorities and logical topologies for the two spanning tree instances. The layout convention used is that designated Ports are shown as horizontal lines, root Ports as vertical lines, and alternate Ports as diagonal lines.



Connectivity of the CIST through Region 2

Connectivity of an MSTI through Region 2

Figure 13-7—CSTI and MSTI Active Topologies in a Region

Figure 13-8 illustrates the extension of the Agreement mechanism to signal from Designated Ports to Root Ports as well as vice versa. To ensure that an MSTI does not connect alternate Master Ports, an Agreement is only recognized at an MSTI Port when the CIST Regional Root associated with the information matches that selected by the receiving port. Proposals, eliciting Agreements, necessarily flow from Designated Ports to Root Ports with the propagation of spanning tree information so a new CIST Regional Root cannot transmit a Proposal directly on its MSTI Root Ports. However updating of a CIST Designated Port's port priority vector with a new Regional Root Identifier forces the port to discard frames for all MSTIs, thus initiating the Proposal from the first Bridge nearer the MSTI Regional Root that learns of the new Regional Root.

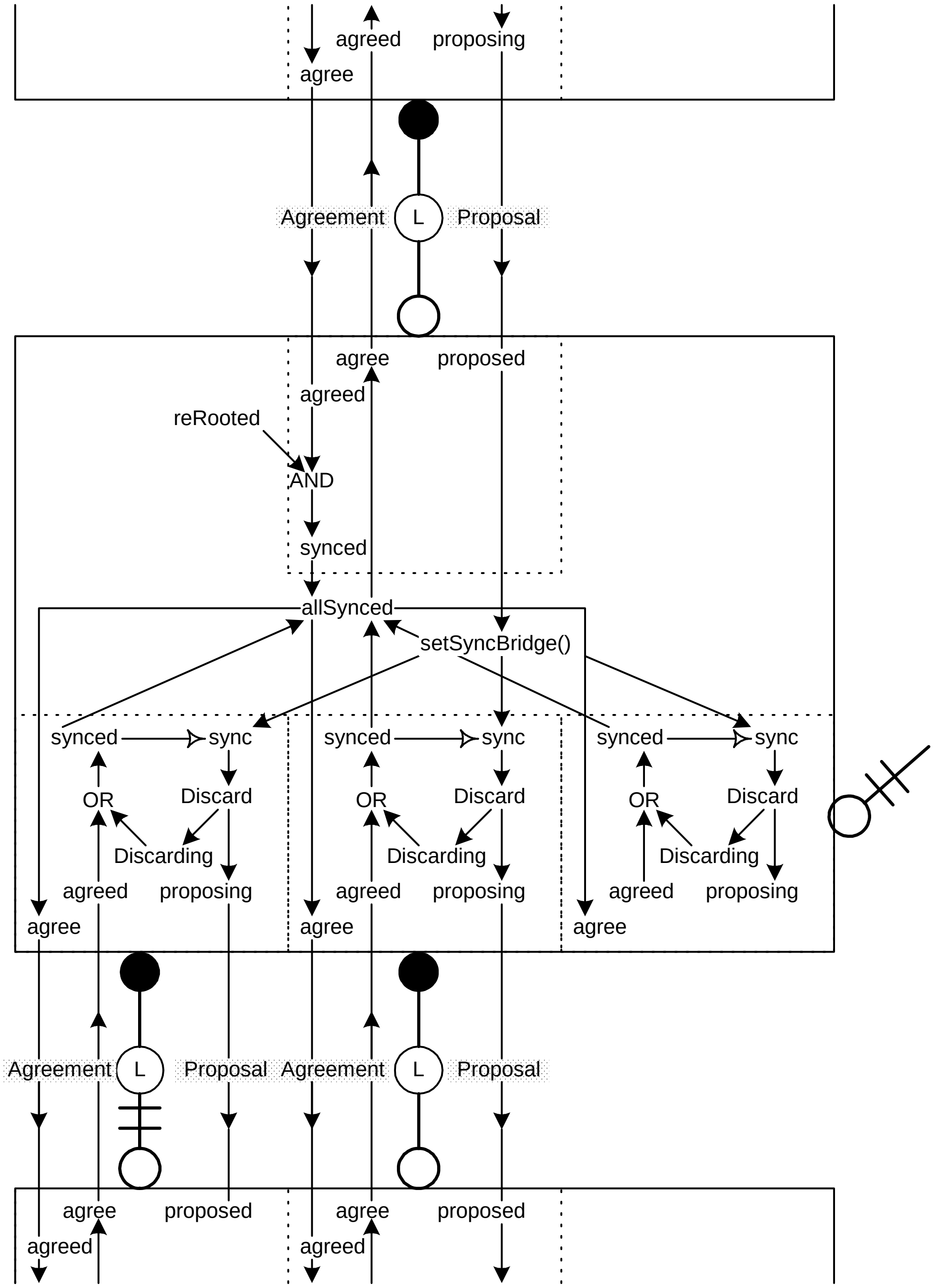


Figure 13-8—Enhanced Agreements

When an Agreement, A_{MR}, is sent by a Root Port P_{MR} on a Regional Root M it attests that the CIST Root Identifier and External Root Path Cost components of the message priority advertised on all LANs connected to the CIST by P_{MR} through M are the same as or worse than those accompanying A_{MR}. The connectivity provided by each MSTI can be independent of that provided by the CIST within the MST Region, and can therefore connect P_{MR} and one or more CIST Root Ports external to but attached at the boundary of the region even as CIST connectivity within the region is interrupted in order to satisfy the conditions for generating $\mathrm{A_{MR}}$. The Agreement cannot therefore be generated unless all MSTI subtrees as well as the CIST subtree internal to the Region are in Agreement. To ensure that an MSTI does not connect to a CIST subtree external to the Region that does not meet the constraints on the CST priority vector components, an Agreement received at an MSTI Designated Port from a Bridge Port not internal to the Region is only recognized if the CIST Root Identifier and External Root Path Cost of the CIST root priority vector selected by the transmitting Bridge Port are equal to or worse than those selected by the receiver. Updating of a CIST Designated Port's port priority vector with a worse CIST Root Identifier and External Root Path Cost forces the port to discard frames for all MSTIs, thus initiating a Proposal that will elicit agreement.

NOTE 2—MSTI Designated Ports are forced to discard frames, as required above, through the following state machine mechanisms. The CIST Port Information machine sets the 'sync' variable for all MSTIs on a transition into the UPDATE state if updating the port priority with the designated priority changes the Regional Root Identifier or replaces the CIST Root Identifier or External Path Cost with a worse tuple.The Port Role Transition machine acts on the 'sync', instructing the port to discard frames, and setting 'synced' and cancelling 'sync' when the port is discarding or an agreement is received.

NOTE 3—A 'cut' in an MSTI can be transferred to the CST, either at a Designated Port attached to the same LAN as an STP Bridge, or at the Root Port of a Bridge in an adjacent Region. However if the CST priority components have already been 'synced', as they mostly likely will have if the original cut was caused by changes in physical topology within the Region, the cut will terminate there. Otherwise the transferred cut precedes a cut in the CIST, and the synced port may terminate the latter. In that way cuts in the CST will proceed through an MST Region by the quickest tree that will carry them.

NOTE 4—In the important topology where the CIST Root Bridge is chosen to be within an MST Region, cuts are not transferred from the CIST to any MSTI in that Region. Thus the propagation of cuts in the CIST will not disrupt MSTI connectivity in the Region.

NOTE 5—Topology change detection by MSTI state machines is based on changes from Root, Master, and Designated Port Roles to Alternate, Backup, Disabled Port Roles, not on changes in Port State. Propagating 'cuts' designed to prevent temporary loops through a Region does not therefore require unnecessary changes to Filtering Databases with attendant temporary flooding of frames.

13.17 Updating Learned Station Location Information

A spanning tree reconfiguration can cause end stations to appear to move from the point of view of any given Bridge, even if that Bridge's Port States do not change, and is signaled from the Bridge whose Port Roles have changed to others using TCN messages. MST BPDUs encode separate TCN messages for the CIST and each MSTI, and MSTP supports the optimizations specified for RSTP (Clause 17.10 of IEEE Std 802.1D, 1998 Edition). Together these facilitate removal of entries for the minimum set of Ports from the Filtering Databases associated with the spanning trees whose active topology has changed. In addition MSTP only detects topology changes following a change of Port Role to Root Port, Master Port, or Designated Port. Temporary cuts in the active topology, introduced to ensure that rapid Port State transitions to Forwarding do not cause loops, and do not therefore cause Filtering Database entries to be flushed throughout the network, unless they are accompanied by Port Role changes.

Changes in the active topology of any MSTI do not change end station locations for the CIST or any other MSTI, unless the underlying changes in the physical topology that gave rise to the reconfiguration also cause those trees to reconfigure. Changes to the CST, i.e. the connectivity provided by the CIST between MST Regions, can cause end station location changes for all trees. Changes to an IST can cause CST end station location changes, but do not affect MSTIs in that Region unless those trees also reconfigure.

NOTE 1—The shorthand terms "end station locations for a given tree", "the CST", and "an IST", are used to mean "the apparent location of end stations as recorded by filtering databases associated with the given tree", "the connectivity provided by the CIST between and not internal to MST Regions", and "the connectivity provided by the CIST internal to a given MST Region" respectively.

On receipt of a CIST TCN Message from a Bridge Port not internal to the Region, or on a change in Port Role for a Bridge Port not internal to the Region, TCN Messages are transmitted through each of the other Ports of the receiving Bridge for each MSTI, and the Filtering Databases for those ports are flushed.

NOTE 2—TCN Messages for the CIST are always encoded in the same way, irrespective of whether they are perceived to have originated from topology changes internal to the Region or outside it. This allows RSTP Bridges whose Root Ports attach to a LAN within an MST Region to receive these TCN Messages correctly.

NOTE 3—The Port receiving a CIST TCN Message from another Bridge Port external to the Region can be a Master Port, a Designated Port attached to the same LAN as an STP Bridge, or a Designated Port attached to a LAN that is within the Region but is attached to by the Root Ports of Bridges in other Regions.

13.18 MSTP and point-to-point links

MSTP uses the adminPointToPointMAC and operPointToPointMAC parameters (6.4.3 of IEEE Std 802.1D, 1998 Edition) to allow the point-to-point status of LANs to be manipulated administratively, and the operational state to be signalled to the MSTP state machines. This use, paralleling that of RSTP (17.11 of IEEE Std 802.1D, 1998 Edition), facilitates use of the Agreement mechanism (13.16) to enable rapid Forwarding Port State transitions.

13.19 Multiple Spanning Tree State Machines

The operation of the Multiple Spanning Tree Protocol is represented by the following common set of state machines:

a) A Port Timers state machine for the Bridge (13.27)
b) A Port Protocol Migration state machine for each Port (13.29)
c) A Port Receive state machine for each Port (13.28)
d) A Port Transmit state machine for each Port (13.30)

with the following set for the CIST and each MSTI:

e) A Port Information state machine for each Port (13.31)
f) A Port Role Selection state machine for the Bridge (13.32)
g) A Port Role Transitions state machine for each Port (13.33)
h) A Port State Transition state machine for each Port (13.34)
i) A Topology Change state machine for each Port (13.35)

The operation of each state machine and its associated variable and procedural definitions is specified in detail below. Each is modeled on the corresponding state machine for RSTP as described in Clause 17 of IEEE Std 802.1D, 1998 Edition. Modifications:

1) support both the CIST and the MSTIs

2) use the extended spanning tree priority vector definition and calculations for the CIST (13.10)
3) provide communication between the CIST state machines and the MSTI state machines as required by 13.16, 13.19, and 13.17.
4) enhance the operation of the topology change state machine to avoid unnecessary removal of end station location information following port state transitions without changes in port roles.

All references to named variables or procedures in the specification of the state machines are to those corresponding to the instance of the state machine using the function unless explicit reference is made to the CIST or given MSTIs.

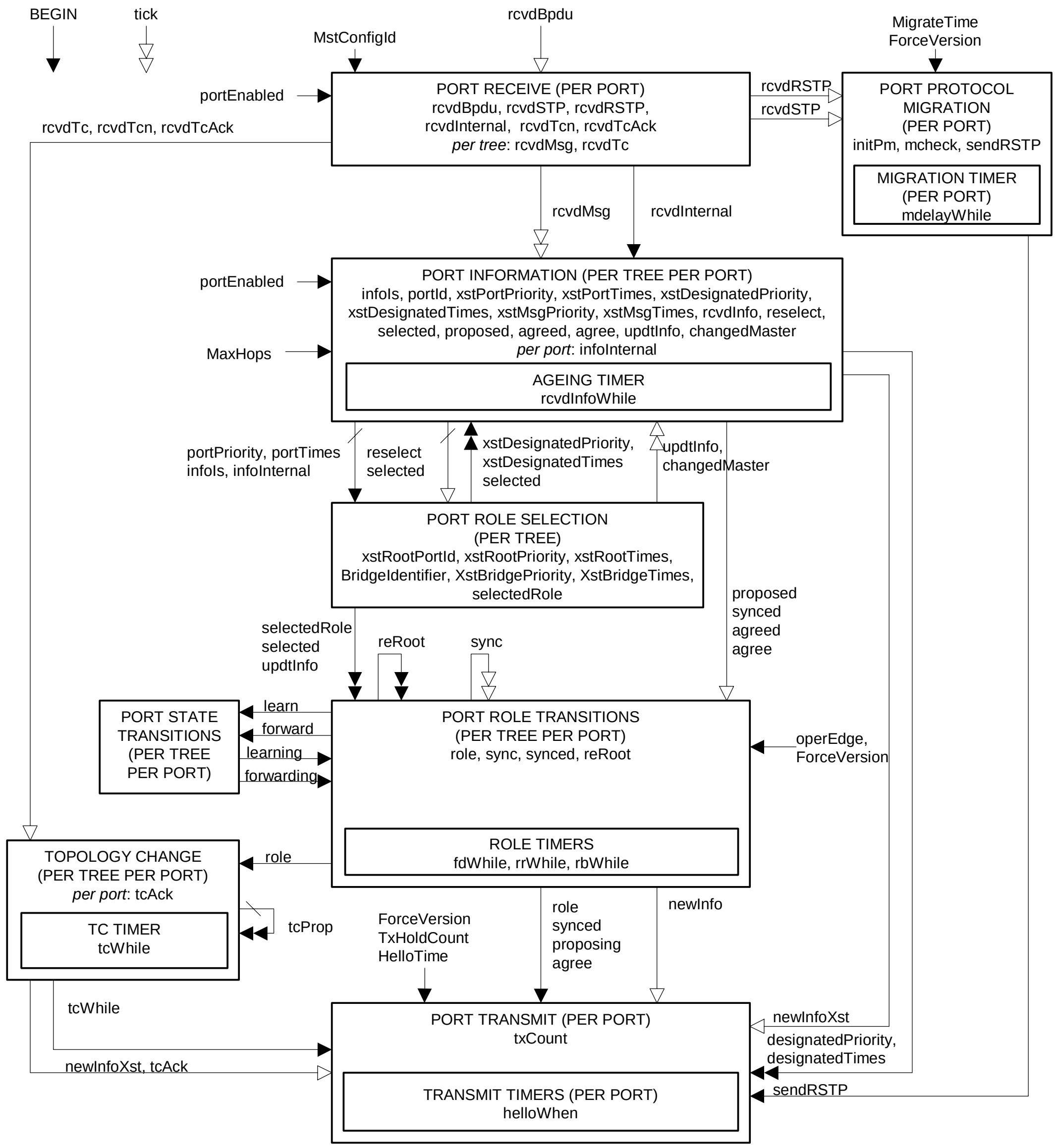
For further economy of specification, the names of CIST and MSTI conditions or procedures providing the same general functionality but differing in detail incorporate the prefix or suffix “Cist” or “Msti”. These are substituted for names beginning or ending in “Xst” in a single state machine description common to the CIST and any given MSTI.

NOTE 1—The specification of RSTP does not use a distinct Port Receive state machine, but combines the functionality into the Port Information state machine. Since separate instances of the latter are required for each tree, each operating on the messages contained in a single BPDU, it is convenient to separate out the aspects of reception that are purely per Port and per BPDU in this specification into a separate Port Receive state machine.

NOTE 2—Individual MSTIs do not implement their own Port Transmit state machine, but signal the need to transmit to a single Port Transmit State machine by setting the newInfoMsti variable. The procedures used by this machine transmit information for the CIST and all MSTIs in a single BPDU.

NOTE 3—A detailed list of the differences between the RSTP state machines specified in IEEE Std. 802.1D, 1998 Edition as amended by IEEE Std 802.1D, 1998 Edition and the state machines specified in this standard is presented in Annex G.

Figure 13-9 illustrates the state machines, their state variables and communication between state machines. This overview diagram is not itself a state machine, but serves to illustrate the principal variables that are used to communicate between the individual machines and the variables local to each machine Figure 13-10 describes its notation.



NOTE: For convenience all timers are collected together into one state machine.

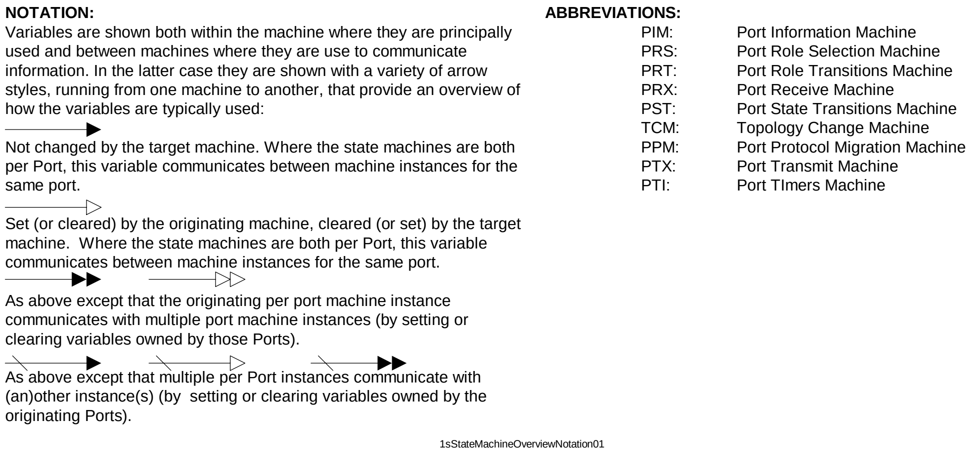
Figure 13-9—MSTP state machines—overview and relationships

13.20 Notational Conventions used in State Diagrams

The notational conventions used in the specification of MSTP are identical to those used in the specification of RSTP and defined in 17.14 of IEEE Std 802.1D, 1998 Edition.

13.21 State Machine Timers

Each of the state machine timers are as specified in 17.15 of IEEE Std 802.1D, 1998 Edition.



NOTATION:

Variables are shown both within the machine where they are principally used and between machines where they are use to communicate information. In the latter case they are shown with a variety of arrow styles, running from one machine to another, that provide an overview of how the variables are typically used:

Not changed by the target machine. Where the state machines are both per Port, this variable communicates between machine instances for the same port.

Set (or cleared) by the originating machine, cleared (or set) by the target machine. Where the state machines are both per Port, this variable communicates between machine instances for the same port.

As above except that the originating per port machine instance communicates with multiple port machine instances (by setting or clearing variables owned by those Ports).

As above except that multiple per Port instances communicate with (an)other instance(s) (by setting or clearing variables owned by the originating Ports).

ABBREVIATIONS:

PIM:	Port Information Machine
PRS:	Port Role Selection Machine
PRT:	Port Role Transitions Machine
PRX:	Port Receive Machine
PST:	Port State Transitions Machine
TCM:	Topology Change Machine
PPM:	Port Protocol Migration Machine
PTX:	Port Transmit Machine
PTI:	Port TImers Machine

Figure 13-10—MSTP overview notation

One instance of the following shall be implemented per-Port:

a) mdelayWhile
b) helloWhen

One instance per-Port of the following shall be implemented for the CIST and one per-Port for each MSTI:

c) fdWhile
d) rrWhile
e) rbWhile
f) tcWhile
g) rcvdInfoWhile

13.22 State Machine Performance Parameters

These parameters are treated as constants by the CIST and MSTI state machines; their values can be modified only by management action.

The following parameters are as specified in 17.16 of IEEE Std 802.1D, 1998 Edition for RSTP. A single value of each parameter applies to the MST Bridge as a whole, including all Ports and all CIST and MSTI state machines.

a) ForceVersion
b) FwdDelay
c) TxHoldCount
d) MigrateTime

The following parameter is as specified in 17.16 of IEEE Std 802.1D, 1998 Edition for RSTP, but may be managed separately for each Port.

e) HelloTime

The following parameter is additional to those specified for RSTP. A single value applies to all Spanning Trees within an MST Region (the CIST and all MSTIs) for which the Bridge is the Regional Root.

f) MaxHops

The following parameter is as specified for RSTP, but has been renamed for clarity in this specification. One value per-Port applies to the CIST.

g) ExternalPortPathCost (specified as PortPathCost in 17.16 of IEEE Std 802.1D, 1998 Edition)

The following parameter is additional to those specified for RSTP, and may be managed separately for the CIST and for each MSTI per-Port.

h) InternalPortPathCost

13.23 Per-Bridge Variables

Per-bridge variable(s) perform the functions described in 17.17 of IEEE Std 802.1D, 1998 Edition, but have enhanced or extended specifications or considerations.

A single instance of each of the following variables applies to the CIST and to all MSTIs.

a) BEGIN (13.23.1)
b) MstConfigId (13.23.8)

NOTE—MstConfigId is not specified in 17.17 of IEEE Std 802.1D, 1998 Edition.

There is one instance per-Bridge of each of the following for the CIST, and one for each MSTI.

c) BridgeIdentifier (13.23.2)

And one instance per-Bridge of each of the following for the CIST.

d) CistBridgePriority (13.23.3)
e) CistBridgeTimes (13.23.4)
f) cistRootPortId (13.23.5)
g) cistRootPriority (13.23.6)
h) cistRootTimes (13.23.7)

And one instance per-Bridge of each of the following for each MSTI.

i) MstiBridgePriority (13.23.9)
j) MstiBridgeTimes (13.23.10)
k) mstiRootPortId (13.23.11)
l) mstiRootPriority (13.23.12)
m) mstiRootTimes (13.23.13)

13.23.1 BEGIN

This variable is controlled by the system initialization process. A value of TRUE causes all CIST and MSTI state machines, including per Port state machines, to transit to their initial state. A value of FALSE allows all state machines to perform transitions out of their initial state, in accordance with the relevant state machine definitions.

Changes to any of the following parameters cause BEGIN to be asserted for the state machines for the Bridge, for all trees, and for each Port:

a) The MST Configuration Identifier.

13.23.2 BridgeIdentifier

The unique Bridge Identifier assigned to this Bridge for this tree (CIST or MSTI).

The 12-bit system ID extension component of a Bridge Identifier (9.2.5 of IEEE Std 802.1D, 1998 Edition) shall be set to zero for the CIST, and to the value of the MSTID for an MSTI, thus allocating distinct Bridge Identifiers to the CIST and each MSTI all based on the use of a single Bridge Address component value for the MST Bridge as a whole.

NOTE—This convention is used to convey the MSTID for each MSTI Configuration Message encoded in an MST BPDU.

The four most significant bits of the Bridge Identifier (the settable Priority component) for the CIST and for each MSTI can be modified independently of the setting of those bits for all other trees, as a part of allowing full and independent configuration control to be exerted over each Spanning Tree instance.

13.23.3 CistBridgePriority

The value of the CIST bridge priority vector, as defined in 13.10. The CIST Root Identifier, CIST Regional Root Identifier, and Designated Bridge Identifier components are all equal to the value of the CIST Bridge Identifier. The remaining components (External Root Path Cost, Internal Root Path Cost, Designated Port Identifier) are set to zero.

CistBridgePriority is used by updtCistRolesBridge() in determining the value of the cistRootPriority variable (see 13.23.6).

13.23.4 CistBridgeTimes

CistBridgeTimes comprises:

a) The current values of Bridge Forward Delay and Bridge Max Age (see Table 17-5 of IEEE Std 802.1D, 1998 Edition). These parameter values are determined only by management;
b) A Message Age value of zero.
c) The current value of MaxHops (13.22).

CistBridgeTimes is used by updtCistRolesBridge() in determining the value of the cistRootTimes variable (13.23.7).

13.23.5 cistRootPortId

The Port Identifier of the Root Port, and a component of the CIST root priority vector (13.10).

13.23.6 cistRootPriority

The CIST Root Identifier, CIST External Root Path Cost, CIST Regional Root Identifier, CIST Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the Bridge's CIST root priority vector (13.10).

13.23.7 cistRootTimes

The Bridge's timer parameter values (Message Age, Max Age, Forward Delay, and remainingHops). The values of these timers are derived from the values stored in cistPortTimes (17.18.8 of IEEE Std 802.1D, 1998 Edition) for the Root Port. Max Age and Forward Delay are set equal to the values held by the Root Port. If the CIST root priority vector was received from a Bridge in a different MST Region (infoInternal

FALSE) Message Age is the value held by the Root Port incremented by the greater of (1/16 Max Age) and 1, rounded to the nearest whole second (see 17.19.21 of IEEE Std 802.1D, 1998 Edition), and remainingHops is set equal to MaxHops. Otherwise, if the CIST root priority vector was received from a Bridge in the same MST Region or the Bridge is itself the CIST Root (rcvdInternal TRUE), Message Age is the value held by the Root Port (in cistRootTimes) and remainingHops is the value held by the Root Port minus one.

13.23.8 MstConfigId

The value of the MST Configuration Identifier (13.7) corresponding to the Bridge’s current MST Region Configuration.

13.23.9 MstiBridgePriority

The value of the MSTI bridge priority vector for a given MSTI (13.11). The MSTI Regional Root Identifier and Designated Bridge Identifier components are equal to the value of the MSTI Bridge Identifier (13.23.2). The remaining components (MSTI Internal Root Path Cost, Designated Port Identifier) are set to zero.

MstiBridgePriority is used by updtMstiRolesBridge() in determining the value of the mstiRootPriority variable (see 13.23.12).

13.23.10 MstiBridgeTimes

MstiBridgeTimes for a given MSTI is composed of a single component:

a) The current value of Bridge Max Hops (13.22). This parameter value is determined only by management.

MstiBridgeTimes is used by updtMstiRolesBridge() in determining the value of the mstiRootTimes variable (see 13.23.13).

13.23.11 mstiRootPortId

The Port Identifier of the Root Port for a given MSTI, and a component of the root priority vector (13.11).

13.23.12 mstiRootPriority

The MSTI Regional Root Identifier, MSTI Internal Root Path Cost, MSTI Designated Bridge Identifier, and MSTI Designated Port Identifier components of the Bridge’s root priority vector (13.11) for a given MSTI.

13.23.13 mstiRootTimes

The value of remainingHops for a given MSTI as stored in mstiPortTimes (13.24.18) for the MSTI Root Port, derived from the value received in mstiMsgTimes by subtracting one.

13.24 Per-Port Variables

The following variables perform the function specified in 17.17 of IEEE Std 802.1D, 1998 Edition. A single per-Port instance applies to the CIST and to all MSTIs.

a) tick
b) txCount
c) operEdge
d) portEnabled

A single per-Port instance of the following variable(s) not specified in IEEE Std 802.1D, 1998 Edition applies to the CIST and or all MSTIs.

e) infoInternal (13.24.10)
f) newInfoCist (13.24.19)
g) newInfoMsti (13.24.20)
h) rcvdInternal (13.24.22)

The following variables perform the function specified in 17.17 of IEEE Std 802.1D, 1998 Edition. A single per-Port instance is used by all state machines.

i) initPm
j) rcvdBpdu
k) rcvdRSTP
l) rcvdSTP
m) rcvdTcAck
n) rcvdTcn
o) sendRSTP
p) tcAck

The following variables are as specified in 17.17 of IEEE Std 802.1D, 1998 Edition. There is one instance per-Port of each variable for the CIST, and one per-Port for each MSTI.

q) forward
r) forwarding
s) infoIs
t) learn
u) learning
v) proposed
w) proposing
x) rcvdTc
y) reRoot
z) reselect
aa) selected
ab) tcProp
ac) updtInfo

The following variables perform the functions described in 17.17 of IEEE Std 802.1D, 1998 Edition, but have enhanced or extended specifications or considerations. There is one instance per-Port of each variable for the CIST, and one per-Port for each MSTI.

ad) agreed (13.24.2)
ae) portId (13.24.21)
af) rcvdInfo (13.24.23) replaces the functionality of the variable previously named rcvdMsg;
ag) role (13.24.25)
ah) selectedRole (13.24.26)
ai) sync (13.24.27)
aj) synced (13.24.28)

The following variables perform the related functions described in 17.17 of IEEE Std 802.1D, 1998 Edition, but have extended specifications. There is one instance per-Port of each variable for the CIST.

ak) cistDesignatedPriority(13.24.4)
al) cistDesignatedTimes (13.24.5)

am) cistMsgPriority (13.24.6)
an) cistMsgTimes (13.24.7)
ao) cistPortPriority (13.24.8)
ap) cistPortTimes (13.24.9)

The following variables perform the related functions described in 17.17 of IEEE Std 802.1D, 1998 Edition, but have enhanced or extended specifications. There is one instance per-Port of each variable for each MSTI.

aq) mstiDesignatedPriority(13.24.11)
ar) mstiDesignatedTimes (13.24.12)
as) mstiMsgPriority (13.24.15)
at) mstiMsgTimes (13.24.16)
au) mstiPortPriority (13.24.17)
av) mstiPortTimes (13.24.18)

The following variable(s) are additional to those specified in 17.17 of IEEE Std 802.1D, 1998 Edition. There is one instance per-Port of each variable for the CIST, and one per-Port for each MSTI.

aw) agree (13.24.1)
ax) changedMaster (13.24.3)
ay) rcvdMsg (13.24.24) provides functionality distinct from the previous rcvdMsg variable, now renamed rcvdInfo (13.24.23)

The following variable(s) specified in 17.17 of IEEE Std 802.1D, 1998 Edition are not required or have been replaced by other variables in this specification.

az) newInfo (replaced by newInfoCist and newInfoMsti)
ba) tc (not required)

13.24.1 agree

This variable is used by the Port Transmit state machine to set the value of the Agreement flag in transmitted Configuration Messages for the given tree.

13.24.2 agreed

A Boolean value indicating that a Configuration Message has been received from another Bridge attached to the same LAN indicating Agreement that all the Port States for the given tree of all other Bridges attached to the same LAN as this Port are known to be likewise compatible with a loop free active topology determined by this Bridge’s priority vectors and, in the absence of further communication with this Bridge, will remain compatible within the design probabilities of protocol failure due to repeated BPDU loss (13.16,13.19).

13.24.3 changedMaster

Set, for all Ports for all MSTIs, by the CIST Port Role Selection state machine using the updtRoleCist() procedure if the root priority vector selected has a different Regional Root Identifier than that previously selected, and has or had a non-zero CIST External Path Cost. changedMaster is always FALSE for the CIST.

NOTE—Changes in Regional Root Identifier will not cause loops if the Regional Root is within an MST Region, as is the case if and only if the MST Region is the Root of the CST. This important optimization allows the MSTIs to be fully independent of each other in the case where they compose the core of a network.

13.24.4 cistDesignatedPriority

The CIST Root Identifier, External Root Path Cost, Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the Port's CIST designated priority vector, as defined in 13.10.

13.24.5 cistDesignatedTimes

The set of timer parameter values (Message Age, Max Age, Forward Delay, and remainingHops) that are used to update Port Times when updtInfo is set. The value of designatedTimes is copied from the cistRootTimes Parameter (13.23.7) by the operation of the updtRolesCist() procedure.

13.24.6 cistMsgPriority

The CIST Root Identifier, External Root Path Cost, Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the CIST message priority vector conveyed in a received BPDU, as defined in 13.10.

13.24.7 cistMsgTimes

The timer parameter values (Message Age, Max Age, Forward Delay, Hello Time, and remainingHops) conveyed in a received BPDU. If the BPDU is an STP or RSTP without MSTP parameters, remainingHops is set to zero.

13.24.8 cistPortPriority

The CIST Root Identifier, External Root Path Cost, Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the Port's port priority vector, as defined in 13.10.

13.24.9 cistPortTimes

The Port's timer parameter values (Message Age, Max Age, Forward Delay, Hello Time, and remainingHops). These timer values are used in BPDUs transmitted from the Port.

13.24.10 infoInternal

If infoIs is Received, indicating that the port has received current information from the Designated Bridge for the attached LAN, infoInternal is set if that Designated Bridge is in the same MST Region as the receiving Bridge, and clear otherwise.

13.24.11 mstiDesignatedPriority

The Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the Port's designated priority vector, as defined in 13.11.

13.24.12 mstiDesignatedTimes

The value of remainingHops used to update mstiPortTimes when updtInfo is set. The value of mstiDesignatedTimes is copied from the mstiRootTimes Parameter (13.23.13) by the operation of the updtMstiRolesBridge() procedure.

13.24.13 mstiMaster

A Boolean variable used to determine the value of the Master flag for this MSTI and Port in transmitted MST BPDUs.

Set TRUE if the Port Role for the MSTI and Port is Root Port or Designated Port, and the Bridge has selected one of its Ports as the Master Port for this MSTI or the mstiMastered flag is set for this MSTI for any other Bridge Port with a Root Port or Designated Port Role. Set FALSE otherwise.

13.24.14 mstiMastered

A Boolean variable used to record the value of the Master flag for this MSTI and Port in MST BPDUs received from the attached LAN.

NOTE—mstiMaster and mstiMastered signal the connection of the MSTI to the CST via the Master Port throughout the MSTI. These variables and their supporting procedures do not affect the connectivity provided by this revision of this standard, but permit future enhancements to MSTP providing increased flexibility in the choice of Master Port without abandoning plug and play network migration. They are therefore omitted from the overviews of protocol operation, including Figure 13-19.

13.24.15 mstiMsgPriority

The Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the MSTI message priority vector, as defined in 13.11 and conveyed in a received BPDU for this MSTI.

13.24.16 mstiMsgTimes

The value of remainingHops received with message priority components of the mstiMsgPriority for this MSTI.

13.24.17 mstiPortPriority

The Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the Port’s MSTI port priority vector, as defined in 13.11.

13.24.18 mstiPortTimes

The value of remainingHops for this MSTI in BPDUs transmitted through the Port.

13.24.19 newInfoCist

A Boolean variable set TRUE if a BPDU conveying changed CIST information is to be transmitted. It is set FALSE by the Port Transmit state machine.

13.24.20 newInfoMsti

A Boolean variable set TRUE if a BPDU conveying changed MSTI information is to be transmitted. It is value is set FALSE by the Port Transmit state machine.

13.24.21 portId

The Port Identifier for this Port. This variable forms a component of the port priority and designated priority vectors (13.10,13.11).

The four most significant bits of the Port Identifier (the settable Priority component) for the CIST and for each MSTI can be modified independently of the setting of those bits for all other trees, as a part of allowing full and independent configuration control to be exerted over each Spanning Tree instance.

13.24.22 rcvdInternal

A Boolean variable set TRUE by the Receive Machine if the BPDU received was transmitted by a Bridge in the same MST Region as the receiving Bridge.

13.24.23 rcvdInfo

Set to the result of the rcvInfoCist procedure for the CIST and the rcvInfoMsti procedure for an MSTI. It can take the values SuperiorDesignatedInfo, RepeatedDesignatedInfo, RootInfo, or OtherInfo.

13.24.24 rcvdMsg

A Boolean variable set TRUE by the Receive Machine if the BPDU received contains a message for this tree.

13.24.25 role

The assigned Port Role. The port is either a DisabledPort, a RootPort, a DesignatedPort, an AlternatePort, a BackupPort, or a MasterPort.

NOTE—The role of MasterPort is introduced for MSTIs for a Port where the CIST Port Role is a RootPort and the spanning tree information received is from another MST Region. An MSTI Master Port forms part of the stable active topology for frames allocated to that MSTI, just as the CIST Root Port forwards frames allocated to the CIST. The Port State for each MSTI may differ for each MSTI as required to suppress temporary loops.

13.24.26 selectedRole

A newly computed role for the Port.

13.24.27 sync

A Boolean value. Set TRUE to force the Port State to be compatible with the loop free active topology determined by the priority vectors held by this Bridge (13.16,13.19) for this tree (CIST, or MSTI), by transitioning the Port State to Discarding and soliciting an Agreement if possible, if the Port is not already synchronized (13.24.28).

13.24.28 synced

A Boolean value. TRUE only if the Port State is compatible with the loop free active topology determined by the priority vectors held by this Bridge for this tree (13.16,13.19).

13.25 State Machine Conditions

The following boolean variable evaluations are defined for notational convenience in the state machines. These definitions also serve to highlight those cases where a state transition for one tree (CIST or MSTI) depends on the state of the variables of one or more other trees.

13.25.1 allSynced

TRUE if and only if synced is TRUE for all Ports for the given Tree (CIST or MSTI).

13.25.2 cist

TRUE only for CIST state machines, i.e. FALSE for MSTI state machine instances.

13.25.3 cistRootPort

TRUE if the CIST role for the given Port is RootPort.

13.25.4 cistDesignatedPort

TRUE if the CIST role for the given Port is DesignatedPort.

13.25.5 mstiRootPort

TRUE if the role for any MSTI for the given Port is RootPort.

13.25.6 mstiDesignatedPort

TRUE if the role for any MSTI for the given Port is DesignatedPort.

13.25.7 rcvdAnyMsg

rcvdAnyMsg is TRUE for a given Port if rcvdMsg is TRUE for the CIST or any MSTI for that Port.

13.25.8 rcvdCistInfo

rcvdCistInfo is TRUE for a given Port if and only if rcvdMsg is TRUE for the CIST for that Port.

13.25.9 rcvdMstiInfo

rcvdMstiInfo is TRUE for a given Port and MSTI if and only if rcvdMsg is FALSE for the CIST for that Port and rcvdMsg is TRUE for the MSTI for that Port.

13.25.10 reRooted

TRUE if the rrWhile timer is clear (zero) for all Ports for the given Tree other than the given Port.

13.25.11 updtCistInfo

updtCistInfo is TRUE for a given Port if and only if updtInfo is TRUE for the CIST for that Port.

13.25.12 updtMstiInfo

updtMstiInfo is TRUE for a given Port and MSTI if and only if updtInfo is TRUE for the MSTI for that Port or either updtInfo or selected are TRUE for the CIST for that Port.

NOTE—The dependency of rcvdMstiInfo and updtMstiInfo on CIST variables for the Port reflects the fact that MSTIs exist in a context of CST parameters. The state machines ensure that the CIST parameters from received BPDUs are processed and updated prior to processing MSTI information.

13.26 State Machine Procedures

The following procedures perform the functions specified in 17.17 of IEEE Std 802.1D, 1998 Edition for the CIST state machines.

a) txTcn()

The following procedures perform the functions specified in 17.17 of IEEE Std 802.1D, 1998 Edition for the CIST or any given MSTI instance.

b) disableForwarding()
c) disableLearning()
d) enableForwarding()
e) enableLearning()
f) flush()
g) updtBPDUVersion()

The following procedures perform the general functions described in 17.17 of IEEE Std 802.1D, 1998 Edition for both the CIST and the MSTI state machines or specifically for the CIST or a given MSTI, but have enhanced or extended specifications or considerations.

h) clearReselectTree() (13.26.4)
i) newTcWhile() (13.26.6)
j) rcvInfoCist() (13.26.7) and rcvInfoMsti() (13.26.8)
k) recordProposalCist() (13.26.13) and recordProposalMsti() (13.26.14)
l) setReRootTree(13.26.16)
m) setSelectedTree() (13.26.17)
n) setSyncTree() (13.26.18)
o) setTcFlags() (13.26.19)
p) setTcPropTree() (13.26.20)
q) txConfig() (13.26.21)
r) txMstp() (13.26.22)

NOTE 1—the equivalent procedure to txMstp() in IEEE Std 802.1D, 1998 Edition is called txRstp().

s) updtRcvdInfoWhileCist() (13.26.23) and updtRcvdInfoWhileMsti() (13.26.24)
t) updtRolesCist() (13.26.25) and updtRolesMsti() (13.26.26)
u) updtRolesDisabledTree() (13.26.27)

NOTE 2—clearReselectBridge() has been replaced by clearReselectTree(); rcvBpdu() by rcvInfoCist() and rcvInfoMsti(); recordProposed() by recordProposalCist() and recordProposalMsti(); setSelectedBridge() by setSelectedTree(); setReRootBridge() by setReRootTree(); setSyncBridge() by setSyncTree(); setTcPropBridge() by setTcPropTree(); updtRcvdInfoWhile() by updtRcvdInfoWhileCist() and updtRcvdInfoWhileMsti(); updtRolesBridge() by updtRolesCist() and updtRolesMsti(); and updtRoleDisabledBridge() by updtRolesDisabledTree().

The following procedures perform functions additional to those described in 17.17 of IEEE Std 802.1D, 1998 Edition for both the CIST and the MSTI state machines or for the CIST or a given MSTI specifically:

v) betterorsameInfoCist() (13.26.1) and betterorsameInfoMsti() (13.26.2)
w) clearAllRcvdMsgs() (13.26.3)
x) fromSameRegion() (13.26.5)
y) recordAgreementCist() (13.26.9) and recordAgreementMsti() (13.26.10)
z) recordMasteredCist() (13.26.11)
aa) recordMasteredMSTI() (13.26.12)
ab) setRcvdMsgs() (13.26.15)

All references to named variables in the specification of procedures are to instances of the variables corresponding to the instance of the state machine using the function, i.e. to the CIST or the given MSTI as appropriate. References to the forwarding and learning functions for a Port apply to all and only those Filtering Databases associated with that specific tree.

13.26.1 betterorsameInfoCist()

Returns TRUE if the received CIST priority vector is better than or the same as (13.10) the CIST port priority vector.

13.26.2 betterorsameInfoMsti()

Returns TRUE if the MSTI priority vector is better than or the same as (13.11) the MSTI port priority vector.

NOTE—This procedure is not invoked if the received BPDU carrying the MSTI information was received from another MST Region. In that event, the Receive Machine (using setRcvdMsgs()) does not set rcvdMsg for any MSTI, and the Port Information Machine's SUPERIOR_DESIGNATED state is not entered.

13.26.3 clearAllRcvdMsgs()

Clears rcvdMsg for the CIST and all MSTIs, for all Ports.

13.26.4 clearReselectTree()

Clears reselect for the tree (the CIST or a given MSTI) for all Ports of the Bridge.

13.26.5 fromSameRegion()

Returns TRUE if rcvdRSTP is TRUE, and the received BPDU conveys an MST Configuration Identifier that matches that held for the Bridge. Returns FALSE otherwise.

13.26.6 newTcWhile()

This procedure sets the value of tcWhile, if and only if it is currently zero, to twice HelloTime on point-to-point links (i.e., links where the operPointToPointMAC parameter is TRUE; see 6.4.3) where the partner bridge port is RSTP capable, and to the sum of the Max Age and Forward Delay components of rootTimes otherwise (non-RSTP capable partners or shared media). The value of HelloTime is taken from cistPortTimes (13.24.9) for this Port.

13.26.7 rcvInfoCist()

Returns SuperiorDesignatedInfo if the received CIST message conveys a message priority (cistMsgPriority—13.24.6) that is superior (13.10) to the Port's port priority vector, or any of the received timer parameter values (cistMsgTimes—13.24.7) differ from those already held for the Port (cistPortTimes—13.24.9).

Returns RepeatedDesignatedInfo if the received CIST message conveys a message priority vector and timer parameters that are the same as the Port's port priority vector or timer values.

Returns RootInfo if the received CIST message conveys a Root Port Role and a CIST message priority that is the same or worse than the CIST port priority vector.

Otherwise, returns OtherInfo.

13.26.8 rcvInfoMsti()

Returns SuperiorDesignatedInfo if the received MSTI message conveys a message priority (mstiMsgPriority—13.24.15) that is superior (13.11) to the Port's port priority vector, or any of the received timer parameter values (mstiMsgTimes—13.24.16) differ from those already held for the Port (mstiPortTimes—13.24.18).

Returns RepeatedDesignatedInfo if the received MSTI message conveys a message priority vector and timer parameters that are the same as the Port's port priority vector or timer values.

Returns RootInfo if the received MSTI message conveys a Root Port Role and a MSTI message priority that is the same or worse than the MSTI port priority vector.

Otherwise, returns OtherInfo.

13.26.9 recordAgreementCist()

If the CIST Message was a Configuration Message received on a point to point link, and the CIST message has the Agreement flag set, and conveys either:

1) a Root Port Role with message priority the same as or worse than the port priority vector, or
2) a Designated Port Role with message priority the same as or better than the port priority vector,

the CIST agreed flag is set. Otherwise the CIST agreed flag is cleared.

Additionally, if the CIST message was received from a Bridge in a different MST Region i.e. the rcvdInternal flag is clear, the agreed flags for this Port for all MSTIs are set or cleared to the same value as the CIST agreed flag. If the CIST message was received from a Bridge in the same MST Region, the MSTI agreed flags are not changed.

13.26.10 recordAgreementMsti()

If the MSTI Message was received on a point to point link and:

a) the message priority vector of the CIST Message accompanying this MSTI Message (i.e. received in the same BPDU) has the same CIST Root Identifier, CIST External Root Path Cost, and Regional Root Identifier as the CIST port priority vector, and
b) the MSTI Message has the Agreement flag set, and conveys either
    1) a Root Port Role with message priority the same as or worse than the MSTI port priority vector, or
    2) a Designated Port Role with message priority the same as or better than the port priority vector,

the MSTI agreed flag is set. Otherwise the MSTI agreed flag is cleared.

NOTE—MSTI Messages received from Bridges external to the MST Region are discarded and not processed by recordAgreeementMsti() or recordProposalMsti().

13.26.11 recordMasteredCist()

If the CIST message was received from a Bridge in a different MST Region, i.e. the rcvdInternal flag is clear, the mstiMastered variable for this Port is cleared for all MSTIs.

13.26.12 recordMasteredMsti()

If the MSTI Message was received on a point to point link and the MSTI Message has the Master flag set, set the mstiMastered variable for the MSTI. Otherwise reset the mstiMastered variable.

13.26.13 recordProposalCist()

If the CIST Message was a Configuration Message received on a point to point link and has the Proposal flag set, the CIST proposed flag is set. Otherwise the CIST proposed flag is cleared.

Additionally, if the CIST message was received from a Bridge in a different MST Region i.e. the rcvdInternal flag is clear, the proposed flags for this Port for all MSTIs are set or cleared to the same value as the CIST proposed flag. If the CIST message was received from a Bridge in the same MST Region, the MSTI proposed flags are not changed.

13.26.14 recordProposalMsti()

If the MSTI Message was received on a point to point link and has the Proposal flag set, the MSTI proposed flag is set. Otherwise the MSTI proposed flag is cleared.

13.26.15 setRcvdMsgs()

Sets rcvdMsg for the CIST, and makes the received CST or CIST message available to the CIST Port Information state machines.

Additionally and if and only if rcvdInternal is set, sets rcvdMsg for each and every MSTI for which an MSTI message is conveyed in the BPDU, and makes available each MSTI message and the common parts of the CIST message priority (the CIST Root Identifier, External Root Path Cost, and Regional Root Identifier) to the Port Information state machine for that MSTI.

13.26.16 setReRootTree()

This procedure sets reRoot TRUE for this tree (the CIST or a given MSTI) for all Ports of the Bridge.

13.26.17 setSelectedTree()

Sets selected TRUE for this tree (the CIST or a given MSTI) for all Ports of the Bridge.

13.26.18 setSyncTree()

Sets sync TRUE for this tree (the CIST or a given MSTI) for all Ports of the Bridge.

13.26.19 setTcFlags()

If the received BPDU is a TCN BPDU, sets rcvdTcn TRUE and sets rcvdTc TRUE for each and every MSTI.

Otherwise, if the received BPDU is a ConfigBPDU or RST BPDU:

a) If the Topology Change Acknowledgment flag is set in the CST message, sets rcvdTcAck TRUE.
b) If rcvdInternal is clear and the Topology Change flag is set in the CST message, sets rcvdTc for the CIST and for each and every MSTI.
c) If rcvdInternal is set, sets rcvdTc for the CIST if the Topology Change flag is set in the CST message, and sets rcvdTc for each MSTI for which the Topology Change flag is set in the corresponding MSTI message.

13.26.20 setTcPropTree()

Sets tcProp TRUE for the given tree (the CIST or an MSTI) for all Ports except the Port that invoked the procedure.

13.26.21 txConfig()

Transmits a Configuration BPDU. The first four components of the message priority vector (13.24.6) conveyed in the BPDU are set to the value of the CIST Root Identifier, External Root Path Cost, Bridge Identifier, and Port Identifier components of the cistPortPriority (13.24.8) for this Port. The topology change flag is set if (tcWhile != 0) for the Port. The topology change acknowledgement flag is set to the value of TcAck for the Port. The remaining flags are set to zero. The value of the Message Age, Max Age, Fwd Delay, and Hello Time parameters conveyed in the BPDU are set to the values held in cistPortTimes (13.24.9) for the Port.

13.26.22 txMstp()

Transmits an MST BPDU (14.3.3), encoded according to the specification contained in 14.6. The first six components of the CIST message priority vector (13.24.6) conveyed in the BPDU are set to the value of cistPortPriority (13.24.8) for this Port. The Port Role in the BPDU (14.2.1) is set to the current value of the role variable for the transmitting port (13.24.25). The Agreement and Proposal flags in the BPDU are set to the values of the agreed (13.24.2) and proposing (13.24 of this standard, 17.18.20 of IEEE Std 802.1D, 1998 Edition) variables for the transmitting Port respectively. The CIST topology change flag is set if (tcWhile != 0) for the Port. The topology change acknowledge flag in the BPDU is never used and is set to zero. The learning flag is set if the learning variable for the CIST (13.24 of this standard, 17.18.9 of IEEE Std 802.1D, 1998 Edition) is TRUE. The forwarding flag is set if the forwarding variable for the CIST (13.24 of this standard, 17.18.5 of IEEE Std 802.1D, 1998 Edition) is TRUE. The value of the Message Age, Max Age, Fwd Delay, and Hello Time parameters conveyed in the BPDU are set to the values held in cstiPortTimes (13.24.9) for the Port.

If the value of the Force Protocol Version parameter is less than 3, no further parameters are encoded in the BPDU and the protocol version parameter is set to 2 (denoting an RST BPDU). Otherwise, the protocol version parameter is set to 3 and the remaining parameters of the MST BPDU are encoded:

a) The version 3 length.
b) The MST Configuration Identifier parameter of the BPDU is set to the value of the MstConfigId variable for the Bridge (13.23.8).
c) The CIST Internal Root Path Cost (13.24.8).
d) The CIST Bridge Identifier.
e) The CIST Remaining Hops.
f) The parameters of each MSTI message, encoded in MSTID order.

NOTE—No more than 64 MSTIs may be supported. The parameter sets for all of these can be encoded in a standard sized Ethernet frame.

13.26.23 updtRcvdInfoWhileCist()

Calculates the effective age, or remainingHops, to limit the propagation and longevity of received Spanning Tree information for the CIST, setting rcvdInfoWhile to the number of seconds that the information received on a Port will be held before it is either refreshed by receipt of a further configuration message or aged out.

If the information was received from a Bridge external to the MST Region (rcvdInternal FALSE), the effective age of the port information (cistPortPriority and cistPortTimes) is taken as the value of the Message Age parameter carried in a received BPDU (cistMsgTimes), incremented by the greater of (1/16th Max Age) and 1 second, and rounded to the nearest whole second. The value of Message Age and Max Age used in this calculation are taken from the cistPortTimes variable (17.18.18) and, the value assigned to rcvdInfoWhile is the lower of:

a) Max Age minus this effective age, and
b) 3 times the Hello Time,

or

c) zero, if the effective age exceeds Max Age.

and the value of the remainingHops component of portTimes is set to MaxHops.

If the information was received from a Bridge in the same MST Region (rcvdInternal TRUE), the Message Age component of cistPortTimes is set equal to the value received (cistMsgTimes) and the remainingHops component is set equal to the value received decremented by one. The value assigned to rcvdInfoWhile is:

d) 3 times the Hello Time,

or

e) zero, if either cistPortTimes Message Age effective exceeds Max Age or remainingHops is less than or equal to zero.

The value of Hello Time used by this procedure is taken from cistPortTimes.

13.26.24 updtRcvdInfoWhileMsti()

Calculates the remainingHops, to limit the propagation and longevity of received Spanning Tree information for an MSTI, setting rcvdInfoWhile to the number of seconds that the information received on a Port will be held before it is either refreshed by receipt of a further configuration message or aged out.

mstiPortTimes remainingHops is set equal to the value received (mstiMsgTimes) decremented by one. The value assigned to rcvdInfoWhile is:

a) 3 times the Hello Time,

or

b) zero, if mstiPortTimes remainingHops is less than or equal to zero.

The value of Hello Time used by this procedure is taken from cistPortTimes.

13.26.25 updtRolesCist()

This procedure calculates the following CIST Spanning Tree priority vectors (13.9, 13.10) and timer values:

a) The *root path priority vector* for each Bridge Port that is not Disabled and has a *port priority vector* (cistPortPriority plus portId—see 13.24.8 and 13.24.21) that has been recorded from a received message and not aged out (infoIs == Received); and
b) The Bridge’s *root priority vector* (cistRootPortId, cistRootPriority—13.23.5, 13.23.6), chosen as the best of the CIST Spanning Tree priority vectors comprising the Bridge’s own *bridge priority vector* (CistBridgePriority—13.23.3) plus all the calculated root path priority vectors whose DesignatedBridgeID component is not equal to the DesignatedBridgeID component of the Bridge’s own bridge priority vector (13.10); and
c) The Bridge’s *root times*, (cistRootTimes—13.23.7), determined as follows:
   1) If the chosen root priority vector is the bridge priority vector, *root times* is equal to CistBridgeTimes (13.23.4).
   2) If the chosen root priority vector is not the bridge priority vector, *root times* is equal to the value of cistPortTimes (13.24.9) for the port associated with the chosen root priority vector.
d) The *designated priority vector* (cistDesignatedPriority—13.24.4) for each port; and
e) The *designated times* for each Port (cistDesignatedTimes—13.24.5) set equal to the value of *root times.*

The CIST port role for each Port is assigned, and its port priority vector and Spanning Tree timer information are updated as follows:

f) If the Port is Disabled (infoIs = Disabled), selectedRole is set to DisabledPort. Otherwise:
g) If the port priority vector information was aged (infoIs = Aged), updtInfo is set and selectedRole is set to DesignatedPort;
h) If the port priority vector was derived from another port on the Bridge or from the Bridge itself as the Root Bridge (infoIs = Mine), selectedRole is set to DesignatedPort. Additionally, updtInfo is set if the port priority vector differs from the designated priority vector or the Port's associated timer parameters differ from those for the Root Port;
i) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), and the root priority vector is now derived from it, selectedRole is set to RootPort and updtInfo is reset;
j) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), the root priority vector is not now derived from it, the designated priority vector is not better than the port priority vector, and the designated bridge and designated port components of the port priority vector do not reflect another port on this bridge, selectedRole is set to AlternatePort and updtInfo is reset;
k) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), the root priority vector is not now derived from it, the designated priority vector is not better than the port priority vector, and the designated bridge and designated port components of the port priority vector reflect another port on this bridge, selectedRole is set to BackupPort and updtInfo is reset.
l) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), the root priority vector is not now derived from it, the designated priority vector is better than the port priority vector, selectedRole is set to DesignatedPort and updtInfo is set.

NOTE—The port role assignment is almost identical to that in 17.19.8 of IEEE Std 802.1D, 1998 Edition, with the addition of the final bullet, erroneously omitted from that specification.

13.26.26 updtRolesMsti()

This procedure calculates the following MST Spanning Tree priority vectors (13.9, 13.11) and timer values for an MSTI:

a) The *root path priority vector* for each Bridge Port that is not Disabled and has a *port priority vector* (mstiPortPriority plus portId—see 13.24.17 and 13.24.21) that has been recorded from a received message and not aged out (infoIs == Received); and
b) The Bridge's *root priority vector* (mstiRootPortId, mstiRootPriority—13.23.11, 13.23.12), chosen as the best of the MSTI Spanning Tree priority vectors for this MSTI comprising the Bridge's own *bridge priority vector* (MstiBridgePriority—13.23.9) plus all the calculated root path priority vectors whose DesignatedBridgeID component is not equal to the DesignatedBridgeID component of the Bridge's own bridge priority vector (13.11); and
c) The Bridge's *root times*, (mstiRootTimes—13.23.13), determined as follows:
    1) If the chosen root priority vector is the bridge priority vector, *root times* is equal to MstiBridgeTimes (13.23.10).
    2) If the chosen root priority vector is not the bridge priority vector, *root times* is equal to the value of mstiPortTimes (13.24.18) for the port associated with the chosen root priority vector.
d) The *designated priority vector* (mstiDesignatedPriority—13.24.11) for each port; and
e) The *designated times* for each Port (mstiDesignatedTimes—13.24.12) set equal to the value of *root times*.

The MSTI port role for each Port is assigned, and its port priority vector and Spanning Tree timer information are updated as follows:

f) If the Port is Disabled (infoIs = Disabled), selectedRole is set to DisabledPort;

g) If the Port is not Disabled, the selected CIST Port Role (calculated prior to invoking this procedure) is RootPort, and the CIST port priority information was received from a Bridge external to the MST Region (infoIs == Received and infoInternal == FALSE), selectedRole is set to MasterPort. Additionally, updtInfo is set if the MSTI port priority vector differs from the designated priority vector or the Port's associated timer parameters differ from those for the Root Port;

h) If the Port is not Disabled, the selected CIST Port Role (calculated prior to invoking this procedure) is AlternatePort, and the CIST port priority information was received from a Bridge external to the MST Region (infoIs == Received and infoInternal == FALSE), selectedRole is set to AlternatePort. Additionally, updtInfo is set if the MSTI port priority vector differs from the designated priority vector or the Port's associated timer parameters differ from those for the Root Port.

Otherwise, if the Port is not Disabled and the CIST port priority information was not received from a Bridge external to the Region (infoIs != Received or infoInternal == TRUE):

i) If the port priority vector information was aged (infoIs = Aged), updtInfo is set and selectedRole is set to DesignatedPort;

j) If the port priority vector was derived from another port on the Bridge or from the Bridge itself as the Root Bridge (infoIs = Mine), selectedRole is set to DesignatedPort. Additionally, updtInfo is set if the port priority vector differs from the designated priority vector or the Port's associated timer parameters differ from those for the Root Port;

k) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), and the root priority vector is now derived from it, selectedRole is set to RootPort and updtInfo is reset;

l) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), the root priority vector is not now derived from it, the designated priority vector is not better than the port priority vector, and the designated bridge and designated port components of the port priority vector do not reflect another port on this bridge, selectedRole is set to AlternatePort and updtInfo is reset;

m) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), the root priority vector is not now derived from it, the designated priority vector is not better than the port priority vector, and the designated bridge and designated port components of the port priority vector reflect another port on this bridge, selectedRole is set to BackupPort and updtInfo is reset.

n) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), the root priority vector is not now derived from it, the designated priority vector is better than the port priority vector, selectedRole is set to DesignatedPort and updtInfo is set.

13.26.27 updtRolesDisabledTree()

This procedure sets selectedRole to DisabledPort for all Ports of the Bridge for a given tree (CIST or MSTI).

13.27 The Port Timers state machine

The Port Timers state machine for a given Port is responsible for decrementing the timer variables for the CIST and all MSTIs for that Port each second.

The Port Timers state machine shall implement the function specified by the state diagram contained in Figure 13-11.

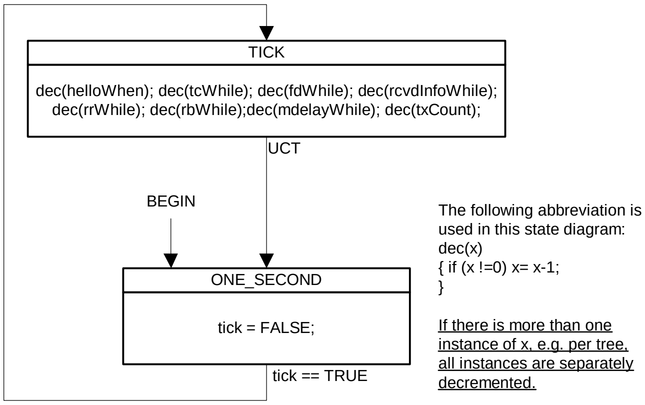

TICK
dec(helloWhen); dec(tcWhile); dec(fdWhile); dec(rcvdInfoWhile);
dec(rrWhile); dec(rbWhile);dec(mdelayWhile); dec(txCount);
UCT
BEGIN
ONE_SECOND
tick = FALSE;
tick == TRUE
The following abbreviation is used in this state diagram:
dec(x)
{ if (x !=0) x= x-1;
}
If there is more than one instance of x, e.g. per tree, all instances are separately decremented.

Figure 13-11—Port Timers state machine

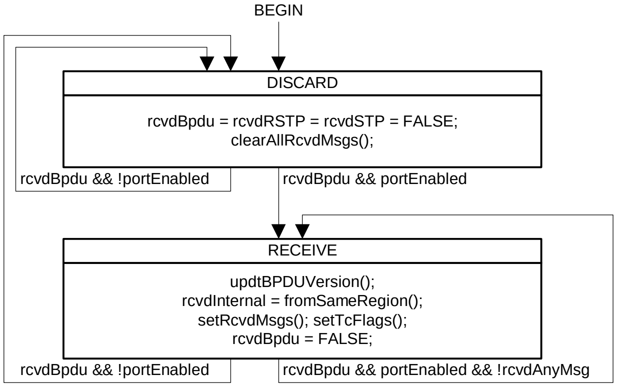


Figure 13-12—Port Receive state machine

13.28 Port Receive state machine

The Port Receive state machine shall implement the function specified by the state diagram contained in Figure 13-12 and the attendant definitions contained in 13.21 through 13.26.

This state machine is responsible for receiving BPDUs. Using the updtBPDUversion() procedure it sets either the rcvdRSTP or the rcvdSTP flag to reflect the type of the BPDU for use by the Port Protocol Migration machine. It sets the rcvdInternal flag if the transmitting Bridge and BPDU are internal to the MST Region, i.e. belong to the same MST Region as this Bridge (13.8). It sets rcvdMsg for the CIST, and additionally for each MSTI if the rcvdBPDU is internal. The next BPDU is not processed until all the rcvdMsg flags have been cleared by the per tree state machines.

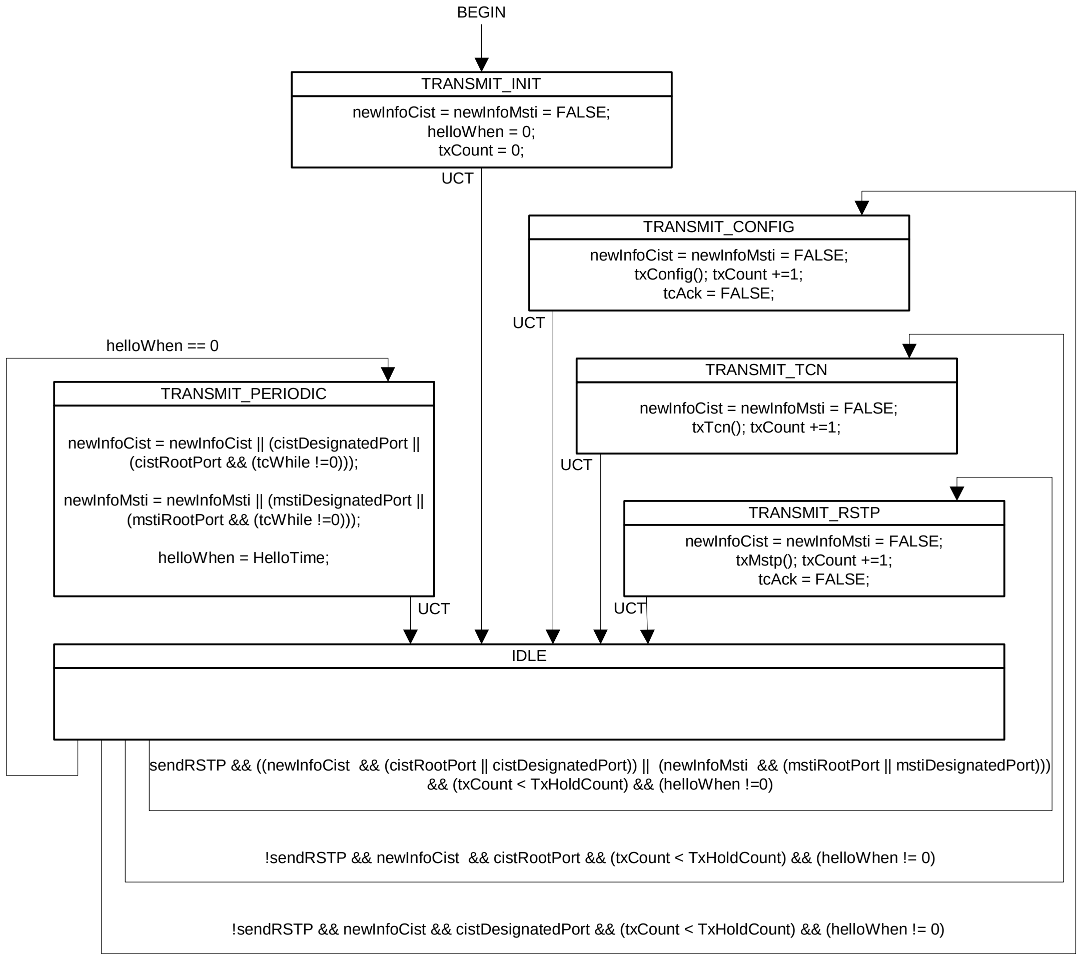
13.29 Port Protocol Migration state machine

The specification of this state machine is identical to that of the Port Protocol Migration state machine for RSTP (Clause 17 of IEEE Std 802.1D, 1998 Edition).

13.30 Port Transmit state machine

The Port Transmit state machine shall implement the function specified by the state diagram contained in Figure 13-13 and the attendant definitions contained in 13.21 through 13.26.

This state machine is responsible for transmitting BPDUs.


BEGIN
TRANSMIT_INIT
newInfoCist = newInfoMsti = FALSE;
helloWhen = 0;
txCount = 0;
UCT
TRANSMIT_CONFIG
newInfoCist = newInfoMsti = FALSE;
txConfig(); txCount +=1;
tcAck = FALSE;
UCT
helloWhen == 0
TRANSMIT_TCN
newInfoCist = newInfoMsti = FALSE;
txTcn(); txCount +=1;
TRANSMIT_PERIODIC
newInfoCist = newInfoCist || (cistDesignatedPort || (cistRootPort && (tcWhile !=0)));
newInfoMsti = newInfoMsti || (mstiDesignatedPort || (mstiRootPort && (tcWhile !=0)));
helloWhen = HelloTime;
UCT
TRANSMIT_RSTP
newInfoCist = newInfoMsti = FALSE;
txMstp(); txCount +=1;
tcAck = FALSE;
UCT
UCT
IDLE
sendRSTP && ((newInfoCist && (cistRootPort || cistDesignatedPort)) || (newInfoMsti && (mstiRootPort || mstiDesignatedPort))) && (txCount < TxHoldCount) && (helloWhen !=0)
!sendRSTP && newInfoCist && cistRootPort && (txCount < TxHoldCount) && (helloWhen != 0)
!sendRSTP && newInfoCist && cistDesignatedPort && (txCount < TxHoldCount) && (helloWhen != 0)

All transtions, except UCT, are qualified by "&& selected &&!updtInfo".

Figure 13-13—Port Transmit state machine

NOTE 1—Any single received BPDU that changes the CIST Root Identifier, CIST External Root Path Cost, or CIST Regional Root associated with MSTIs should be processed in their entirety, or not at all, before encoding BPDUs for transmission.This recommendation is made to minimize the number of BPDUs to be transmitted following receipt of a BPDU carrying new information. It is not required for correctness and has not therefore been incorporated into the state machines.

NOTE 2—If a CIST state machine sets newInfoCist, this machine will ensure that a BPDU is transmitted conveying the new CIST information. If MST BPDUs can be transmitted through the port this BPDU will also convey new MSTI information for all MSTIs. If an MSTI state machine sets newInfoMsti, and MST BPDUs can be transmitted though the port, this machine will ensure that a BPDU is transmitted conveying information for the CIST and all MSTIs. Separate newInfoCist and newInfoMsti variables are provided to avoid requiring useless transmission of a BPDU through a port that can only transmit STP BPDUs (as required by the ForceVersion parameter or Port Protocol Migration machine) following a change in MSTI information without any change to the CIST.

13.31 Port Information state machine

The Port Information state machine for each tree shall implement the function specified by the state diagram contained in Figure 13-14 and the attendant definitions contained in 13.21 through 13.26.

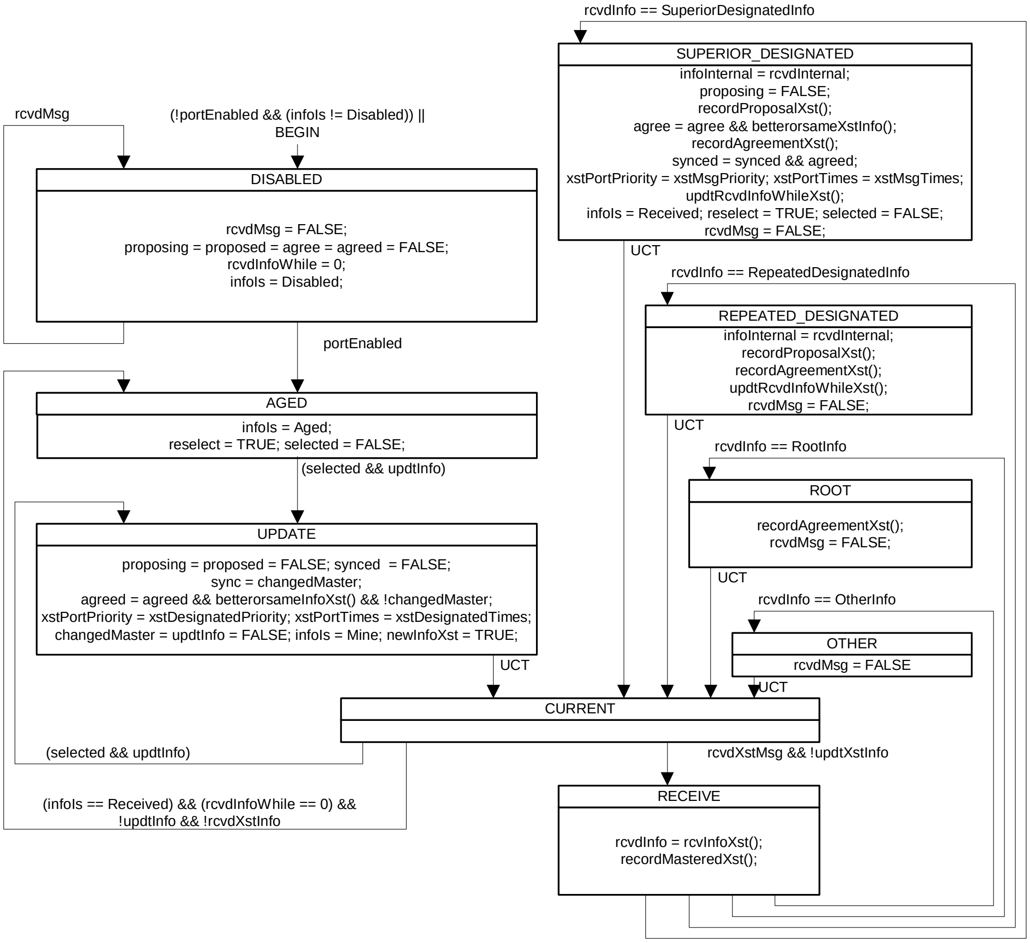

rcvdInfo == SuperiorDesignatedInfo
SUPERIOR_DESIGNATED
infoInternal = rcvdInternal;
proposing = FALSE;
recordProposalXst();
agree = agree && betterorsameXstInfo();
recordAgreementXst();
synced = synced && agreed;
xstPortPriority = xstMsgPriority; xstPortTimes = xstMsgTimes;
updtRcvdInfoWhileXst();
infoIs = Received; reselect = TRUE; selected = FALSE;
rcvdMsg = FALSE;
UCT
rcvdMsg
(!portEnabled && (infoIs != Disabled)) ||
BEGIN
DISABLED
rcvdMsg = FALSE;
proposing = proposed = agree = agreed = FALSE;
rcvdInfoWhile = 0;
infoIs = Disabled;
rcvdInfo == RepeatedDesignatedInfo
REPEATED_DESIGNATED
infoInternal = rcvdInternal;
recordProposalXst();
recordAgreementXst();
updtRcvdInfoWhileXst();
rcvdMsg = FALSE;
portEnabled
AGED
infoIs = Aged;
reselect = TRUE; selected = FALSE;
UCT
rcvdInfo == RootInfo
(selected && updtInfo)
ROOT
recordAgreementXst();
rcvdMsg = FALSE;
UPDATE
proposing = proposed = FALSE; synced = FALSE;
sync = changedMaster;
agreed = agreed && betterorsameInfoXst() && !changedMaster;
xstPortPriority = xstDesignatedPriority; xstPortTimes = xstDesignatedTimes;
changedMaster = updtInfo = FALSE; infoIs = Mine; newInfoXst = TRUE;
UCT
rcvdInfo == OtherInfo
OTHER
rcvdMsg = FALSE
UCT
UCT
CURRENT
(selected && updtInfo)
rcvdXstMsg && !updtXstInfo
RECEIVE
(infoIs == Received) && (rcvdInfoWhile == 0) &&
!updtInfo && !rcvdXstInfo
rcvdInfo = rcvInfoXst();
recordMasteredXst();

Figure 13-14—Port Information state machine

This state machine is responsible for recording the Spanning Tree information currently in use by the CIST or a given MSTI for a given Port, ageing that information out if it was derived from an incoming BPDU, and recording the origin of the information in the infoIs variable. The selected variable is cleared and reselect set to signal to the Port Role Selection machine that port roles need to be recomputed. The infoIs and portPriority variables from all ports are used in that computation and, together with portTimes, determine new values of designatedPriority and designatedTimes. The selected variable is set by the Port Role Selection machine once the computation is complete.

13.32 Port Role Selection state machine

The Port Role Selection machine for each tree shall implement the function specified by the state diagram contained in Figure 13-15 and the attendant definitions contained in 13.21 through 13.26.

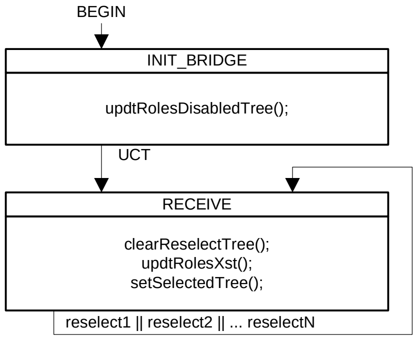


Figure 13-15—Port Role Selection

NOTE—The specification of this state machine is identical to that of the Port Role Selection state machine for RSTP (Clause 17 of IEEE Std 802.1D, 1998 Edition) but makes use of revised procedures as detailed in Clause 13.26 of this specification. These procedures have also been renamed relative to IEEE Std 802.1D, 1998 Edition; updtRoleDisabledBridge to updtRoleDisabledTree, clearReselectBridge to clearReselectTree, updtRolesBridge to updtRolesCist and updtRolesMsti, and setSelectedBridge to setSelectedTree.

13.33 Port Role Transitions state machine

The Port Role Transitions state machine shall implement the function specified by the state diagram contained in Figure 13-16 and Figure 13-17 and the attendant definitions contained in 13.21 through 13.26.

As Figure 13-16 and Figure 13-17 are component parts of the same state machine, the global transitions associated with both diagrams are possible exit transitions from the states shown in either of the diagrams. Figure 13-16 shows the Port Roles for Ports that do not form part of the active topology of the given Tree.

Figure 13-17 shows the Port Roles that form part of the active topology.

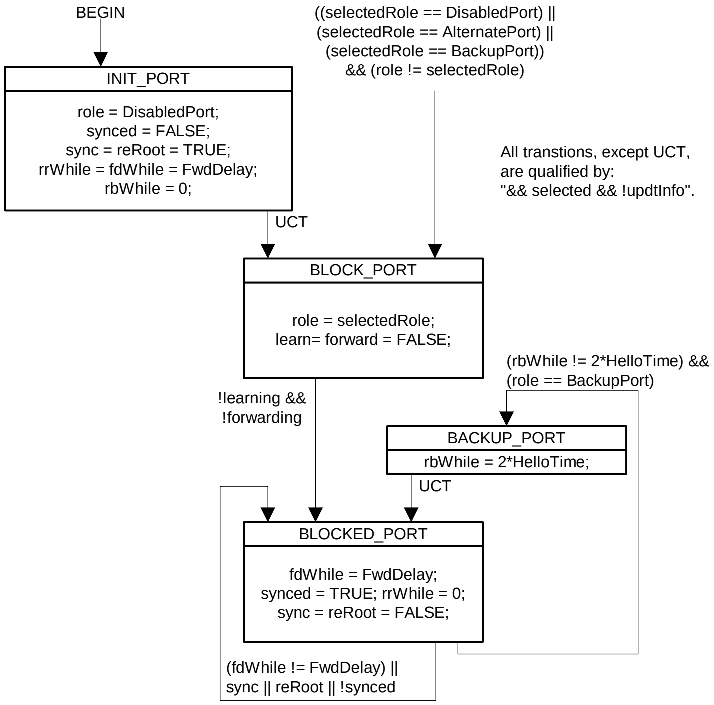
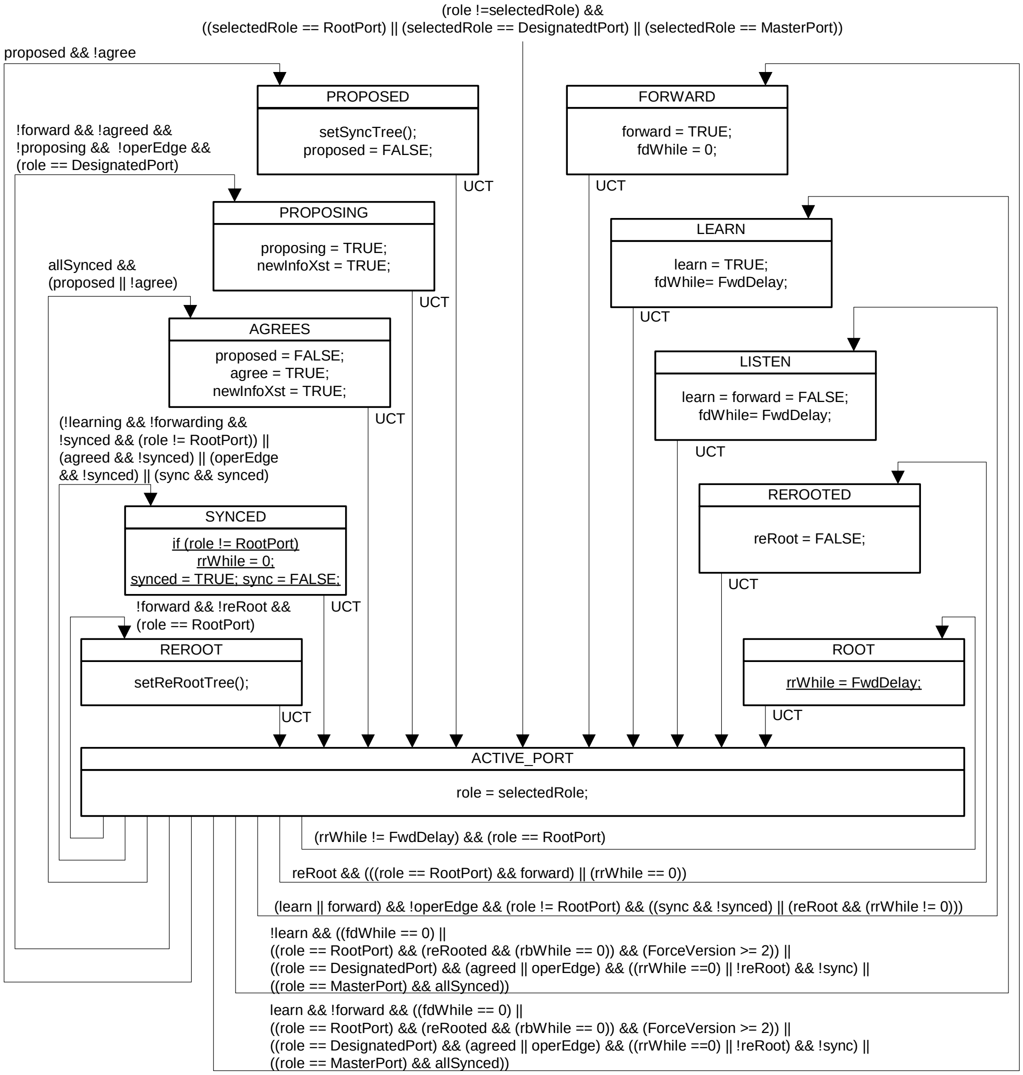


Figure 13-16—Port Role Transitions state machine— Part 1: Disabled, Alternate, and Backup Roles

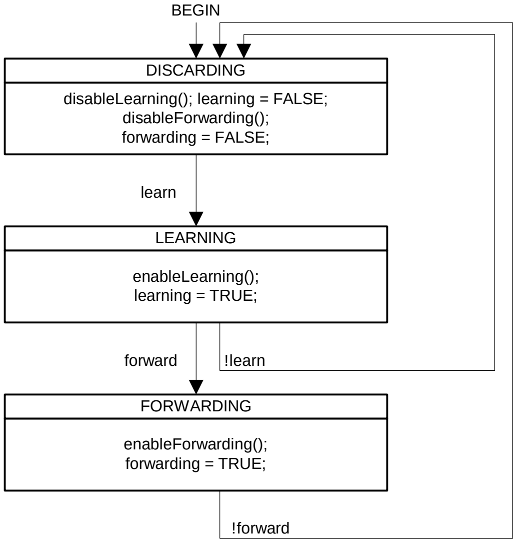

(role !=selectedRole) &&
((selectedRole == RootPort) || (selectedRole == DesignatedtPort) || (selectedRole == MasterPort))
proposed && !agree
PROPOSED
setSyncTree();
proposed = FALSE;
FORWARD
forward = TRUE;
fdWhile = 0;
!forward && !agreed &&
!proposing && !operEdge &&
(role == DesignatedPort)
UCT
UCT
PROPOSING
proposing = TRUE;
newInfoXst = TRUE;
LEARN
learn = TRUE;
fdWhile= FwdDelay;
allSynced &&
(proposed || !agree)
UCT
UCT
AGREES
proposed = FALSE;
agree = TRUE;
newInfoXst = TRUE;
LISTEN
learn = forward = FALSE;
fdWhile= FwdDelay;
(!learning && !forwarding &&
!synced && (role != RootPort)) ||
(agreed && !synced) || (operEdge
&& !synced) || (sync && synced)
UCT
UCT
REROOTED
reRoot = FALSE;
SYNCED
if (role != RootPort)
rrWhile = 0;
synced = TRUE; sync = FALSE;
UCT
!forward && !reRoot &&
(role == RootPort)
UCT
REROOT
setReRootTree();
ROOT
rrWhile = FwdDelay;
UCT
UCT
ACTIVE_PORT
role = selectedRole;
(rrWhile != FwdDelay) && (role == RootPort)
reRoot && (((role == RootPort) && forward) || (rrWhile == 0))
(learn || forward) && !operEdge && (role != RootPort) && ((sync && !synced) || (reRoot && (rrWhile != 0)))
!learn && ((fdWhile == 0) ||
((role == RootPort) && (reRooted && (rbWhile == 0)) && (ForceVersion >= 2)) ||
((role == DesignatedPort) && (agreed || operEdge) && ((rrWhile ==0) || !reRoot) && !sync) ||
((role == MasterPort) && allSynced))
learn && !forward && ((fdWhile == 0) ||
((role == RootPort) && (reRooted && (rbWhile == 0)) && (ForceVersion >= 2)) ||
((role == DesignatedPort) && (agreed || operEdge) && ((rrWhile ==0) || !reRoot) && !sync) ||
((role == MasterPort) && allSynced))

All transtions, except UCT, are qualified by "&& selected && !updtInfo".

**Figure 13-17—Port Role Transitions state machine—
Part 2: Root, Designated, and Master Roles**

13.34 Port State Transition state machine

The Port State Transition state machine for each tree shall implement the function specified by the state diagram contained in Figure 13-18 and the attendant definitions contained in 13.21 through 13.26 above.



NOTE: A small system dependent delay may occur on each of the transitions shown.

Figure 13-18—Port State Transition state machine

13.35 Topology Change state machine

The Topology Change state machine for each tree shall implement the function specified by the state diagram contained in Figure 13-19 and the attendant definitions contained in 13.21 through 13.26.

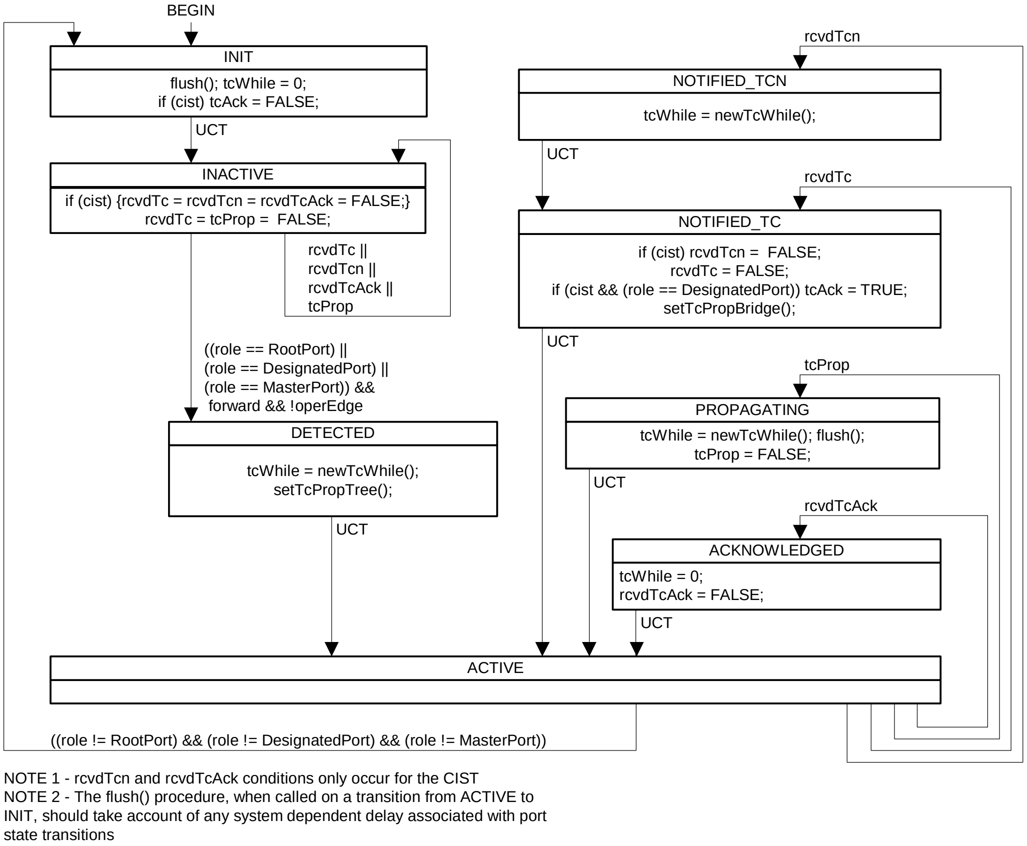

BEGIN
INIT
flush(); tcWhile = 0;
if (cist) tcAck = FALSE;
UCT
INACTIVE
if (cist) {rcvdTc = rcvdTcn = rcvdTcAck = FALSE;}
rcvdTc = tcProp = FALSE;
rcvdTc ||
rcvdTcn ||
rcvdTcAck ||
tcProp
((role == RootPort) ||
(role == DesignatedPort) ||
(role == MasterPort)) &&
forward && !operEdge
DETECTED
tcWhile = newTcWhile();
setTcPropTree();
UCT
rcvdTcn
NOTIFIED_TCN
tcWhile = newTcWhile();
UCT
rcvdTc
NOTIFIED_TC
if (cist) rcvdTcn = FALSE;
rcvdTc = FALSE;
if (cist && (role == DesignatedPort)) tcAck = TRUE;
setTcPropBridge();
UCT
tcProp
PROPAGATING
tcWhile = newTcWhile(); flush();
tcProp = FALSE;
UCT
rcvdTcAck
ACKNOWLEDGED
tcWhile = 0;
rcvdTcAck = FALSE;
UCT
ACTIVE
((role != RootPort) && (role != DesignatedPort) && (role != MasterPort))
NOTE 1 - rcvdTcn and rcvdTcAck conditions only occur for the CIST
NOTE 2 - The flush() procedure, when called on a transition from ACTIVE to
INIT, should take account of any system dependent delay associated with port
state transitions

Figure 13-19—Topology Change state machine

13.36 Performance

This subclause places requirements on the setting of the parameters of MSTP. It recommends default operational values for performance parameters. These have been specified in order to avoid the need to set values prior to operation, and have been chosen with a view to maximizing the ease with which Bridged LAN components interoperate.

The constraints on parameter values for correct operation are essentially the same as specified in IEEE Std. for RSTP, and provide for the integration of MST Bridges into LANs that contain Bridges using STP. Bridges using MSTP shall conform to the parameter value requirements of 17.39 of IEEE Std 802.1D, 1998 Edition. Implementations of MSTP and managers of Bridged Local Area Networks should note the recommendations of that Clause. Maximum, minimum, default, and or applicable ranges are specified and recommended for values of the following parameters:

a) Maximum Bridge Diameter
b) Maximum Bridge Transit Delay
c) Maximum BPDU Transmission Delay
d) Maximum Message Age Increment Overestimate
e) Bridge Priority and Port Priority
f) External Port Path Cost (referred to as Path Cost in 17.39 of IEEE Std 802.1D, 1998 Edition)
g) Port Hello Time (HelloTime in 13.22)

NOTE—In MSTP Bridges, Hello Time is manageable on a per-Port basis, rather than per-Bridge in STP and RSTP. Port Hello Time therefore replaces the Bridge Hello Time parameter found in STP and RSTP.

h) Bridge Max Age
i) Bridge Forward Delay

This standard also makes recommendations on the applicable values of Internal Port Path Cost, a parameter specific to MSTP.

13.36.1 Internal Port Path Costs

It is recommended that default values of the Internal Port **Path Cost** parameter for each Bridge Port be based on the values shown in Table 13-3, the values being chosen according to the speed of the LAN segment to which each Port is attached.

Table 13-3—Internal Port Path Costs

Parameter	Link Speed	Recommended value	Recommended range	Range
Internal Port Path Cost	<=100 Kb/s	200 000 000	20 000 000 – 200 000 000	1 – 200 000 000
	1 Mb/s	20 000 000	2 000 000 – 200 000 000	1 – 200 000 000
	10 Mb/s	2 000 000	200 000 – 20 000 000	1 – 200 000 000
	100 Mb/s	200 000	20 000 – 2 000 000	1 – 200 000 000
	1 Gb/s	20 000	2 000 – 200 000	1 – 200 000 000
	10 Gb/s	2 000	200 – 20 000	1 – 200 000 000
	100 Gb/s	200	20 – 2 000	1 – 200 000 000
	1 Tb/s	20	2 – 200	1 – 200 000 000
	10 Tb/s	2	1 – 20	1 – 200 000 000

Where intermediate link speeds are created as a result of the aggregation of 2 or more links of the same speed (see IEEE Std 802.3ad), it may be appropriate to modify the recommended values shown to reflect the change in link speed. However, as the primary purpose of the Path Cost is to establish the active topology of the network, it may be inappropriate for the Path Cost to track the effective speed of such links too closely, as the resultant active topology may differ from that intended by the network administrator. For example, if the network administrator had chosen an active topology that makes use of aggregated links for resilience (rather than for increased data rate), it would be inappropriate to cause a Spanning Tree topology change as a result of one of the physical links in an aggregation failing. Similarly, with links that can autonegotiate their data rate, reflecting such changes of data rate in changes to Path Cost may not be appropriate, depending upon the intent of the network administrator. Hence, as a default behavior, such dynamic changes of data rate should not automatically cause changes in Path Cost for the Port concerned.

NOTE 1—The values shown apply to both full duplex and half duplex operation. The intent of the recommended values and ranges shown is to minimize the number of Bridges in which path costs need to be managed in order to exert control over the topology of the Bridged LAN.

NOTE 2—The values shown are the same as those recommended in IEEE Std 802.1t-2001.

Insert a new Clause 14 as follows:

14. Use of BPDUs by MSTP

This clause specifies the BPDU formats, encoding, and decoding used to exchange protocol parameters with other Bridges operating MSTP, RSTP, or STP, by a Bridge Protocol Entity operating MSTP (Clause 13).

14.1 BPDU Structure

14.1.1 Transmission and representation of octets

All BPDUs shall contain an integral number of octets. The octets in a BPDU are numbered starting from 1 and increasing in the order they are put into a Data Link Service Data Unit (DLSDU).When bit positions in an octet or a sequence of octets encode a number, the number is encoded as an unsigned binary numeral with bit positions in lower octet numbers having more significance. Within an octet the bits are numbered from 8 to 1, where 1 is the low-order bit. Where sequences of bits are represented, high order bits are shown to the left of lower order bits in the same octet, and bits in lower octet numbers are shown to the left of bits in higher octet numbers.

14.1.2 Components

A Protocol Identifier is encoded in the initial octets of all BPDUs. The single Protocol Identifier value of 0000 0000 0000 0000 identifies the Spanning Tree family of protocols (the Spanning Tree Algorithm and Protocol, the Rapid Spanning Tree Algorithm and Protocol, and the Multiple Spanning Tree Protocol).

14.2 Encoding of parameter types

The following parameter types are encoded as specified in 9.1 of IEEE Std 802.1D, 1998 Edition.

a) Protocol Identifiers.
b) Protocol Version Identifiers.
c) BPDU Types.
d) Flags.
e) Port Identifiers.
f) Timer values.
g) Length values.

Additional considerations follow for encoding:

h) Port Roles
i) Bridge Identifiers
j) Port Identifiers
k) External Root Path Costs
l) Internal Root Path Costs

This standard specifies new or extended parameter types and encodings for:

m) Hop Counts

14.2.1 Encoding of Port Role values

Port Role values shall be encoded in two consecutive flag bits, taken to represent an unsigned integer, as follows:

a) A value of 0 indicates Master Port;
b) A value of 1 indicates Alternate or Backup;
c) A value of 2 indicates Root;
d) A value of 3 indicates Designated.

14.2.2 Allocation and encoding of Bridge Identifiers

The 12-bit system ID extension component of a Bridge Identifier (9.2.5 of IEEE Std 802.1D, 1998 Edition) is used to allocate distinct Bridge Identifiers to each Spanning Tree instance supported by the operation of MSTP, based on the use of a single Bridge Address component value for the MST Bridge as a whole. The system ID extension value zero shall be allocated to the Bridge Identifier used by MSTP in support of the CIST; the system ID extension value allocated to the Bridge Identifier used by a given MSTI shall be equal to the MSTID.

NOTE 1—This convention is used to convey the MSTID for each MSTI parameter set in an MST BPDU.

The four most significant bits of the Bridge Identifier for a given Spanning Tree instance (the settable Priority component) can be modified independently of the other Bridge Identifiers supported by the Bridge, allowing full configuration control to be exerted over each Spanning Tree instance with regard to bridge priority.

NOTE 2—Only these four bits of the transmitting Bridge’s Bridge Identifier are encoded in BPDUs for each MSTI. The remainder of the Bridge Identifier is derived from the CIST Bridge Identifier and the MSTID using the system ID extension convention described above.

14.2.3 Allocation and encoding of Port Identifiers

The four most significant bits of the Port Identifier for a given Spanning Tree instance (the settable Priority component) can be modified independently for each Spanning Tree instance supported by the Bridge.

NOTE—Only these four bits of the transmitting Bridge’s Port Identifier are encoded in a BPDU for each MSTI. The remainder of the Port Identifier is derived from the CIST Port Identifier.

14.2.4 Encoding of External Root Path Cost

The External Root Path Cost shall be encoded as specified by 9.2.6 of IEEE Std 802.1D, 1998 Edition for Root Path Cost in four octets, taken to represent a number of arbitrary cost units. Subclause 8.10.2 of IEEE Std 802.1D, 1998 Edition contains recommendations as to the increment to the Root Path Cost, in order that some common value can be placed on this parameter without requiring a management installation practice for Bridges in a Bridged LAN.

14.2.5 Encoding of Internal Root Path Cost

The Internal Root Path Cost shall be encoded in four octets, taken to represent a number of arbitrary cost units that may differ from those used for External Path Cost. Table 13-3 contains recommendations for the use of these units. These recommendations allow higher LAN speeds to be represented in support of both current and future technologies, while still allowing common values to be assigned without a management installation practice.

NOTE—This revision from the original 802.1D recommendations for STP Path Cost causes no operational difficulties because there was no installed base of Bridges using the Internal Root Path Cost parameter prior to approval of this standard.

14.2.6 Encoding of Hop Counts

The number of remaining Hops parameter shall be encoded in a single octet.

14.3 BPDU formats and parameters

14.3.1 STP BPDUs

The formats of STP BPDU Configuration and TCN BPDUs are as specified in Clause 9 of IEEE Std 802.1D, 1998 Edition.

14.3.2 RST BPDUs

The format of RST BPDUs is as specified in Clause 9 of IEEE Std 802.1D, 1998 Edition.

14.3.3 MST BPDUs

The format of MST BPDUs is compatible with that specified for RST BPDUs (Clause 9 of IEEE Std 802.1D, 1998 Edition), with the addition of fields to convey information for the IST and each MSTI, and is shown in Figure 14-1. Each transmitted MST BPDU shall contain the parameters specified and no others.

NOTE—The BPDU specified in this clause is carried in an LLC Type 1 frame following the DSAP, LSAP, and UI fields (7.12 on Addressing in IEEE Std 802.1D, 1998 Edition). The consequence of the inclusion of those 3 octets in an 802.3 or Ethernet MAC frame is that, if the MAC Addresses in the frame are aligned on an even octet boundary then so are the BPDU octet pairs 6 and 7, 14 and 15, 18 and 19, etc.

14.4 Validation of received BPDUs

An MST Bridge Protocol Entity shall examine Octets 1 and 2 (conveying the Protocol Identifier), Octet 3 (conveying the Protocol Version Identifier encoded as a number), Octet 4 (conveying the BPDU Type) and the total length of the received BPDU (including the preceding fields, but none prior to the Protocol Identifier) to determine the further processing required as follows:

a) If the Protocol Identifier is 0000 0000 0000 0000, the BPDU Type is 0000 0000, and the BPDU contains 35 or more octets, it shall be decoded as an STP Configuration BPDU.
b) If the Protocol Identifier is 0000 0000 0000 0000, the BPDU Type is 1000 0000 (where bit 8 is shown at the left of the sequence), and the BPDU contains 4 or more octets, it shall be decoded as an STP TCN BPDU (9.3.2 of IEEE Std 802.1D, 1998 Edition).
c) If the Protocol Identifier is 0000 0000 0000 0000, the Protocol Version Identifier is 2, and the BPDU Type is 0000 0010 (where bit 8 is shown at the left of the sequence), and the BPDU contains 36 or more octets, it shall be decoded as an RST BPDU.
d) If the Protocol Identifier is 0000 0000 0000 0000, the Protocol Version Identifier is 3 or greater, and the BPDU Type is 0000 0010, and the BPDU:
    1) contains 35 or more but less than 103 octets; or
    2) contains a Version 1 Length that is not 0; or
    3) contains a Version 3 length that does not represent an integral number, from 0 to 64 inclusive, of MSTI Configuration Messages;

    it shall be decoded as an RST BPDU.

e) If the Protocol Identifier is 0000 0000 0000 0000, the Protocol Version Identifier is 3 or greater, and the BPDU Type is 0000 0010, and the BPDU:
   1) contains 102 or more octets; and
   2) a Version 1 Length of 0; and
   3) a Version 3 length representing an integral number, from 0 to 64 inclusive, of MSTI Configuration Messages;

   it shall be decoded as an MST BPDU.

f) Otherwise the BPDU shall be discarded and not processed.

NOTE 1—The LLC LSAP that identifies BPDUs is reserved for standard protocols, no other protocols using that LSAP have been standardized though they may be at some future time. At that time BPDUs with different Protocol Identifiers may be processed according to the rules of those protocols, but will still be discarded from the point of view of MSTP.

NOTE 2—These validation rules are in accord with the approach to backward compatibility of future version enhancements set out in 9.3.4 of IEEE Std 802.1D, 1998 Edition. Tests (a) and (b) above do not check the Protocol Version Identifier.

NOTE 3—These validation rules do not contain a loopback check of the form specified in 9.3.4 of IEEE Std 802.1D, 1998 Edition.

14.5 Transmission of BPDUs

An MST Bridge Protocol Entity shall encode 0000 0000 0000 0000 in Octets 1 and 2 (conveying the Protocol Identifier), the remaining fields shall be encoded to convey an STP Configuration BPDU, an STP TCN BPDU, an RST BPDU, or an MST BDU as required by the Force Protocol Version parameter, the Port Protocol Migration state machine, and other protocol parameters, all as specified in Clause 13.

a) If transmission of an STP Configuration BPDU is required, the Protocol Version Identifier shall be 0, and the BPDU Type shall be 0000 0000.
b) If transmission of an STP TCN BPDU is required, the Protocol Version Identifier shall be 0, and the BPDU Type shall be 1000 0000.
c) If transmission of an RST BPDU is required, the Protocol Version Identifier shall be 2, and the BPDU Type shall be 0000 0010.
d) If transmission of an MST BPDU is required, the Protocol Version Identifier shall be 3, and the BPDU Type shall be 0000 0010.

The remaining parameters for STP Configuration, RST, and MST BPDUs shall be encoded as specified below.

14.6 Encoding and decoding of STP Configuration, RST, and MST BPDUs

STP Configuration, RST, and MST BPDU protocol parameters are encoded for transmission, and decoded, checked or ignored on receipt as follows:

a) Bit 1 of Octet 5 conveys the CIST Topology Change flag.
b) Bit 2 of Octet 5 conveys the CIST Proposal flag in RST and MST BPDUs. It is unused in STP Configuration BPDUs, and shall be transmitted as 0 and ignored on receipt.
c) Bits 3 and 4 of Octet 5 conveys the CIST Port Role in RST and MST BPDUs. It is unused in STP Configuration BPDUs, and shall be transmitted as 0 and ignored on receipt.
d) Bit 5 of Octet 5 conveys the CIST Learning flag in RST and MST BPDUs. It is unused in STP Configuration BPDUs, and shall be transmitted as 0 and ignored on receipt.
e) Bit 6 of Octet 5 conveys the CIST Forwarding flag in RST and MST BPDUs. It is unused in STP Configuration BPDUs, and shall be transmitted as 0 and ignored on receipt.

f) Bit 7 of Octet 5 conveys the CIST Agreement flag in RST and MST BPDUs. It is unused in STP Configuration BPDUs, and shall be transmitted as 0 and ignored on receipt.
g) Bit 8 of Octet 5 conveys the Topology Change Acknowledge Flag in STP Configuration BPDUs. It is unused in RST and MST BPDUs, and shall be transmitted as 0 and ignored on receipt.
h) Octets 6 through 13 convey the CIST Root Identifier.

NOTE 1—The 12 bit system id extension component of the CIST Root Identifier can be received and subsequently transmitted as an arbitrary value, even in MST BPDUs, since the CIST Root may be an STP Bridge.

i) Octets 14 through 17 convey the CIST External Root Path Cost.
j) Octets 18 through 25 shall take the value of the CIST Regional Root Identifier when transmitted in RST and MST BPDUs, and the value of the CIST Bridge Identifier of the transmitting Bridge when transmitted in STP Configuration BPDUs. On receipt of an STP Configuration or RST BPDU both the CIST Regional Root Identifier and the CIST Designated Bridge Identifier shall be decoded from this field. On receipt of an MST BPDU the CIST Regional Root Identifier shall be decoded from this field.
k) Octets 26 and 27 convey the CIST Port Identifier of the transmitting Bridge Port.
l) Octets 28 and 29 convey the Message Age timer value.
m) Octets 30 and 31 convey the Max Age timer value.
n) Octets 32 and 33 convey the Hello Time timer value used by the transmitting Bridge Port.
o) Octets 34 and 35 convey the Max Age timer value.

No further octets shall be encoded in STP Configuration BPDUs. Additional octets in received BPDUs identified by the validation procedure (14.4) as STP Configuration BPDUs shall be ignored. The specification of encoding or decoding of further octets in this subclause refers only to RST and MST BPDUs.

p) Octet 36 conveys the Version 1 Length. This shall be transmitted as 0. It is checked on receipt by the validation procedure (14.4).

No further octets shall be encoded in RST BPDUs. Additional octets in received BPDUs identified by the validation procedure (14.4) as RST BPDUs shall be ignored. The specification of encoding or decoding of further octets in this subclause refers only to MST BPDUs.

NOTE 2—As Version 2 does not specify any additional fields beyond the end of the Version 0 information, there is no Version 2 Length field specified in Version 2 of the protocol (see Clause 9 of IEEE Std 802.1D, 1998 Edition), and therefore no need for a Version 2 length field here.

q) Octets 37 and 38 convey the Version 3 Length. Its value is the number of octets taken by the parameters that follow in the BPDU. It is checked on receipt by the validation procedure (14.4).
r) Octets 39 through 89 convey the elements of the MST Configuration Identifier (13.7):
    1) The Configuration Identifier Format Selector is encoded in octet 39 and shall take the value 0000 0000;
    2) The Configuration Name is encoded in octets 40 through 71;
    3) The Revision Level is encoded as a number in octets 72 through 73;
    4) The Configuration Digest is encoded in octets 74 through 89.
s) Octets 90 through 93 convey the CIST Internal Root Path Cost.
t) Octets 94 through 101 convey the CIST Bridge Identifier of the transmitting Bridge. The 12 bit system id extension component of the CIST Bridge Identifier shall be transmitted as 0. The behavior on receipt is unspecified if it is non-zero.

NOTE 3—The 4 most significant bits of the Bridge Identifier constitute the manageable priority component for each MSTI and are separately encoded in MSTI Configuration Messages in the BPDU.

NOTE 4—The 4 most significant bits constitute the manageable priority component of each MSTI and are separately encoded in MSTI Configuration Messages in the BPDU.

u) Octet 102 encodes the value of remaining Hops for the CIST.
v) A sequence of zero or more, up to a maximum of 64, MSTI Configuration Messages follows, each encoded as specified below.

14.6.1 MSTI Configuration Messages

A single instance of the following set of parameters is encoded for each MSTI supported by the transmitting Bridge.

a) Bits 1, 2, 3 and 4, 5, 6, 7, and 8, respectively, of Octet 1 convey the Topology Change flag, Proposal flag, Port Role, Learning flag, Forwarding flag, Agreement flag, and Master flag for this MSTI.
b) Octets 2 through 9 convey the Regional Root Identifier. This includes the value of the MSTID for this Configuration Message encoded in bits 4 through 1 of Octet 1, and bits 8 through 1 of Octet 2.

NOTE—The 4 most significant bits of each MSTI's Regional Root Identifier constitute a manageable priority component.

c) Octets 10 through 13 convey the Internal Root Path Cost.
d) Bits 5 through 8 of Octet 14 convey the value of the Bridge Identifier Priority for this MSTI. Bits 1 through 4 of Octet 14 shall be transmitted as 0, and ignored on receipt.
e) Bits 5 through 8 of Octet 15 convey the value of the Port Identifier Priority for this MSTI. Bits 1 through 4 of Octet 15 shall be transmitted as 0, and ignored on receipt.
f) Octet 16 conveys the value of remainingHops for this MSTI.

	Octet
Protocol Identifier	1–2
Protocol Version Identifier	3
BPDU Type	4
CIST Flags	5
CIST Root Identifier	6–13
CIST External Path Cost	14–17
CIST Regional Root Identifier	18–25
CIST Port Identifier	26–27
Message Age	28–29
Max Age	30–31
Hello Time	32–33
Forward Delay	34–35
Version 1 Length = 0	36
Version 3 Length	37–38
MST Configuration Identifier	39–89
CIST Internal Root Path Cost	90–93
CIST Bridge Identifier	94–101
CIST Remaining Hops	102
MSTI Configuration Messages (may be absent)	103–*39* + *Version 3 Length*

Figure 14-1—MST BPDU parameters and format

	Octet
MSTI Flags	1
MSTI Regional Root Identifier	2–9
MSTI Internal Root Path Cost	10–13
MSTI Bridge Priority	14
MSTI Port Priority	15
MSTI Remaining Hops	16

Figure 14-2—MSTI Configuration Message parameters and format

Annex A

(normative)

PICS proforma

Delete existing Tables A.4 through A.13 (of IEEE Std 802.1Q, 1998 Edition, as modified by IEEE Std 802.1u-2001 and IEEE Std 802.1v-2001), and insert new Tables A.4 through A.15, as follows:

A.4 PICS proforma for IEEE Std 802.1Q-2002

A.4.1 Implementation identification

Supplier	
Contact point for queries about the PICS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification - e.g., name(s) and version(s) of machines and/or operating system names	

NOTE 1—Only the first three items are required for all implementations; other information may be completed as appropriate in meeting the requirement for full identification.

NOTE 2—The terms Name and Version should be interpreted appropriately to correspond with a supplier’s terminology (e.g., Type, Series, Model).

A.4.2 Protocol summary, IEEE Std 802.1Q-2002

Identification of protocol specification	IEEE Std 802.1Q-2002, IEEE Standards for Local and Metropolitan Area Networks: Standard for Virtual Bridged Local Area Networks
Identification of amendments and corrigenda to the PICS proforma which have been completed as part of the PICS	Amd. : Corr. : Amd. : Corr. :

A.4.2 Protocol summary, IEEE Std 802.1Q-2002 *(continued)*

Have any Exception items been required? (See A.3.3: the answer Yes means that the implementation does not conform to IEEE Std 802.1Q-2002)	No [ ]	Yes [ ]

Date of Statement	

A.5 Major capabilities and options

Item	Feature	Status	References	Support
(1a)*	Communications Support		{D}6.5	
	Which MAC types are supported on Bridge Ports, implemented in conformance with the relevant MAC standards?			
(1a.1)*	CSMA/CD, IEEE Std 802.3	O.1		Yes [ ] No [ ]
(1a.2)*	Token Bus, IEEE Std 802.4	O.1		Yes [ ] No [ ]
(1a.3)*	Token Ring, IEEE Std 802.5	O.1		Yes [ ] No [ ]
(1a.4)*	FDDI, ISO 9314-2	O.1		Yes [ ] No [ ]
(1a.5)*	DQDB, IEEE Std 802.6	O.1		Yes [ ] No [ ]
(1a.6)*	ISLAN, IEEE Std 802.9	O.1		Yes [ ] No [ ]
(1a.7)*	ISLAN 16-T, IEEE Std 802.9a	O.1		Yes [ ] No [ ]
(1a.8)*	Demand Priority, IEEE Std 802.12 (IEEE Std 802.3 format)	O.1		Yes [ ] No [ ]
(1a.9)*	Demand Priority, IEEE Std 802.12 (ISO/IEC 8802-5 format)	O.1		Yes [ ] No [ ]
(1a.11)*	Wireless LAN, ISO/IEC 8802-11(IEEE Std 802.11)	O.1		Yes [} No [ ]
(1b)	Is LLC Type 1 supported on all Bridge Ports in conformance with IEEE Std 802.2?	M	8.2, 8.3, 8.14, IEEE Std 802.2	Yes [ ]
(1c)*	Is Source-Routing Transparent Bridge operation supported on any of the Bridge Ports? (If support is claimed, the PICS proforma detailed in IEEE Std 802.1D, Annex D, shall also be completed).	O	{D}Annex C	Yes [ ] No [ ]
(2)	Relay and filtering of frames (A.6)	M	8.5, 8.6, 8.7, 8.8, 8.9	Yes [ ]
(2a)	Does the Bridge support Basic Filtering Services?	M	{D}6.6.5, 8.7.2	Yes [ ]
(2b)*	Does the Bridge support Extended Filtering Services?	O	{D}6.6.5, 8.7.2	Yes [ ] No [ ]
	If item (2b) is not supported, mark “N/A” and continue at (2e).			N/A[ ]
(2c)*	Does the Bridge support dynamic Group forwarding and filtering behavior?	2b:M	{D}6.6.5	Yes [ ] No [ ]

A.5 Major capabilities and options *(continued)*

Item	Feature	Status	References	Support
(2d)	Does the Bridge support the ability for static filtering information for individual MAC Addresses to specify a subset of Ports for which forwarding or filtering decisions are taken on the basis of dynamic filtering information?	2b:O	{D}6.6.5	Yes [ ] No [ ]
(2e)*	Does the Bridge support expedited traffic classes on any of its Ports?	O	8.1.2, 8.6.5	Yes [ ] No [ ]
(4)*	Does the Bridge support management of the priority of relayed frames?	O	{D}6.5, 8.5.1, 8.6.5, 8.6.7, Table 8-1, Table 8-2, Table 8-3	Yes [ ] No [ ]
(5)	Maintenance of filtering information (A.7)	M	8.8, 8.10	Yes [ ]
(7a)	Can the Filtering Database be read by management?	O	8.10	Yes [ ] No [ ]
(7c)*	Can Static Filtering Entries be created and deleted?	O	8.10.1	Yes [ ] No [ ]
(7g)	Can Static Filtering Entries be created and deleted in the Permanent Database?	O	8.10.10	Yes [ ] No [ ]
(7h)	Can Static Filtering Entries be created for a given MAC Address specification with a distinct Port Map for each inbound Port?	O	8.10.1	Yes [ ] No [ ]
(7i)	Can Group Registration Entries be dynamically created, updated and deleted by GMRP?	2c:M	8.10.4, {D}10	Yes [ ] N/A [ ]
(10)	Addressing (A.8)	M	8.14	Yes [ ]
(9a)*	Can the Bridge be configured to use 48-bit Universal Addresses?	O.3	8.14	Yes [ ] No [ ]
(9b)*	Can the Bridge be configured to use 48-bit Local Addresses?	O.3	8.14	Yes [ ] No [ ]
(13)*	Spanning Tree algorithm and protocol (A.9)	O.4	5, {D}8, {D}9	Yes [ ] N [ ]
(rst)*	Rapid Spanning Tree algorithm and protocol	O.4	5, {D}9, {D}17	Yes [ ] No [ ]
(mst)*	Multiple Spanning Tree algorithm and protocol	O.4	5, 7, 8.4.1, 8.4.2, 8.6.2, 8.10.7, 8.11, 8.12, 8.14.3, 11.2.3.4, 11.3.1, 13, 14	Yes [ ] No [ ]
(msti)	Support the CIST plus a stated maximum number of MSTIs, where that number is at least 2 and at most 64	mst:M	5.2, 8.10.7, 13.14	Yes [ ] MSTIs: _____ N/A [ ]
(16)*	Does the Bridge support management of the Spanning Tree topology?	O	{D}8.2	Yes [ ] No [ ]
(17)*	Does the Bridge support management of the protocol timers?	O	{D}8.10	Yes [ ] No [ ]
(19)*	VLAN Bridge Management Operations	O	12	Yes [ ] No [ ]

A.5 Major capabilities and options *(continued)*

Item	Feature	Status	References	Support
(20a)*	Are the Bridge Management Operations supported via a Remote Management Protocol?	19:O.5	{D}5	Yes [ ] No [ ] N/A [ ]
(20b)*	Are the Bridge Management Operations supported via a local management interface?	19:O.5	{D}5	Yes [ ] No [ ] N/A [ ]
(23a)*	Does the implementation support, on each Port, one or more of the permissible combinations of values for the Acceptable Frame Types parameter?	M	5.1, 8.4.3	Yes [ ]
(23a.1)	State which Ports support: — Admit only VLAN-tagged frames; — Admit all frames.	M	5.1, 8.4.3	Ports: _____ Ports: _____
(23a.2)	On Ports that support both values, is the parameter configurable via management?	M	5.1, 8.4.3, 12.10	Yes [ ] N/A [ ]
(23b)	Does the implementation support the ability to insert tag headers into, modify tag headers in, and remove tag headers from relayed frames, as required by the capabilities of each Bridge Port?	M	5.1, 6.1, 9	Yes [ ]
(23c)	Does the implementation support the ability to perform automatic configuration and management of VLAN topology information by means of GVRP on all Ports?	M	5.1, 11	Yes [ ]
(23d)	Does the implementation support the ability for the Filtering Database to contain static and dynamic configuration information for at least one VLAN, by means of Static and Dynamic VLAN Registration Entries?	M	5.1, 8.10	Yes [ ]
(23d.1)	State the maximum number of VLANs supported by the implementation.	M	5.1, 8.10, 9.3.2.3	_____ VLANs
(23d.2)	State the range of VID values supported by the implementation.	M	8.10, 9.3.2.3	0 through _____
(23e)*	VLAN Learning support		5.1, 8.10.3, 8.10.7, 8.10.8	
(23e.1)	Does the implementation support at least one FID?	M		Yes [ ]
(23e.2)	Can the implementation allocate at least one VID to each FID supported?	M		Yes [ ]
(23e.4)	State the maximum number of FIDs that can be supported by the implementation.	M	8.10.7	____ FIDs
(23e.5)	State the maximum number of VIDs that can be allocated to each FID.	M	8.10.7	____ VIDs
(23e.6)	Does the implementation support configuration of VLAN Learning Constraints via management?	O	5.2, 8.10.7, 12.10.3	Yes [ ] No [ ]

A.5 Major capabilities and options *(continued)*

Item	Feature	Status	References	Support
(23e.7)	State the number of VLAN Learning Constraints that can be configured in the implementation.	23e.6:M	5.2, 8.10.7, 12.10.3	____ Constraints
(23e.8)	Does the implementation support configuration of VID to FID allocations via management?	O	5.2, 8.10.7.1, 12.10.3	Yes [ ] No [ ]
(23e.9)	Does the implementation take account of the allocation of VIDs to FIDs when making forwarding decisions relative to group MAC Addresses?	O	8.10.8	Yes [ ] No [ ]
(23f)	On Ports that support untagged and priority-tagged frames, does the implementation support:		5.1, 8.4.4, 12.10	
(23f.1)	— A PVID value?	M		Yes [ ] N/A [ ]
(23f.2)	— The ability to configure one VLAN whose Untagged set includes that Port?	M		Yes [ ] N/A [ ]
(23f.3)	— Configuration of the PVID value via management operations?	M		Yes [ ] N/A [ ]
(23f.4)	— Configuration of Static Filtering Entries via management operations?	M		Yes [ ] N/A [ ]
(23f.5)	— The ability to configure more than one VLAN whose Untagged set includes that Port?	O		Yes [ ] No [ ] N/A [ ]
(23g)*	Does the implementation support the ability to enable and disable Ingress Filtering?	O	5.2, 8.4.5	
(23h)	Does the implementation support VLAN management operations?	19:O	5.2, 12.10.2, 12.10.3	Yes [ ] No [ ]
(23i)	Is the minimum tagged frame length that can be transmitted on IEEE Std 802.3 Ports less than 68 (but 64 or more) octets?	1a.1:O	6.5	Yes [ ] No [ ] N/A [ ]
(23j)*	When transmitting untagged frames and the canonical_format_indicator parameter indicates that the mac_service_data_unit may contain embedded MAC Addresses in a format inappropriate to the destination MAC method, which of the following procedures is adopted by the Bridge:		6.1, 6.4.2.2	
(23j.1)	Convert any embedded MAC Addresses in the mac_service_data_unit to the format appropriate to the destination MAC method.	O.7		Yes [ ] No [ ]
(23j.2)	Discard the frame without transmission on that Port.	O.7		Yes [ ] No [ ]
(23k)	Does the Bridge perform frame translations, where necessary, in accordance with the procedures described in ISO/IEC 11802-5, IETF RFC 1042, and IETF RFC 1390?	TB:M	6.1, 6.4.2.2	Yes [ ] No [ ] N/A [ ]

A.5 Major capabilities and options *(continued)*

Item	Feature	Status	References	Support	
(23l)*	Does the implementation support Port-and-Protocol-based classification of frames on any or all Ports?	O	8.6	Yes [ ]	No [ ]
(23m)*	Does the implementation support a Protocol Group Database?	23l:M	8.9.4	Yes [ ]	N/A [ ]

Predicates:
TB = True if the Bridge supports translational Bridging; i.e., the Bridge supports 802.3/Ethernet MAC methods on one or more Ports and Token Ring/FDDI MAC methods on one or more Ports.

A.6 Relay and filtering of frames

Item	Feature	Status	References	Support
(2f)	Are received frames with MAC method errors discarded?	M	{D}6.4, 8.5	Yes [ ]
(2g)	Are correctly received frames submitted to the Learning Process?	M	8.5	Yes [ ]
(2h)	Are user data frames the only type of frame relayed?	M	8.5	Yes [ ]
(2i)	Are request with no response frames the only frames relayed?	M	8.5	Yes [ ]
(2j)	Are all frames addressed to the Bridge Protocol Entity submitted to it?	M	8.5	Yes [ ]
(2k)	Are user data frames the only type of frame transmitted?	M	8.7	Yes [ ]
(2l)	Are request with no response frames the only frames transmitted?	M	8.7	Yes [ ]
(ingr)	Are frames assigned to VLANs, and discarded or permitted ingress, in accordance with classification rules?	M	8.6.1, 8.9	Yes [ ]
(actve)	Are frames allocated to spanning trees, and forwarded or discarded in accordance with the active topology for their spanning tree instance?	M	8.6.2	Yes [ ]
(filter)	Are frames filtered as specified?	M	8.6.3	Yes [ ]
(egrs)	Are frames filtered and formatted in accordance with egress rules?	M	8.6.4	Yes [ ]
(pmap)	Is priority mapping performed as specified?	M	8.6.7	
(form)	Are frames formatted in accordance with the tagged frame format?	M	8.6.8, 9	Yes [ ]
(2m)	Are relayed frames queued for transmission only under the conditions in 8.6.5?	M	8.6.5, {D}8.4	Yes [ ]

A.6 Relay and filtering of frames *(continued)*

Item	Feature	Status	References	Support
(2n)	Is the order of relayed frames preserved in accordance with the requirements of the forwarding process?	M	8.6.5, 8.1.1	Yes [ ]
(2o)	Is a relayed frame submitted to a MAC Entity for transmission only once?	M	8.6.6, {D}6.3.4	Yes [ ]
(2p)	Is a maximum bridge transit delay enforced for relayed frames?	M	8.6.5	Yes [ ]
(2q)	Are queued frames discarded if a Port leaves the Forwarding State?	M	8.6.5	Yes [ ]
(2r)	Is the user priority of relayed frames preserved where possible?	M	{D}6.4	Yes [ ]
(2s)	Is the user priority set to the Default User Priority for the reception Port otherwise?	M	{D}6.4	Yes [ ]
(2t)	Is the user priority regenerated by means of the User Priority Regeneration Table?	M	8.5.1, Table 8-1	Yes [ ]
(2u)	Is mapping of Regenerated User Priority to Traffic Class performed by means of the Traffic Class Table?	M	8.5.1, Table 8-2	Yes [ ]
(2v)	Is the access priority derived from the Regenerated User Priority as defined by the values in Table 8-3 for each outbound MAC method supported by the Bridge?	M	8.6.7, Table 8-3	Yes [ ]
(2w)	Does the Bridge generate an M_UNITDATA.indication primitive on receipt of a valid frame transmitted by the Bridge Port's local MAC entity?	MS1:X	{D}6.5.4, ISO 9314-2	No [ ] N/A [ ]
(2x)	Is only Asynchronous service used?	MS1:M	ISO 9314-2, 8.1.4	Yes [ ] N/A [ ]
(2y)	On receiving a frame from an FDDI ring for forwarding, does the bridge set the C indicator?	MS1:O	{D}6.5.4, ISO 9314-2, 7.3.8	Yes [ ] No [ ] N/A [ ]
(2z)	On receiving a frame from an FDDI ring for forwarding, does the bridge leave the C indicator unaltered?	MS1:O	{D}6.5.4, ISO 9314-2, 7.3.8	Yes [ ] No [ ] N/A [ ]
	If item 4 is not supported, mark "N/A" and continue at item (4d).			N/A [ ]
(4a)*	Can the Default User Priority parameter for each Port be set to any value in the range 0 through 7?	4:O.6	{D}6.4	Yes [ ] No [ ]
(4b)*	Can the entries in the User Priority Regeneration Table for each Port be set to the full range of values shown in Table 8-1?	4:O.6	8.5.1, Table 8-1	Yes [ ] No [ ]
(4c)*	Can the entries in the Traffic Class Table for each Port be set to the full range of values shown in Table 8-2?	MS2:O	8.6.5, Table 8-2	Yes [ ] No [ ] N/A [ ]

A.6 Relay and filtering of frames *(continued)*

Item	Feature	Status	References	Support
	If item 4 is supported, mark “N/A” and continue at item (4g)			N/A [ ]
(4d)	Does the Bridge support the recommended default value of the Default User Priority parameter for each Port?	¬ 4:M	{D}6.4	Yes [ ]
(4e)	Does the Bridge support the recommended default mappings between received user priority and Regenerated User Priority for each Port as defined in Table 8-1?	¬ 4:M	8.5.1, Table 8-1	Yes [ ]
(4f)	Does the Bridge support the recommended default user_priority to traffic class mappings shown in Table 8-2 for each Port?	MS3:M	8.6.5, Table 8-2	Yes [ ] N/A [ ]
(4g)	Is the Bridge able to use any values other than those shown in Table 8-3 when determining the access priority for the MAC methods shown?	X	8.6.7, Table 8-3	No [ ]

Predicates:
MS1 = 1a.4 AND NOT (1a.1 OR 1a.2 OR 1a.3 OR 1a.5 OR 1a.6 OR 1a.7 OR 1a.8)
MS2 = 2e AND 4
MS3 = 2e AND NOT 4

A.7 Maintenance of filtering entries in the Filtering Database

Item	Feature	Status	References	Support
(5a)	Are Dynamic Filtering Entries created and updated if and only if the Port State permits?	M	8.10, 8.10.3, {D}8.4	Yes [ ]
(5b)	Are Dynamic Filtering Entries created on receipt of frames with a group source address?	X	8.10, 8.10.3	No [ ]
(5c)	Does the Filtering Database support Static Filtering Entries?	M	8.10.1	Yes [ ]
(5d)	Can a Dynamic Filtering Entry be created that conflicts with an existing Static Filtering Entry?	X	8.8, 8.10, 8.10.1, 8.10.3	No [ ]
(5e)	Does the Filtering Database support Dynamic Filtering Entries?	M	8.10.3	Yes [ ]
(5f)	Does the creation of a Static Filtering Entry remove any conflicting information in a Dynamic Filtering Entry for the same address?	M	8.10.1, 8.10.3	Yes [ ]
(5g)	Does each Static Filtering Entry specify a MAC Address specification and a Port Map?	M	8.10.1	Yes [ ]
(5h)	Are Dynamic Filtering Entries removed from the Filtering Database if not updated for the Ageing Time period?	M	8.10.3	Yes [ ]
(5i)	Does each Dynamic Filtering Entry specify a MAC Address specification and a Port Map?	M	8.10.3	Yes [ ]

A.7 Maintenance of filtering entries in the Filtering Database *(continued)*

Item	Feature	Status	References	Support
(5j)	Is the Filtering Database initialized with the entries contained in the Permanent Database?	M	8.10.10	Yes [ ]
	If item (2c) is not supported, mark N/A and continue at item (6a).			N/A [ ]
(5k)	Does each Group Registration Entry specify a MAC Address specification and a Port Map?	2c:M	8.10.4	Yes [ ]
(5l)	Can the MAC Address specification in Group Registration Entries represent All Groups, All Unregistered Groups, or a specific group MAC Address?	2c:M	8.10.4	Yes [ ]
(5m)	Are Group Registration Entries created, updated and removed from the Filtering Database in accordance with the specification of GMRP?	2c:M	8.10.4, {D}10	Yes [ ]
(5n)	Are Group Registration Entries created, updated and removed from the Filtering Database by any means other than via the operation of GMRP?	2c:X	8.10.4, {D}10	No [ ]
(6a)	State the Filtering Database Size.	M	8.10	____ entries
(6b)	State the Permanent Database Size.	M	8.10	____ entries
	If item (7c) is not supported, mark N/A and continue at item (8a).			N/A [ ]
(7d)	Can Static Filtering Entries be made for individual MAC Addresses?	**7c:**M	8.10.1	Yes [ ]
(7e)	Can Static Filtering Entries be made for group MAC Addresses?	**7c:**M	8.10.1	Yes [ ]
(7f)	Can a Static Filtering Entry be made for the broadcast MAC Address?	**7c:**M	8.10.1	Yes [ ]
(8a)	Can the Bridge be configured to use the default value of Ageing Time recommended in Table 8-4?	O	8.10.3, Table 8-4	Yes [ ] No [ ]
(8b)	Can the Bridge be configured to use any of the range of values of Ageing Time specified in Table 7-4?	O	8.10.3, Table 8-4	Yes [ ] No [ ]

A.8 Addressing

Item	Feature	Status	References	Support
(10a)	Does each Port have a separate MAC Address?	M	8.14.3	Yes [ ]
(10b)	Are all BPDUs transmitted to the same group address?	M	8.14.3, {D}8.2	Yes [ ]
	If item (9a) is not supported, mark N/A and continue at item (10d1).			N/A [ ]

A.8 Addressing *(continued)*

Item	Feature	Status	References	Support
(10c)	Are all BPDUs transmitted to the Bridge Protocol Group Address when Universal Addresses are used?	**9a:**M	8.14.3 {D}8.2	Yes [ ]
(10d)	Is the source address of BPDUs the address of the transmitting Port?	**9a:**M	8.14.3	Yes [ ]
(10d1)	Is the LLC address of BPDUs the standard LLC address identified for the Spanning Tree Protocol?	M	8.14.3, Table 8-9	Yes [ ]
(10e)	Is the Bridge Address a Universal Address?	**M**	8.14.5, {D}8.2	Yes [ ] N/A [ ]
(10f)	Are frames addressed to any of the Reserved Addresses relayed by the Bridge?	X	8.14.6	No [ ]
	If item (13) is not supported, mark N/A and continue at item (11c).			N/A [ ]
(11a)	Is Bridge Management accessible through each Port using the MAC Address of the Port and the LSAP assigned?	**13:**O	8.14.4	Yes [ ] No [ ]
(11b)	Is Bridge Management accessible through all Ports using the All LANs Bridge Management Group Address?	13:O	8.14.4	Yes [ ] No [ ]
(11c)	Is the Bridge Address the Address of Port 1?	**9a:**O	8.14.5	Yes [ ] No [ ] N/A [ ]
(11d)*	Are Group Addresses additional to the Reserved Addresses pre-configured in the Permanent Database?	O	8.14.6	Yes [ ] No [ ]
	If item (11d) is not supported, mark N/A and continue at item (12a).			N/A [ ]
(11e)	Can the additional pre-configured entries in the Filtering Database be deleted?	**11d:**O	8.14.6	Yes [ ] No [ ]
(12a)	Can a group MAC Address be assigned to identify the Bridge Protocol Entity?	**9b:**M	{D}8.2	Yes [ ] N/A [ ]
(12c)	Does each Port of the Bridge have a distinct identifier?	M	{D}8.2, {D}8.5.5.1	Yes [ ]

A.9 Spanning Tree Algorithm

Item	Feature	Status	References	Support
	If item (13) is not supported, mark N/A and continue at the start of A.10.			N/A [ ]
(13a)	Are all the following Bridge Parameters maintained?	13:M	{D}8.5.3	Yes [ ]
	Designated Root		{D}8.5.3.1	
	Root Cost		{D}8.5.3.2	

A.9 Spanning Tree Algorithm *(continued)*

Item	Feature	Status	References	Support
	Root Port		{D}8.5.3.3	
	Max Age		{D}8.5.3.4	
	Hello Time		{D}8.5.3.5	
	Forward Delay		{D}8.5.3.6	
	Bridge Identifier		{D}8.5.3.7	
	Bridge Max Age		{D}8.5.3.8	
	Bridge Hello Time		{D}8.5.3.9	
	Bridge Forward Delay		{D}8.5.3.10	
	Topology Change Detected		{D}8.5.3.11	
	Topology Change		{D}8.5.3.12	
	Topology Change Time		{D}8.5.3.13	
	Hold Time		{D}8.5.3.14	
(13b)	Are all the following Bridge Timers maintained?	13:M	{D}8.5.4	Yes [ ]
	Hello Timer		{D}8.5.4.1	
	Topology Change Notification Timer		{D}8.5.4.2	
	Topology Change Timer		{D}8.5.4.3	
(13c)	Are all the following Port Parameters maintained for each Port?	13:M	{D}8.5.5	Yes [ ]
	Port Identifier		{D}8.5.5.1	
	State		{D}8.5.5.2, {D}8.4	
	Path Cost		{D}8.5.5.3	
	Designated Root		{D}8.5.5.4	
	Designated Cost		{D}8.5.5.5	
	Designated Bridge		{D}8.5.5.6	
	Designated Port		{D}8.5.5.7	
	Topology Change Acknowledge		{D}8.5.5.8	
	Configuration Pending		{D}8.5.5.9	
	Change Detection Enabled		{D}8.5.5.10	
(13d)	Are all the following Timers maintained for each Port?	13:M	{D}8.5.6	Yes [ ]
	Message Age Timer		{D}8.5.6.1	
	Forward Delay Timer		{D}8.5.6.2	
	Hold Timer		{D}8.5.6.3	

A.9 Spanning Tree Algorithm *(continued)*

Item	Feature	Status	References	Support
(13e)	Are Protocol Parameters and Timers maintained, and BPDUs transmitted, as required on each of the following events?	13:M	{D}8.7, {D}8.9, {D}8.5.3, {D}8.5.4, {D}8.5.5, {D}8.5.6	Yes [ ]
	Received Configuration BPDU		{D}8.7.1	
	Received Topology Change Notification BPDU		{D}8.7.2	
	Hello Timer Expiry		{D}8.7.3	
	Message Age Timer Expiry		{D}8.7.4	
	Forward Delay Timer Expiry		{D}8.7.5	
	Topology Change Notification Timer Expiry		{D}8.7.6	
	Topology Change Timer Expiry		{D}8.7.7	
	Hold Timer Expiry		{D}8.7.8	
(13f)	Do the following operations modify Protocol Parameters and Timers, and transmit BPDUs as required?	13:M	{D}8.8, {D}8.9, {D}8.5.3, {D}8.5.4, {D}8.5.5, {D}8.5.6	Yes [ ]
	Initialization		{D}8.8.1	
	Enable Port		{D}8.8.2	
	Disable Port		{D}8.8.3	
	Set Bridge Priority		{D}8.8.4	
	Set Port Priority		{D}8.8.5	
	Set Path Cost		{D}8.8.6	
(13g)	Does the implementation support the ability to set the value of the Change Detection Enabled parameter to Disabled?	13:O	{D}8.5.5.10	Yes [ ] No [ ]
(14a)	Does the Bridge underestimate the increment to the Message Age parameter in transmitted BPDUs?	13:X	{D}8.10.1	No [ ]
(14b)	Does the Bridge underestimate Forward Delay?	13:X	{D}8.10.1	No [ ]
(14c)	Does the Bridge overestimate the Hello Time interval?	13:X	{D}8.10.1	No [ ]
(15a)	Does the Bridge use the specified value for Hold Time?	13:M	{D}8.10.2, {D}Table 8-3	Yes [ ]
	If item (16) is not supported, mark N/A and continue at (17a).			N/A [ ]
(16a)	Can the relative priority of the Bridge be set?	13 AND 16:M	{D}8.2, {D}8.5.3.7, {D}8.8.4	Yes [ ]

A.9 Spanning Tree Algorithm *(continued)*

Item	Feature	Status	References	Support
(16b)	Can the relative priority of the Ports be set?	13 AND 16:M	{D}8.2, {D}8.5.5.1, {D}8.8.5	Yes [ ]
(16c)	Can the path cost for each Port be set?	13 AND 16:M	{D}8.2, {D}8.5.5.3, {D}8.8.6	Yes [ ]
	If item (17) is not supported, mark N/A and continue at (18a).			N/A [ ]
(17a)	Can Bridge Max Age be set to any of the range of values specified?	13 AND 17:M	{D}8.10.2, {D}8.5.3.8, {D}Table 8-3	Yes [ ]
(17b)	Can Bridge Hello Time be set to any of the range of values specified?	13 AND 17:M	{D}8.10.2, {D}8.5.3.9, {D}Table 8-3	Yes [ ]
(17c)	Can Bridge Forward Delay be set to any of the range of values specified?	13 AND 17:M	{D}8.10.2, {D}8.5.3.10, {D}Table 8-3	Yes [ ]
(18a)	Do all BPDUs contain an integral number of octets?	13:M	{D}9.1.1	Yes [ ]
(18b)	Are all the following BPDU parameter types encoded as specified?	13:M	{D}9.1.1, {D}9.2	Yes [ ]
	Protocol Identifiers		{D}9.2.1	
	Protocol Version Identifiers		{D}9.2.2	
	BPDU Types		{D}9.2.3	
	Flags		{D}9.2.4	
	Bridge Identifiers		{D}9.2.5	
	Root Path Cost		{D}9.2.6	
	Port Identifiers		{D}9.2.7	
	Timer Values		{D}9.2.8	
(18c)	Do Configuration BPDUs have the format and parameters specified?	13:M	{D}9.3.1	Yes [ ]
(18d)	Do Topology Change Notification BPDUs have the format and parameters specified?	13:M	{D}9.3.2	Yes [ ]
(18e)	Are received BPDUs validated as specified?	13:M	{D}9.3.3	Yes [ ]

A.10 Rapid Spanning Tree Algorithm

Item	Feature	Status	References	Support
	If item (rst) is not supported, mark N/A and continue at the start of A.11.			N/A [ ]
(ids)	Provision of identifiers for Bridge and Ports	rst:M	{D}17.2	Yes [ ]
(par1)	Not exceed the values in {D}17.28.2 for max Bridge transit delay, max message age increment overestimate and max BPDU transmission delay	rst:M	{D}5.1, {D}17.28.2	Yes [ ]
(par2)	Use the value given in {D}Table 17-5 for Transmission Limit	rst:M	{D}5.1, {D}Table 17-5	Yes [ ]
(inc)	Inclusion of active Ports in computation of the active topology	rst:M	{D}17.5	Yes [ ]
(pro)	Processing of BPDUs received on Ports included in the computation of the active topology	rst:M	{D}17.5	Yes [ ]
(dis)	Discarding received frames in the Discarding state	rst:M	{D}17.5	Yes [ ]
(lrn)	Incorporating station location information to the Filtering Database in the Learning and Forwarding states	rst:M	{D}17.5	Yes [ ]
(nlrn)	Not incorporating station location information to the Filtering Database in the Discarding state	rst:M	{D}17.5	Yes [ ]
(rlrn)	Transfer learned MAC addresses from a retiring Root Port to a new Root Port	rst:O	{D}17.10	Yes [ ] No [ ]
(sm)	A single instance of the Port Role Selection state machine per Bridge and an instance of all other state machines per Port	rst:M	{D}17.13	Yes [ ]
(ptmr)	Port Timers state machine support	rst:M	{D}17.15, {D}17.20	Yes [ ]
(pism)	Port Information state machine support	rst:M	{D}17.15, {D}17.21	Yes [ ]
(prssm)	Port Role Selection state machine support	rst:M	{D}17.15, {D}17.22	Yes [ ]
(prtsm)	Port Role Transitions state machine support	rst:M	{D}17.15, {D}17.23	Yes [ ]
(pstsm)	Port State Transition state machine support	rst:M	{D}17.15, {D}17.24	Yes [ ]
(tcsm)	Topology Change state machine support	rst:M	{D}17.15, {D}17.25	Yes [ ]
(ppmsm)	Port Protocol Migration state machine support	rst:M	{D}17.15, {D}17.26	Yes [ ]
(ptsm)	Port Transmit state machine support	rst:M	{D}17.15, {D}17.27	Yes [ ]
(cde)	Not support Change Detection Enabled parameter	rst:M	{D}5.2	Yes [ ]

A.10 Rapid Spanning Tree Algorithm *(continued)*

Item	Feature	Status	References	Support
(estm)	Not: Underestimate the increment to the Message Age parameter in transmitted BPDUs. Underestimate Forward Delay. Overestimate the Hello Time interval when acting as the Root.	rst:M	{D}17.28.1	Yes [ ]
(htim)	Use of Transmission Limit	rst:M	{D}Table 17-5	Yes [ ]
(prel)	Enforcement of parameter relationships	rst:M	{D}17.28.2	Yes [ ]
(pcst)	No defaulting to use of automatic path cost changes	rst:M	{D}17.28.2	Yes [ ]
(prv)	Range and granularity of priority values	rst:M	{D}17.28.2	Yes [ ]
(pcv)	Range and granularity of path cost values	rst:M	{D}17.28.2	Yes [ ]
	If item (16) is not supported, mark N/A and continue at (tmr1)			N/A [ ]
(mgt1)	Can the relative priority of the Bridge be set?	rst AND **16:**M	{D}17.2, {D}17.4, {D}17.13	Yes [ ]
(mgt2)	Can the relative priority of the Ports be set?	rst AND **16:**M	{D}17.2, {D}17.4, {D}17.13	Yes [ ]
(mgt3)	Can the path cost for each Port be set?	rst AND **16:**M	{D}17.2, {D}17.4, {D}17.13	Yes [ ]
	If item (17) is not supported, mark N/A and continue at (pdu1)			N/A [ ]
*(tmr1)	Can Bridge Max Age be set to any of the range of values specified?	rst AND **17:**M	{D}17.2, {D}17.13, {D}Table 17-5	Yes [ ]
(tmr2)	Can Bridge Hello Time be set to any of the range of values specified?	rst AND **17:**M	{D}17.2, {D}17.13, {D}Table 17-5	Yes [ ]
(tmr3)	Can Bridge Forward Delay be set to any of the range of values specified?	rst AND **17:**M	{D}17.2, {D}17.13, {D}Table 17-5	Yes [ ]
*(pdu1)	Do all BPDUs contain an integral number of octets?	rst:M	{D}9.1.1	Yes [ ]
(pdu2)	Are all the following BPDU parameter types encoded as specified?	rst:M	{D}9.1.1, {D}9.2	Yes [ ]
	Protocol Identifiers		{D}9.2.1	
	Protocol Version Identifiers		{D}9.2.2	
	BPDU Types		{D}9.2.3	
	Flags		{D}9.2.4	
	Bridge Identifiers		{D}9.2.5	

A.10 Rapid Spanning Tree Algorithm *(continued)*

Item	Feature	Status	References	Support
	Root Path Cost		{D}9.2.6	
	Port Identifiers		{D}9.2.7	
	Timer Values		{D}9.2.8	
(pdu3)	Do Configuration BPDUs have the format, parameters, and parameter values specified?	rst:M	{D}9.3.1	Yes [ ]
(pdu4)	Do Topology Change Notification BPDUs have the format, parameters, and parameter values specified?	rst:M	{D}9.3.2	Yes [ ]
(pdu5)	Do Rapid Spanning Tree BPDUs have the format, parameters, and parameter values specified?	rst:M	{D}9.3.3	Yes [ ]
(pdu6)	Are received BPDUs validated as specified?	rst:M	{D}9.3.4	Yes [ ]

A.11 Multiple Spanning Tree Algorithm

Item	Feature	Status	References	Support
	If item (mst) is not supported, mark N/A and continue at the start of A.12.			N/A [ ]
(maxfid)	Support at least as many FIDs as MSTIs	mst:M	5.1, 5.2, 8.10.7	Yes [ ]
(assfid)	Associate each FID to a spanning tree	mst:M	5.1, 8.11.3	Yes [ ]
(confid)	Transmit and receive MST Configuration Identifier information	mst:M	5.1, 8.11.2	Yes [ ]
(pstate)	Support a set of port state information per spanning tree per port	mst:M	5.1, 8.4.1, 8.4.2, 13.34	Yes [ ]
(proto)	Support an instance of spanning tree protocol per spanning tree per port	mst:M	5.1, 8.12, 13	Yes [ ]
(baddr)	Use the Bridge Group Address as specified	mst:M	5.1, 8.14.3	Yes [ ]
(default)	Support default Bridge Forward Delay and Bridge Priority parameter values as specified	mst:M	5.1, 13.23	Yes [ ]
(gvrpctx)	Support GVRP in multiple spanning tree contexts	mst:M	5.1, 11.2.3.3, 11.2.3.4	Yes [ ]
(manage)	Support VLAN bridge management for the bridge protocol entity in all supported spanning trees	mst:M	5.1, 12.8	Yes [ ]
(manag1)	Support independent management of bridge and port priority and path cost per spanning tree	mst:M	5.1, 12.8.1	Yes [ ]
(manag2)	Support VLAN management per spanning tree	mst:M	5.1, 12.10.1	Yes [ ]
(manag3)	Support MSTI configuration management	mst:M	5.1, 12.12	Yes [ ]
(mids)	Provision of identifiers for Bridge and Ports	mst:M	13.23.2, 13.24.21, {D}17.2	Yes [ ]

A.11 Multiple Spanning Tree Algorithm *(continued)*

Item	Feature	Status	References	Support
(mpar1)	Not exceed the values in {D}17.28.2 for max Bridge transit delay, max message age increment overestimate and max BPDU transmission delay	mst:M	13.36, {D}5.1, {D}17.28.2	Yes [ ]
(mpar2)	Use the value given in {D}Table 17-5 for Transmission Limit	mst:M	13, {D}5.1, {D}Table 17-5	Yes [ ]
(minc)	Inclusion of active Ports in computation of the active topology for a given spanning tree	mst:M	13, {D}17.5	Yes [ ]
(mpro)	Processing of BPDUs received on Ports included in the computation of the active topology for a given spanning tree	mst:M	13, {D}17.5	Yes [ ]
(mdis)	Discarding received frames in the Discarding state for a given spanning tree	mst:M	13, {D}17.5	Yes [ ]
(mlrn)	Incorporating station location information to the Filtering Database in the Learning and Forwarding states for a given spanning tree	mst:M	13, {D}17.5	Yes [ ]
(mnlrn)	Not incorporating station location information to the Filtering Database in the Discarding state for a given spanning tree	mst:M	13, {D}17.5	Yes [ ]
(mrlrn)	Transfer learned MAC addresses from a retiring Root Port to a new Root Port for a given spanning tree	mst:O	13, {D}17.10	Yes [ ] No [ ]
(msm)	Instances of state machines per Bridge, per Port and per spanning tree instance, as specified	mst:M	13.19	Yes [ ]
(mptmr)	Port Timers state machine support	mst:M	13.21, 13.27	Yes [ ]
(mprsm)	Port Receive state machine support	mst:M	13.21, 13.28	Yes [ ]
(mmsm)	Port Protocol Migration state machine support	mst:M	13.21, 13.29	Yes [ ]
(mptsm)	Port Transmit state machine support	mst:M	13.21, 13.30	Yes [ ]
(mpism)	Port Information state machine support	mst:M	13.21, 13.31	Yes [ ]
(mprssm)	Port Role Selection state machine support	mst:M	13.21, 13.32	Yes [ ]
(mprtsm)	Port Role Transitions state machine support	mst:M	13.21, 13.33	Yes [ ]
(mpstsm)	Port State Transition state machine support	mst:M	13.21, 13.34	Yes [ ]
(mtcsm)	Topology Change state machine support	mst:M	13.21, 13.35	Yes [ ]
(mcde)	Not support Change Detection Enabled parameter	mst:M	{D}5.2	Yes [ ]
(mestm)	Not: Underestimate the increment to the Message Age parameter in transmitted BPDUs. Underestimate Forward Delay. Overestimate the Hello Time interval.	mst:M	13.35, {D}17.28.1	Yes [ ]
(mhtim)	Use of Transmission Limit	mst:M	13.35, {D}Table 17-5	Yes [ ]
(mprel)	Enforcement of parameter relationships	mst:M	13.35, {D}17.28.2	Yes [ ]

A.11 Multiple Spanning Tree Algorithm *(continued)*

Item	Feature	Status	References	Support
(mprv)	Range and granularity of priority values	mst:M	13.35, {D}17.28.2	Yes [ ]
(mpcv)	Range and granularity of path cost values	mst:M	13.35, {D}17.28.2	Yes [ ]
	If item (16) is not supported, mark N/A and continue at (mtmr1)			N/A [ ]
(mmgt1)	Can the relative priority of the Bridge be set?	mst AND **16:**M	{D}17.2, {D}17.4, {D}17.13	Yes [ ]
(mmgt2)	Can the relative priority of the Ports be set?	mst AND **16:**M	{D}17.2, {D}17.4, {D}17.13	Yes [ ]
(mmgt3)	Can the path cost for each Port be set?	mst AND **16:**M	{D}17.2, {D}17.4, {D}17.13	Yes [ ]
	If item (17) is not supported, mark N/A and continue at (mpdu1)			N/A [ ]
*(mtmr1)	Can Bridge Max Age be set to any of the range of values specified?	mst AND **17:**M	{D}17.2, {D}17.13, {D}Table 17-5	Yes [ ]
(mtmr2)	Can Port Hello Time (13.22) be set to any of the range of values specified?	mst AND **17:**M	{D}17.2, {D}17.13, {D}Table 17-5	Yes [ ]
(mtmr3)	Can Bridge Forward Delay be set to any of the range of values specified?	mst AND **17:**M	{D}17.2, {D}17.13, {D}Table 17-5	Yes [ ]
*(mpdu1)	Do all BPDUs contain an integral number of octets?	mst:M	14.1.1	Yes [ ]
(mpdu2)	Are all the BPDU parameter types encoded as specified?	mst:M	14.2, {D}9.1.1, {D}9.2	Yes [ ]
(mpdu3)	Do Configuration BPDUs have the format, parameters, and parameter values specified?	mst:M	{D}9.3.1	Yes [ ]
(mpdu4)	Do Topology Change Notification BPDUs have the format, parameters, and parameter values specified?	mst:M	{D}9.3.2	Yes [ ]
(mpdu5)	Do Rapid Spanning Tree BPDUs have the format, parameters, and parameter values specified?	mst:M	{D}9.3.3	Yes [ ]
(mpdu6)	Do Multiple Spanning Tree BPDUs have the format, parameters, and parameter values specified?	mst:M	14.3	Yes [ ]
(mpdu7)	Are received BPDUs validated as specified?	mst:M	14.4, 14.6	Yes [ ]
(mpdu8)	Are Configuration, TCN, RST and MST BPDUs encoded and transmitted as specified?	mst:M	14.5, 14.6	Yes [ ]

A.12 Bridge Management

Item	Feature	Status	References	Support
	If item (19) is not supported, mark N/A and continue at (20c).			N/A [ ]
(19a)	Discover Bridge	**19:**M	12.4.1.1	Yes [ ]
(19b)	Read Bridge	**19:**M	12.4.1.2	Yes [ ]
(19c)	Set Bridge Name	**19:**M	12.4.1.3	Yes [ ]
(19d)	Reset Bridge	**19:**M	12.4.1.4	Yes [ ]
(19e)	Read Port	**19:**M	12.4.2.1	Yes [ ]
(19f)	Set Port Name	**19:**M	12.4.2.2	Yes [ ]
(19g)	Read Forwarding Port Counters	**19:**M	12.6.1.1	Yes [ ]
(19g.1)	Are the Forwarding Port Counters maintained per VLAN?	19:O		Yes [ ] No [ ]
(19g.2)	Does the implementation support the Discard on Error Details parameter?	19:O		Yes [ ] No[ ]
(19h)	Read Filtering Database	**19:**M	12.7.1.1	Yes [ ]
(19i)	Set Filtering Database Ageing Time	**19:**M	12.7.1.2	Yes [ ]
(19j)	Read Permanent Database	**19:**M	12.7.6.1	Yes [ ]
(19k)	Create Filtering Entry	**19:**M	12.7.7.1	Yes [ ]
(19l)	Delete Filtering Entry	**19:**M	12.7.7.2	Yes [ ]
(19m)	Read Filtering Entry	**19:**M	12.7.7.3	Yes [ ]
(19n)	Read Filtering Entry Range	**19:**M	12.7.7.4	Yes [ ]
(19o)	Read CIST Bridge Protocol Parameters	**19:**M	12.8.1.1	Yes [ ]
(m19o)	Read MSTI Bridge Protocol Parameters	19 AND mst:M	12.8.1.2	Yes [ ] N/A [ ]
(19p)	Set CIST Bridge Protocol Parameters	**19:**M	12.8.1.3	Yes [ ]
(m19p)	Set MSTI Bridge Protocol Parameters	**19** AND mst**:**M	12.8.1.4	Yes [ ] N/A [ ]
(19q)	Read CIST Port Parameters	**19:**M	12.8.2.1	Yes [ ]
(m19q)	Read MSTI Port Parameters	**19** AND mst**:**M	12.8.2.2	Yes [ ] N/A [ ]
(19r)	Force CIST Port State	**19:**M	12.8.2.3	Yes [ ]
(m19r)	Force MSTI Port State	**19** AND mst**:**M	12.8.2.4	Yes [ ] N/A [ ]
(19s)	Set CIST Port Parameters	**19:**M	12.8.2.5	Yes [ ]
(m19s)	Set MSTI Port Parameters	**19** AND mst**:**M	12.8.2.6	Yes [ ] N/A [ ]
(migr)	Force BPDU Migration Check	19 AND (rst OR mst):M	12.8.2.7	Yes [ ] N/A [ ]

A.12 Bridge Management *(continued)*

Item	Feature	Status	References	Support
(19t)	Read Port Default User Priority	MS4:M	12.6.2.1	Yes [ ] N/A [ ]
(19u)	Set Port Default User Priority	MS4:M	12.6.2.2	Yes [ ] N/A [ ]
(19v)	Read Port User Priority Regeneration Table	MS5:M	12.6.2.3	Yes [ ] N/A [ ]
(19w)	Set Port User Priority Regeneration Table	MS5:M	12.6.2.4	Yes [ ] N/A [ ]
(19x)	Read Port Traffic Class Table	MS7:M	12.6.3.1	Yes [ ] N/A [ ]
(19y)	Set Port Traffic Class Table	MS7:M	12.6.3.2	Yes [ ] N/A [ ]
(19z)	Read Outbound Access Priority Table	MS6:M	12.6.2.5	Yes [ ] N/A [ ]
(19aa)	Read GARP Timers	MS8:M	12.9.1.1	Yes [ ] N/A [ ]
(19ab)	Set GARP Timers	MS8:M	12.9.1.2	Yes [ ] N/A [ ]
(19ac)	Read GARP Protocol Controls	MS8:M	12.9.2.1	Yes [ ] N/A [ ]
(19ad)	Set GARP Protocol Controls	MS8:M	12.9.2.2	Yes [ ] N/A [ ]
(19ae)	Read GARP State	MS8:M	12.9.3.1	Yes [ ] N/A [ ]
(19af)	Read Bridge VLAN Configuration	19:M	12.10.1.1	Yes [ ] N/A [ ]
(19ah)	Configure PVID values	19:M	12.10.1.2	Yes [ ] N/A [ ]
(19ai)	Configure Acceptable Frame Types parameter	23a.2:M	12.10.1.3	Yes [ ] N/A [ ]
(19aj)	Configure Enable Ingress Filtering parameters	23g:M	12.10.1.4	Yes [ ] N/A [ ]
(19ak)	Reset Bridge VLAN Bridge.	19:M	12.10.1.5	Yes [ ] N/A [ ]
(19al)	Notify VLAN Registration Failure	19:M	12.10.1.6	Yes [ ] N/A [ ]
(19am)	Read VLAN Configuration	19:M	12.10.2.1	Yes [ ] N/A [ ]
(19an)	Create VLAN Configuration	19:M	12.10.2.2	Yes [ ] N/A [ ]
(19ao)	Delete VLAN Configuration	19:M	12.10.2.3	Yes [ ] N/A [ ]
	If item (mst) is not supported, mark N/A and continue at (19ap)			N/A [ ]
(rmst)	Read MSTI List	19 AND mst:M	12.12.1.1	Yes [ ]
(cmst)	Create MSTI	19 AND mst:M	12.12.1.2	Yes [ ]
(dmst)	Delete MSTI	19 AND mst:M	12.12.1.3	Yes [ ]
(rfmst)	Read FID to MSTI allocation	19 AND mst:M	12.12.2.1	Yes [ ]
(sfmst)	Set FID to MSTI allocation	19 AND mst:M	12.12.2.2	Yes [ ]
(rmste)	Read MST Configuration Table Element	19 AND mst:M	12.12.3.1	Yes [ ]
(rmstv)	Read VIDs assigned to MSTID	19 AND mst:M	12.12.3.2	Yes [ ]

A.12 Bridge Management *(continued)*

Item	Feature	Status	References	Support
(rmstc)	Read MSTI Configuration Identifier	19 AND mst:M	12.12.3.3	Yes [ ]
(smstc)	Set MSTI Configuration Identifier	19 AND mst:M	12.12.3.4	Yes [ ]
	If Item (23e.6) is not supported, mark N/A and continue at Item (19at).			N/A
(19ap)	Read VLAN Learning Constraints	23e.6:M	12.10.3.1	Yes [ ]
(19aq)	Read VLAN Learning Constraints for VID	23e.6:M	12.10.3.2	Yes [ ]
(19aq)	Set VLAN Learning Constraint	23e.6:M	12.10.3.3	Yes [ ]
(19ar)	Delete VLAN Learning Constraint	23e.6:M	12.10.3.4	Yes [ ]
(19as)	Notify Learning Constraint Violation	23e.6:M	12.10.3.10	Yes [ ]
	If Item (23e.8) is not supported, mark N/A and continue at Item (20c).			N/A
(19at)	Read VID to FID allocations	23e.8:M	12.10.3.5	Yes [ ]
	Read FID allocation for VID	23e.8:M	12.10.3.6	Yes [ ]
	Read VIDs allocated to FID	23e.8:M	12.10.3.7	Yes [ ]
	Set VID to FID allocation	23e.8:M	12.10.3.8	Yes [ ]
	Delete VID to FID allocation	23e.8:M	12.10.3.9	Yes [ ]
	If item (20a) is not supported, mark N/A and continue at (20e).			N/A [ ]
(20c)	What Management Protocol standard(s) or specification(s) are supported?	**20a:**M	{D}5	
(20d)	What standard(s) or specifications for Managed Objects and Encodings are supported?	**20a:**M	{D}5	
	If item (20b) is not supported, mark N/A and continue at A.11.			N/A [ ]
(20e)	What specification of the local management interface is supported?	**20b:**M	{D}5	

Predicates:
MS4=19 AND 4a
MS5=19 AND 4b
MS6=19 AND 4
MS7=19 AND 4c
MS8=19 AND 2b

A.13 Performance

Item	Feature	Status	References	Support
(21a)	Specify a Guaranteed Port Filtering Rate, and the associated measurement interval *TF*, for each Bridge Port in the format specified below.	M	{D}16.1	
(21b)	Specify a Guaranteed Bridge Relaying Rate, and the associated measurement interval *TR*, in the format specified below. Supplementary information shall clearly identify the Ports.	M	{D}16.2	

Guaranteed Bridge Relaying Rate	TR
_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)

Port number(s) or other identification	Guaranteed port filtering rate (specify for all ports)	T_F (specify for all ports)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)

A.14 GARP and GMRP

Item	Feature	Status	References	Support
	If Item 2b is not supported, mark N/A and continue at item (22i).			N/A [ ]
(22a)	Is the GMRP Application address used as the destination MAC Address in all GMRP protocol exchanges?	2b:M	{D}10.4.1, {D}Table 12-1	Yes [ ]
(22b)	Are GMRP protocol exchanges achieved by means of LLC Type 1 procedures, using the LLC address for Spanning Tree protocol?	2b:M	{D}12.4, {D}12.5, {D}Table 7-8	Yes [ ]

A.14 GARP and GMRP *(continued)*

Item	Feature	Status	References	Support
(22c)	Are GMRP protocol exchanges achieved using the GARP PDU formats, and the definition of the attribute type and value encodings defined for GMRP?	2b:M	10, {D}10.3.1, {D}12.4, {D}12.5, {D}12.11	Yes [ ]
(22d)	Does the implementation support the operation of the Applicant, Registrar, and Leave All state machines?	2b:M	{D}12.8	Yes [ ]
(22e)	Does the Bridge propagate registration GMRP information only on Ports that are part of the active topology of the GIP Context for the VLAN on which the registration was received?	2b:M	10, {D}12.3.3, {D}12.3.4	Yes [ ]
(22f)	Are GARP PDUs received on Ports that are in the Forwarding State forwarded, filtered or discarded in accordance with the requirements for handling GARP Application addresses?	2b:M	{D}7.12.3, {D}12.5	Yes [ ]
(22g)	Does the GMRP application operate as defined in Clause 10 of ISO/IEC 15802-3, as modified by Clause 10 of this standard?	2b:M	10, {D}10, {D}10.3	Yes [ ]
(22h)	Are received GARP PDUs that are not well formed for any GARP Applications supported, discarded?	2b:M	10, {D}10.3.1, {D}12.4, {D}12.5, {D}12.10, {D}12.11	Yes [ ]
(22i)	Does the implementation support the use of the Restricted Group Registration parameter for each Port?	2b:O	5.2, {D}10.3.2	Yes [ ] No [ ]
(22j)	Are all GARP PDUs that are (a) Received on Ports that are in the Forwarding State, and are (b) Destined for GARP applications that the Bridge does not support, forwarded on all other Ports that are in Forwarding?	M	8.14.3, {D}12.5	Yes [ ]
(22k)	Are any GARP PDUs that are (a) Received on any Port, and (b) Destined for GARP applications that the Bridge does not support, submitted to any GARP Participants?	X	8.14.3, {D}12.5	No [ ]
(22l)	Are any GARP PDUs that are (a) Received on any Ports that are not in the Forwarding State, and are (b) Destined for GARP applications that the Bridge does not support, forwarded on any other Ports of the Bridge?	X	8.14.3, {D}12.5	No [ ]

A.14 GARP and GMRP *(continued)*

Item	Feature	Status	References	Support
(22m)	Are any GARP PDUs that are (a) Received on any Ports that are in the Forwarding State, and are (b) Destined for GARP applications that the Bridge supports, forwarded on any other Ports of the Bridge?	X	8.14.3, {D}12.5	No [ ]
(22n)	Are all GARP PDUs that are: (a) Received on any Port, and (b) Destined for GARP applications that the Bridge supports, submitted to the appropriate GARP Participants?	M	8.14.3, {D}12.5	Yes [ ]
22o	Are all GARP PDUs received on disabled Ports discarded?	M	{D}12.2	Yes [ ]

A.15 VLAN support

Item	Feature	Status	References	Support	
	Ingress rules				
(24a)	Can the PVID or the VID in any member of the VID Set for any Port be assigned the value of the null VLAN ID?	X	8.4.4, Table 9-2	No [ ]	
(24b)	Are frames discarded (or not discarded) in accordance with the settings of the Acceptable Frame Types parameters?	M	8.6.1	Yes [ ]	
(24c)	Are all frames received classified as belonging to exactly one VLAN, as defined in the ingress rules?	M	8.6.1	Yes [ ]	
(24d)	Is Ingress Filtering performed in accordance with the value of the Enable Ingress Filtering parameter?	M	8.6.1	Yes [ ]	
(24e)	Are all frames that are not discarded as a result of the application of the ingress rules submitted to the Forwarding Process and to the Learning Process?	M	8.6.1	Yes [ ]	
(24f)	State which Ports support Port-and-Protocol-based classification rules.	23l:M	8.4.4	Ports:	_____
(24f.1)	For each Port that supports Port-and-Protocol-based classification rules, is a VID Set supported?	23l:M	8.4.4	Port: Yes [ ]	_____ N/A [ ]
(24f.2)	For each Port that supports Port-and-Protocol-based classification rules, state how many entries are supported in the VID Set.	23l:M	8.4.4	Port: _____	_____ Entries
(24f.3)	For each Port that supports Port-and-Protocol-based classification rules, is the VID Set configurable via management?	23l:M	12.10.1.2	Port: Yes [ ]	_____ N/A [ ]

A.15 VLAN support *(continued)*

Item	Feature	Status	References	Support	
(24g.1)	State how many entries are supported in the Protocol Group Database.	23m:M	8.9.4	Entries	_____
(24g.2)	Is the Protocol Group Database configurable via management?	23m:O	12.10.2.1	Yes [ ]	No [ ]
(24g.3)	Does the Protocol Group Database support entries of format Ethernet?	23m:O	8.9.4	Yes [ ]	No [ ]
(24g.4)	Does the Protocol Group Database support entries of format RFC_1042?	23m:O	8.9.4	Yes [ ]	No [ ]
(24g.5)	Does the Protocol Group Database support entries of format SNAP_8021H?	23m:O	8.9.4	Yes [ ]	No [ ]
(24g.6)	Does the Protocol Group Database support entries of format SNAP_Other?	23m:O	8.9.4	Yes [ ]	No [ ]
(24g.7)	Does the Protocol Group Database support entries of format LLC_Other?	23m:O	8.9.4	Yes [ ]	No [ ]
(24g.8)	Does the Protocol Group Database support entries of at least one of the following formats: Ethernet, RFC_1042, SNAP_8021H, SNAP_Other, LLC_Other?	23m: M	8.9.4	Yes [ ]	
	Egress rules				
(25a)	Are frames discarded if the transmission Port is not present in the Member set for the frame's VID?	M	8.6.4, 8.10.9	Yes [ ]	
(25b)	Are frames discarded if the value of the include_tag parameter is False, and the Bridge does not support the ability to translate embedded MAC Address information from the format indicated by the canonical_format_indicator parameter to the format appropriate to the media type on which the data request will be carried?	23j.2:M	8.6.4	Yes [ ]	N/A [ ]
(25c)	Are frames transmitted as VLAN-tagged frames or as untagged frames in accordance with the value of the untagged set for the frame's VID?	M	8.6.4	Yes [ ]	
	Filtering Database				
(26a)	Does the implementation support Static VLAN Registration Entries as defined in 8.11.2?	M	8.10.2	Yes [ ]	
(26b)	Does the implementation support the creation of a separate Static VLAN Registration Entry with a distinct Port Map for each VLAN from which frames are received by the Forwarding Process?	O	8.10.2	Yes [ ]	No [ ]
(26c)	Does the implementation support Dynamic VLAN Registration Entries as defined in 8.11.5?	M	8.10.5	Yes [ ]	

A.15 VLAN support *(continued)*

Item	Feature	Status	References	Support
(26d)	Does the implementation support the creation of a separate Dynamic VLAN Registration Entry with a distinct Port Map for each VLAN from which frames are received by the Forwarding Process?	O	8.10.5	Yes [ ] No [ ]
(26e)	Does the implementation allocate VIDs to FIDs in accordance with the specification in 8.11.7?	M	8.10.7, 8.10.7.2	Yes [ ]
(26f)	Does the implementation correctly detect Learning Constraint violations?	M	8.10.7.3	Yes [ ]
(26g)	Is determination of the Member set and the untagged set for a given VLAN achieved as defined in 8.11.9?	M	8.10.9	Yes [ ]
	Tagged frames			
(27a)	Do VLAN-tagged frames transmitted by the Bridge conform to the format defined in Clause 9 for the MAC type on which they are transmitted?	M	9	Yes [ ]
(27b)	Are all BPDUs transmitted untagged?	M	8.14.7	Yes [ ]
	VLAN use of GMRP. If item (2b) is not supported, mark N/A and continue at item (29a).			N/A [ ]
(28a)	Does the implementation of GMRP recognize the use of VLAN Contexts for the transmission and reception of GMRP PDUs?	2b:M	10, 10.1, 10.2 10.3	Yes [ ]
(28b)	Does the implementation of GMRP support the creation of distinct GMRP Participants for each VLAN context?	2b:M	10.2	Yes [ ]
(28c)	Does the implementation support the identification of VLAN contexts in transmitted GMRP PDUs by means of VLAN-tagged or untagged frames, in accordance with the member set and untagged set for the VLAN Context concerned?	2b:M	10.3	Yes [ ]
(28d)	Are GMRP PDUs transmitted only on Ports that are part of the active topology for the VLAN Context concerned?	2b:M	10.1	Yes [ ]
	VLAN Topology Management			
(29a)	Does the implementation support the creation, updating and removal of Dynamic VLAN Registration Entries in the Filtering Database under the control of GVRP?	M	11	Yes [ ]
(29b)	Does the Permanent Database contain an entry for the Default VID that defines Registration Fixed on all Ports?	O	11.2.1.3	Yes [ ] No [ ]
(29c)	Is the GVRP Application address used as the destination MAC Address in all GVRP protocol exchanges?	M	11, Table 11-1	Yes [ ]

A.15 VLAN support *(continued)*

Item	Feature	Status	References	Support	
(29d)	Are GVRP protocol exchanges achieved by means of LLC Type 1 procedures, using the LLC address for Spanning Tree protocol?	M	11, {D}12.4, {D}12.5, {D}Table 7-8	Yes [ ]	
(29e)	Are GVRP protocol exchanges achieved using the GARP PDU formats, and the definition of the attribute type and value encodings defined for GVRP?	M	11, 11.2.3.1, {D}12.4, {D}12.5, {D}12.11	Yes [ ]	
(29f)	Does the implementation support the operation of the Applicant, Registrar, and Leave All state machines?	M	{D}12.8	Yes [ ]	
(29g)	Does the Bridge propagate registration GVRP information only on Ports that are part of the active topology of the base Spanning Tree Context?	M	11, {D}12.3.3, {D}12.3.4	Yes [ ]	
(29h)	Does the GVRP application operate as defined in Clause 11?	M	11	Yes [ ]	
(29i)	Does the implementation support the use of the Restricted VLAN Registration parameter?	O	5.2, 11.2.3.2.2, 11.2.3.2.3	Yes [ ]	No [ ]

Annex E

(informative)

Interoperability considerations

E.6 Intermixing IEEE Std 802.1Q Version 1.0 bridges with future IEEE P802.1Q bridges

Delete E.6.3.

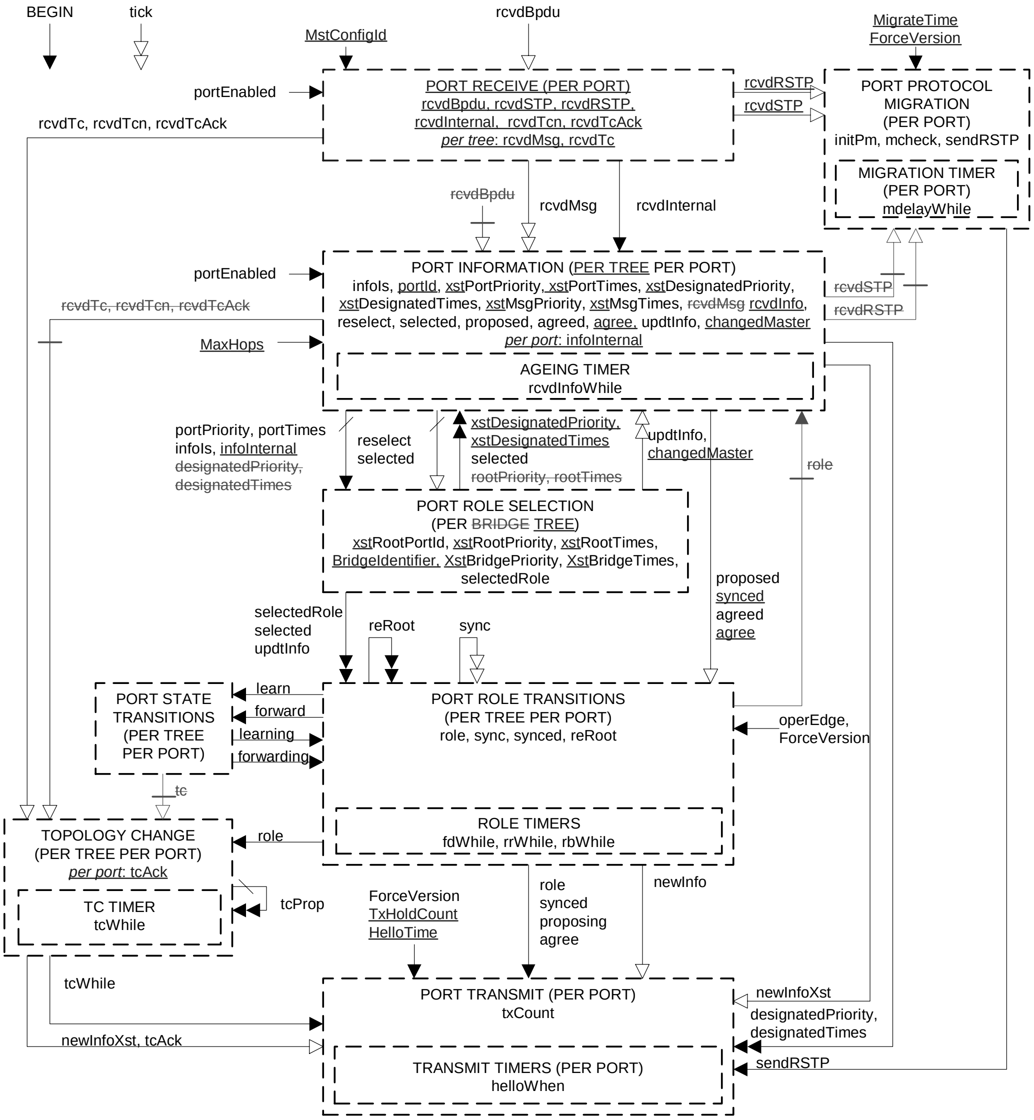
Insert new Annex G, as follows:

Annex G

(informative)

Differences between 802.1s and 802.1w state machines

This annex documents the differences between the RSTP state machines defined in Clause 17 of IEEE Std 802.1w-2001 and the MSTP state machines defined in Clause 13. The differences are illustrated by means of redline and ~~strikeout~~ markings, showing the changes made to the RSTP state machines in order to create the MSTP state machines.



NOTE 1: For convenience all timers are collected together into one state machine.

NOTE 2: This overview diagram is not itself a state machine, but serves to illustrate the principal variables that are used to communicate between the individual RST state machines and the variables local to each machine.

Figure G-1—MSTP state machines - overview and relationships

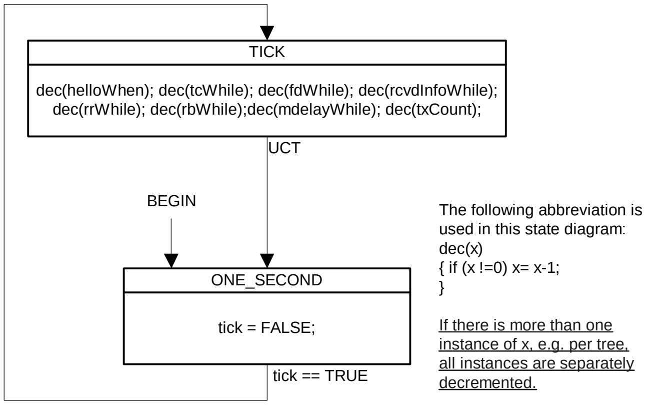

TICK
dec(helloWhen); dec(tcWhile); dec(fdWhile); dec(rcvdInfoWhile);
dec(rrWhile); dec(rbWhile);dec(mdelayWhile); dec(txCount);
UCT
BEGIN
ONE_SECOND
tick = FALSE;
tick == TRUE
The following abbreviation is used in this state diagram:
dec(x)
{ if (x !=0) x= x-1;
}
If there is more than one instance of x, e.g. per tree, all instances are separately decremented.

Figure G-2—Port Timers state machine

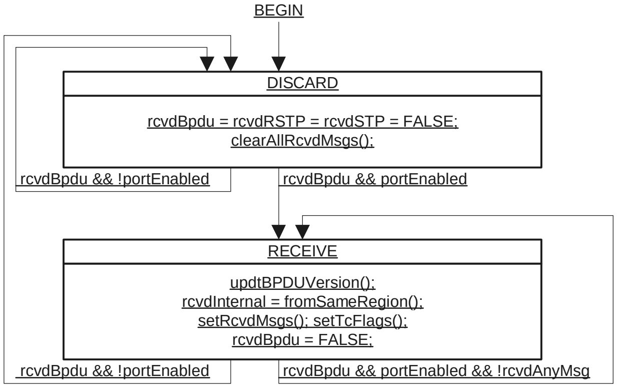
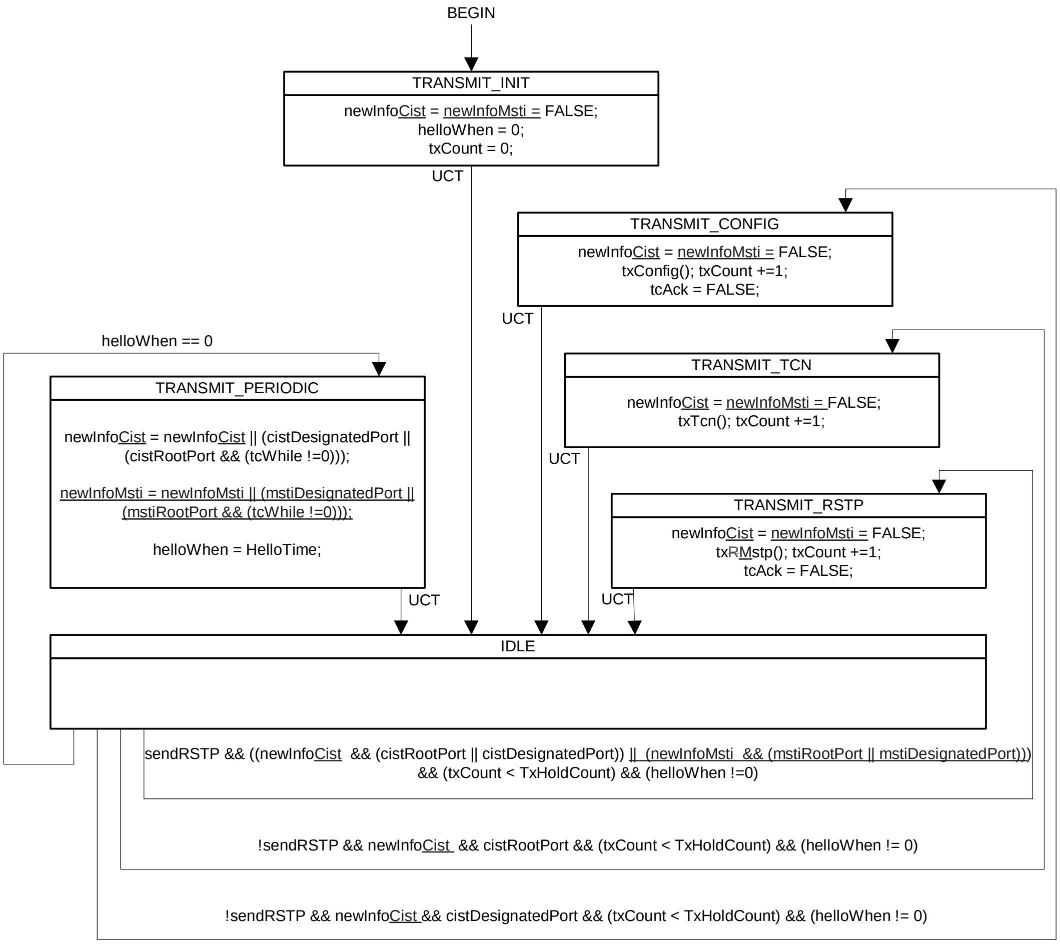


Figure G-3—Port Receive state machine


BEGIN
TRANSMIT_INIT
newInfoCist = newInfoMsti = FALSE;
helloWhen = 0;
txCount = 0;
UCT
TRANSMIT_CONFIG
newInfoCist = newInfoMsti = FALSE;
txConfig(); txCount +=1;
tcAck = FALSE;
UCT
helloWhen == 0
TRANSMIT_TCN
newInfoCist = newInfoMsti = FALSE;
txTcn(); txCount +=1;
TRANSMIT_PERIODIC
newInfoCist = newInfoCist || (cistDesignatedPort ||
(cistRootPort && (tcWhile !=0)));
newInfoMsti = newInfoMsti || (mstiDesignatedPort ||
(mstiRootPort && (tcWhile !=0)));
helloWhen = HelloTime;
UCT
TRANSMIT_RSTP
newInfoCist = newInfoMsti = FALSE;
txRMstp(); txCount +=1;
tcAck = FALSE;
UCT
UCT
IDLE
sendRSTP && ((newInfoCist && (cistRootPort || cistDesignatedPort)) || (newInfoMsti && (mstiRootPort || mstiDesignatedPort)))
&& (txCount < TxHoldCount) && (helloWhen !=0)
!sendRSTP && newInfoCist && cistRootPort && (txCount < TxHoldCount) && (helloWhen != 0)
!sendRSTP && newInfoCist && cistDesignatedPort && (txCount < TxHoldCount) && (helloWhen != 0)

All transtions, except UCT, are qualified by "&& selected &&!updtInfo".

Figure G-4—Port Transmit state machine

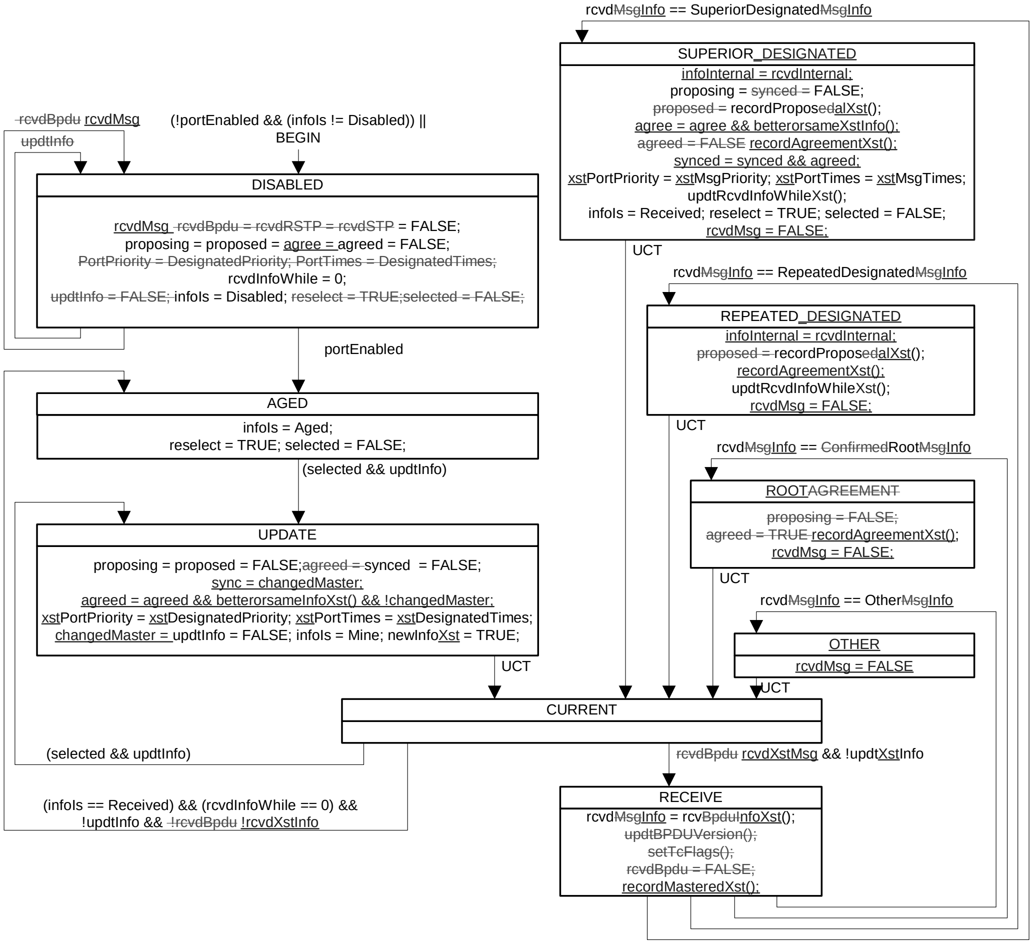

~~rcvdBpdu~~ rcvdMsg
~~updtInfo~~
(!portEnabled && (infoIs != Disabled)) ||
BEGIN
DISABLED
rcvdMsg ~~rcvdBpdu = rcvdRSTP = rcvdSTP~~ = FALSE;
proposing = proposed = agree = agreed = FALSE;
~~PortPriority = DesignatedPriority; PortTimes = DesignatedTimes;~~
rcvdInfoWhile = 0;
~~updtInfo = FALSE;~~ infoIs = Disabled; ~~reselect = TRUE;selected = FALSE;~~
portEnabled
AGED
infoIs = Aged;
reselect = TRUE; selected = FALSE;
(selected && updtInfo)
UPDATE
proposing = proposed = FALSE;~~agreed =~~ synced = FALSE;
sync = changedMaster;
agreed = agreed && betterorsameInfoXst() && !changedMaster;
xstPortPriority = xstDesignatedPriority; xstPortTimes = xstDesignatedTimes;
changedMaster = updtInfo = FALSE; infoIs = Mine; newInfoXst = TRUE;
UCT
CURRENT
(selected && updtInfo)
(infoIs == Received) && (rcvdInfoWhile == 0) &&
!updtInfo && ~~!rcvdBpdu~~ !rcvdXstInfo
rcvd~~Msg~~Info == SuperiorDesignated~~Msg~~Info
SUPERIOR_DESIGNATED
infoInternal = rcvdInternal;
proposing = ~~synced =~~ FALSE;
~~proposed =~~ recordPropos~~ed~~alXst();
agree = agree && betterorsameXstInfo();
~~agreed = FALSE~~ recordAgreementXst();
synced = synced && agreed;
xstPortPriority = xstMsgPriority; xstPortTimes = xstMsgTimes;
updtRcvdInfoWhileXst();
infoIs = Received; reselect = TRUE; selected = FALSE;
rcvdMsg = FALSE;
UCT
rcvd~~Msg~~Info == RepeatedDesignated~~Msg~~Info
REPEATED_DESIGNATED
infoInternal = rcvdInternal;
~~proposed =~~ recordPropos~~ed~~alXst();
recordAgreementXst();
updtRcvdInfoWhileXst();
rcvdMsg = FALSE;
UCT
rcvd~~Msg~~Info == ~~Confirmed~~Root~~Msg~~Info
ROOT~~AGREEMENT~~
~~proposing = FALSE;~~
~~agreed = TRUE~~ recordAgreementXst();
rcvdMsg = FALSE;
UCT
rcvd~~Msg~~Info == Other~~Msg~~Info
OTHER
rcvdMsg = FALSE
UCT
~~rcvdBpdu~~ rcvdXstMsg && !updtXstInfo
RECEIVE
rcvd~~Msg~~Info = rcv~~Bpdu~~InfoXst();
~~updtBPDUVersion();~~
~~setTcFlags();~~
~~rcvdBpdu = FALSE;~~
recordMasteredXst();

Figure G-5—Port Information state machine

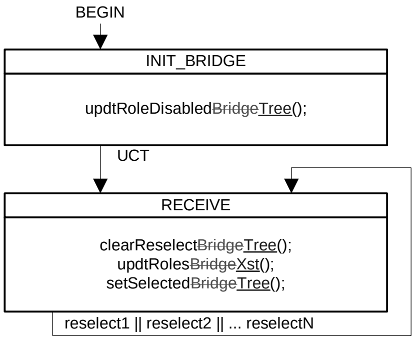

BEGIN
INIT_BRIDGE
updtRoleDisabled~~Bridge~~Tree();
UCT
RECEIVE
clearReselect~~Bridge~~Tree();
updtRoles~~Bridge~~Xst();
setSelected~~Bridge~~Tree();
reselect1 || reselect2 || ... reselectN

Figure G-6—Port Role Selection

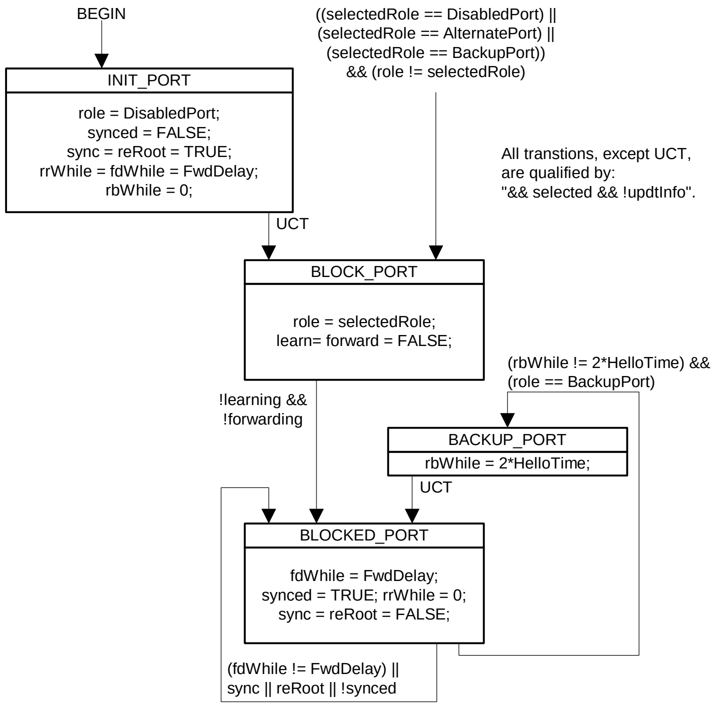
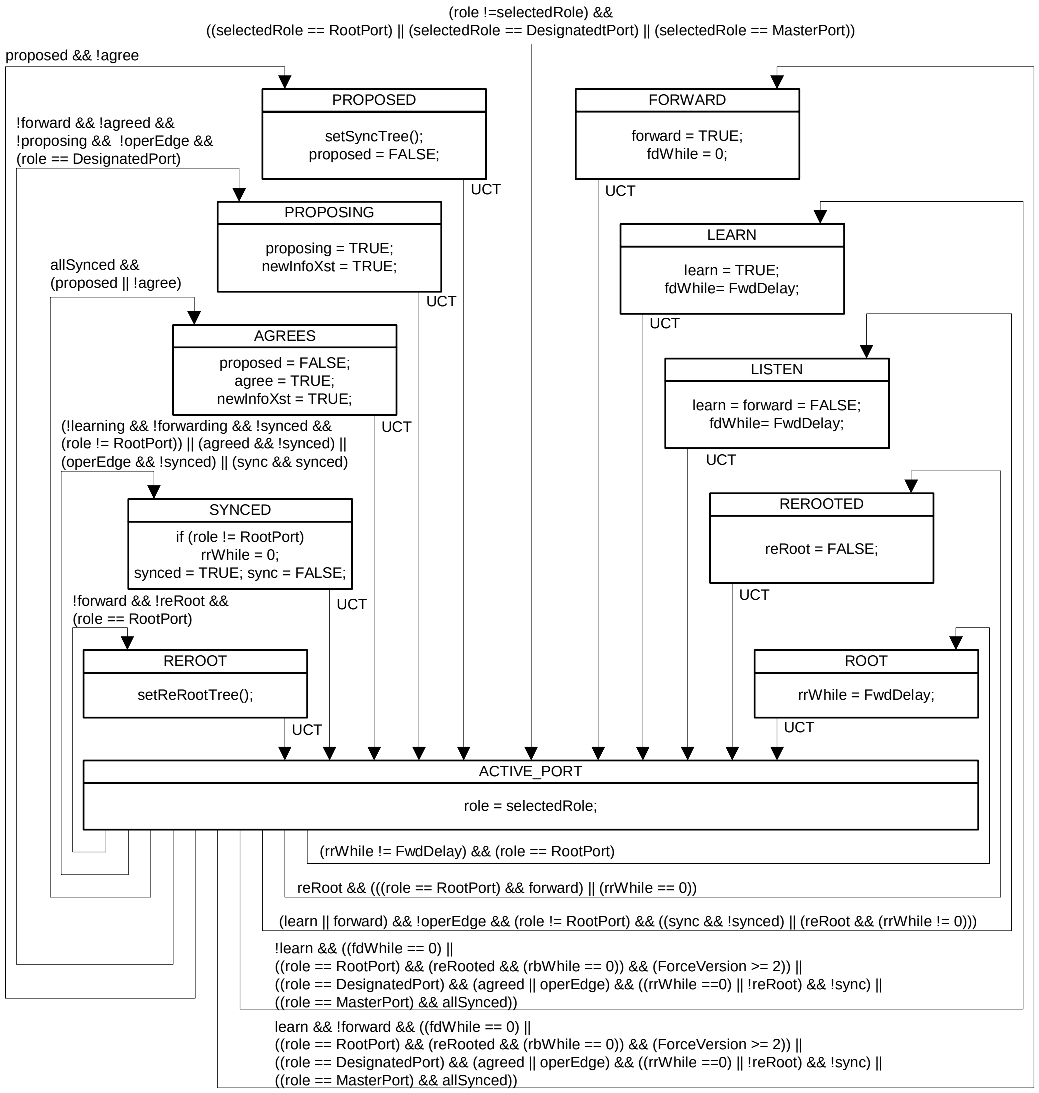


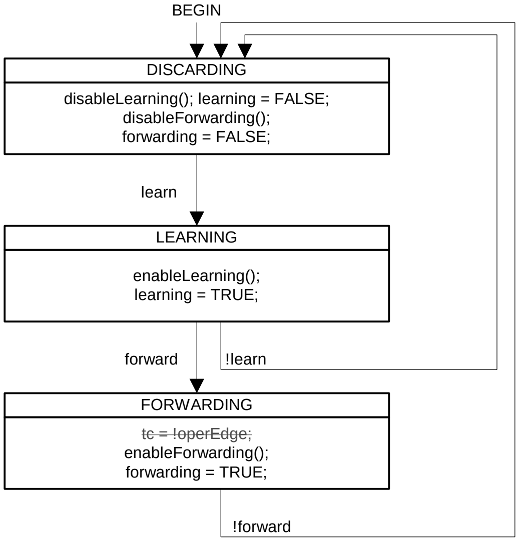
**Figure G-7—Port Role Transitions state machine—
Part 1: Disabled, Alternate, and Backup Roles**


(role !=selectedRole) &&
((selectedRole == RootPort) || (selectedRole == DesignatedtPort) || (selectedRole == MasterPort))
proposed && !agree
PROPOSED
setSyncTree();
proposed = FALSE;
UCT
FORWARD
forward = TRUE;
fdWhile = 0;
UCT
!forward && !agreed &&
!proposing && !operEdge &&
(role == DesignatedPort)
PROPOSING
proposing = TRUE;
newInfoXst = TRUE;
UCT
LEARN
learn = TRUE;
fdWhile= FwdDelay;
UCT
allSynced &&
(proposed || !agree)
AGREES
proposed = FALSE;
agree = TRUE;
newInfoXst = TRUE;
UCT
LISTEN
learn = forward = FALSE;
fdWhile= FwdDelay;
UCT
(!learning && !forwarding && !synced &&
(role != RootPort)) || (agreed && !synced) ||
(operEdge && !synced) || (sync && synced)
SYNCED
if (role != RootPort)
rrWhile = 0;
synced = TRUE; sync = FALSE;
UCT
REROOTED
reRoot = FALSE;
UCT
!forward && !reRoot &&
(role == RootPort)
REROOT
setReRootTree();
UCT
ROOT
rrWhile = FwdDelay;
UCT
ACTIVE_PORT
role = selectedRole;
(rrWhile != FwdDelay) && (role == RootPort)
reRoot && (((role == RootPort) && forward) || (rrWhile == 0))
(learn || forward) && !operEdge && (role != RootPort) && ((sync && !synced) || (reRoot && (rrWhile != 0)))
!learn && ((fdWhile == 0) ||
((role == RootPort) && (reRooted && (rbWhile == 0)) && (ForceVersion >= 2)) ||
((role == DesignatedPort) && (agreed || operEdge) && ((rrWhile ==0) || !reRoot) && !sync) ||
((role == MasterPort) && allSynced))
learn && !forward && ((fdWhile == 0) ||
((role == RootPort) && (reRooted && (rbWhile == 0)) && (ForceVersion >= 2)) ||
((role == DesignatedPort) && (agreed || operEdge) && ((rrWhile ==0) || !reRoot) && !sync) ||
((role == MasterPort) && allSynced))

All transtions, except UCT, are qualified by "&& selected && !updtInfo".

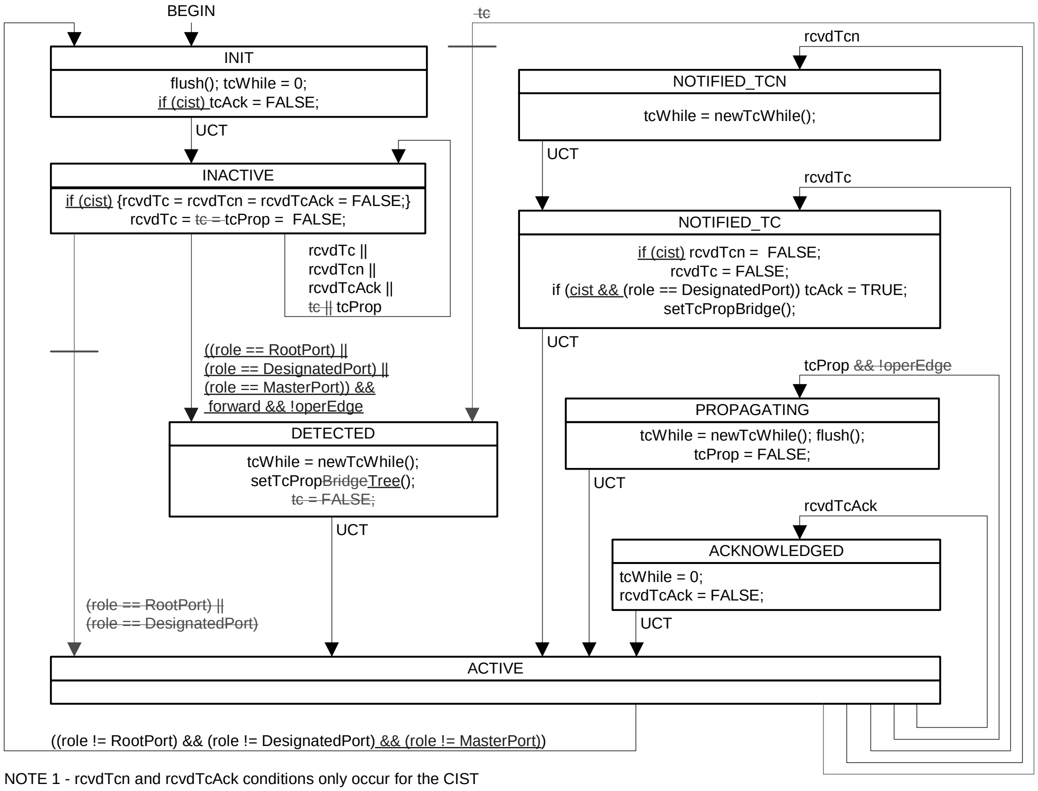
**Figure G-8—Port Role Transitions state machine—
Part 2: Root, Designated, and Master Roles**

NOTE—Figure G-8 combines the Root Port and Designated Port role figures from the RSTP definition in IEEE Std 802.1w-2001; the differences between this figure and the RSTP figures are therefore not shown.



NOTE: A small system dependent delay may occur on each of the transitions shown.

Figure G-9—Port State Transition state machine



NOTE 1 - rcvdTcn and rcvdTcAck conditions only occur for the CIST
NOTE 2 - The flush() procedure, when called on a transition from ACTIVE to INIT, should take account of any system dependent delay associated with port state transitions

Figure G-10—Topology Change state machine