

IEEE Std 802.1Q™, 2012 Edition

(Incorporating IEEE Std 802.1Q™-2011, IEEE Std 802.1Qbe™-2011, IEEE Std 802.1Qbc™-2011, IEEE Std 802.1Qbb™-2011, IEEE Std 802.1Qaz™-2011, IEEE Std 802.1Qbf™-2011, IEEE Std 802.1Qbg™-2012, IEEE Std 802.1aq™-2012, and IEEE Std 802.1Q™-2011/Cor 2-2012)

IEEE Standard for Local and metropolitan area networks—

Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks

Sponsor

**LAN/MAN Standards Committee
of the
IEEE Computer Society**

Copyright © 2012 by the Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street
New York, NY 10017, USA
All rights reserved.

All rights reserved. This document is an unapproved draft of a proposed IEEE Standard. As such, this document is subject to change. **USE AT YOUR OWN RISK!** Because this is an unapproved draft, this document must not be utilized for any conformance/compliance purposes. Permission is hereby granted for IEEE Standards Committee participants to reproduce this document for purposes of IEEE standardization activities only. Prior to submitting this document to another standards development organization for standardization activities, permission must first be obtained from the Manager, Standards Licensing and Contracts, IEEE Standards Activities Department. Other entities seeking permission to reproduce this document, in whole or in part, must obtain permission from the Manager, Standards Licensing and Contracts, IEEE Standards Activities Department.

IEEE Standards Department
Copyright and Permissions
445 Hoes Lane, P.O. Box 1331

Abstract: This standard specifies how the MAC Service is supported by Virtual Bridged Local Area Networks, the principles of operation of those networks, and the operation of VLAN-aware Bridges, including management, protocols, and algorithms.

Keywords: Bridged Local Area Networks, local area networks (LANs), MAC Bridges, metropolitan area networks, Multiple Spanning Tree Protocol (MSTP), Rapid Spanning Tree Protocol (RSTP), Virtual Bridged Local Area Networks (virtual LANs), Provider Bridged Local Area Networks, Shortest Path Bridging (SPB) Protocol

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied **“AS IS.”**

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation, or every ten years for stabilization. When a document is more than five years old and has not been reaffirmed, or more than ten years old and has not been stabilized, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon his or her independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration. A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal interpretation of the IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Recommendations to change the status of a stabilized standard should include a rationale as to why a revision or withdrawal is required. Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854-4141
USA

Authorization to photocopy portions of any individual standard for internal or personal use is granted by the Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; (978) 750-8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

This introduction is not part of IEEE Std 802.1Q, 2012 Edition, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks.

Please be advised IEEE Std 802.1Q, 2012 Edition is for convenience of the user only. It does not supersede the individual published documents listed below.

IEEE Standard 802.1Q, 2012 Edition, incorporates the text of the following amendments into that of the IEEE Std 802.1Q–2011 revision.

IEEE Std 802.1Qbe–2011	Multiple I-SID Registration Protocol
IEEE Std 802.1Qbc–2011	Provider Bridging—Remote Customer Service Interfaces
IEEE Std 802.1Qbb–2011	Priority-based Flow Control
IEEE Std 802.1Qaz–2011	Enhanced Transmission Selection for Bandwidth Sharing Between Traffic Classes
IEEE Std 802.1Qbf–2011	PBB–TE Infrastructure Segment Protection
IEEE Std 802.1Qbg–2011	Edge Virtual Bridging
IEEE Std 802.1Qaq–2011	Shortest Path Bridging
IEEE Std 802.1Q–2011/Cor 2–2012	Technical and editorial corrections

The IEEE Std 802.1Q–2011 revision of this standard incorporated the text of the following amendments into that of the IEEE Std 802.1Q™–2005 revision.

IEEE Std 802.1ad™–2005	Provider Bridges
IEEE Std 802.1ak™–2007	Multiple Registration Protocol
IEEE Std 802.1ag™–2007	Connectivity Fault Management
IEEE Std 802.1ah™–2008	Provider Backbone Bridges
IEEE Std 802.1Q–2005/Cor-1–2008	Corrections to the Multiple Registration Protocol
IEEE Std 802.1ap™–2008	Management Information Base (MIB) Definitions for VLAN Bridges
IEEE Std 802.1Qaw™–2009	Management of Data Driven and Data Dependent Connectivity Faults
IEEE Std 802.1Qay™–2009	Provider Backbone Bridge Traffic Engineering
IEEE Std 802.1aj™–2009	Two-Port Media Access Control (MAC) Relay
IEEE Std 802.1Qav™–2009	Forwarding and Queuing Enhancements for Time-Sensitive Streams
IEEE Std 802.1Qau™–2010	Congestion Notification
IEEE Std 802.1Qat™–2010	Stream Reservation Protocol

Clause 13 of IEEE Std 802.1Q–2011 was also revised to include an updated specification of the Rapid Spanning Tree Protocol (RSTP), superseding references to IEEE Std 802.1D–2004.

The IEEE Std 802.1Q–2005 revision of this standard incorporated the text of the following amendments into that of IEEE Std 802.1Q–1998.

IEEE Std 802.1u™–2001	Technical and Editorial Corrections
IEEE Std 802.1v™–2001	VLAN Classification by Protocol and Port
IEEE Std 802.1s™–2002	Multiple Spanning Trees

This standard was first published as IEEE Std 802.1Q–1998, making use of the concepts and mechanisms of LAN Bridging that were introduced by IEEE Std 802.1D™ and defining additional mechanisms to allow the implementation of Virtual Bridged Local Area Networks.

For an introduction to this standard that details each of the provisions introduced by amendments and revisions throughout its development refer to clause 1.3 Introduction.

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

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854-4141
USA

Notice to users

Laws and regulations

Users of these documents should consult all applicable laws and regulations. Compliance with the provisions of this standard does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

This document is copyrighted by the IEEE. It is made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

Updating of IEEE documents

Users of IEEE standards should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Standards Association website at

<http://ieeexplore.ieee.org/xpl/standards.jsp>, or contact the IEEE at the address listed previously. For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA website at <http://standards.ieee.org>.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/updates/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/interp/index.html>.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents or patent applications for which a license may be required to implement an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention. A patent holder or patent applicant has filed a statement of assurance that it will grant licenses under these rights without compensation or under reasonable rates and nondiscriminatory, reasonable terms and conditions to applicants desiring to obtain such licenses. The IEEE makes no representation as to the reasonableness of rates, terms, and conditions of the license agreements offered by patent holders or patent applicants. Further information may be obtained from the IEEE Standards Department.

Participants

At the time the 2011 revision of this standard was submitted to the IEEE-SA Standards Board for approval, the IEEE 802.1 Working Group had the following membership:

Anthony Jeffree, *Chair and Editor*
Paul Congdon, *Vice Chair*
Stephen Haddock, *Chair, Interworking Task Group*

Zehavit Alon	Anoop Ghanwani	Donald Pannell
Yafan An	Eric Gray	Glenn Parsons
Ting Ao	Yingjie Gu	Joseph Pelissier
Peter Ashwood-Smith	Craig Gunther	Rene Raeber
Christian Boiger	Hitoshi Hayakawa	Karen Randall
Paul Bottorff	Hal Keen	Dan Romascanu
Rudolf Brandner	Yongbum Kim	Jessy Rouyer
Craig Carlson	Philippe Klein	Panagiotis Saltsidis
Claudio Desanti	Oliver Kleineberg	Michael Seaman
Zheming Ding	Michael Krause	Rakesh Sharma
Donald Eastlake	Li Li	Kevin B. Stanton
Janos Farkas	Jeff Lynch	Robert Sultan
Donald Fedyk	Thomas Mack-Crane	Michael Teener
Norman Finn	John Messenger	Patricia Thaler
Ilango Ganga	John Morris	Chait Tumuluri
Geoffrey Garner	Eric Multanen	Maarten Visser
	David Olsen	

The following members of the individual balloting committee voted on the 2011 revision of this standard. Balloters may have voted for approval, disapproval, or abstention.

Thomas Alexander	C. Huntley	Maximilian Riegel
Zehavit Alon	Akio Iso	Robert Robinson
Danilo Antonelli	Atsushi Ito	Jessy Rouyer
Hugh Barrass	Raj Jain	Randall Safier
Robert Boatright	Junghoon Jee	Panagiotis Saltsidis
Tomo Bogataj	Anthony Jeffree	Peter Saunderson
Gennaro Boggia	Shinkyu Kaku	Bartien Sayogo
Nancy Bravin	Piotr Karocki	Benson Schliesser
William Byrd	Stuart J. Kerry	Michael Seaman
Juan Carreon	Yongbum Kim	Rich Seifert
Keith Chow	Bruce Kraemer	Gil Shultz
Charles Cook	John Lemon	Kapil Sood
Wael Diab	Michael Lerer	Matthew Squire
Russell Dietz	Li Li	Kevin B. Stanton
Thomas Dineen	William Lumpkins	Thomas Starai
Sourav Dutta	Greg Luri	Walter Struppler
Jose Dominic Espejo	Thomas Mack-Crane	Robert Sultan
Donald Fedyk	Elvis Maculuba	Joseph Tardo
Prince Francis	Arthur Marris	William Taylor
Yukihiro Fujimoto	Jeffery Masters	Patricia Thaler
Ilango Ganga	Jonathon McLendon	David Thompson
Randall Groves	Joseph Moran	Geoffrey Thompson
Craig Gunther	Michael S. Newman	Jeffrey Towne
C. Guy	Nick S. A. Nikjoo	Prabodh Varshney
Stephen Haddock	Satoshi Obara	Ludwig Winkel
Marek Hajduczenia	David Olsen	Michael Wright
David Hunter	Glenn Parsons	Oren Yuen

When the IEEE-SA Standards Board approved the 2011 revision of this standard on 16 May 2011, it had the following membership:

Richard H. Hulett, *Chair*
John Kulick, *Vice Chair*
Robert M. Grow, *Past President*
Judith Gorman, *Secretary*

Masayuki Ariyoshi
William Bartley
Ted Burse
Clint Chaplin
Weal Diab
Jean-Philippe Faure
Alexander Gelman
Paul Houzé

Jim Hughes
Joseph L. Koepfinger*
David J. Law
Thomas Lee
Hung Ling
Oleg Logvinov
Ted Olsen

Gary Robinson
Jon Walter Rosdahl
Sam Sciacca
Mike Seavey
Curtis Siller
Phil Winston
Howard Wolfman
Don Wright

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish K. Aggarwal, *NRC Representative*
Richard DeBlasio, *DOE Representative*
Michael Janezic, *NIST Representative*

Michelle Turner
IEEE Standards Program Manager, Document Development

Kathryn Bennett
IEEE Standards Program Manager, Technical Program Development

Historical participants

Since the initial publication, many IEEE standards have added functionality or provided updates to material included in this standard. The following is a historical list of participants who have dedicated their valuable time, energy, and knowledge to the creation of this material:

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Letter Ballot
IEEE Std 802.1Q-1998	8 December 1998	William P. Lidinsky , <i>Chair</i> Mick Seaman , <i>Chair, Interworking Task Group</i> Tony Jeffree , <i>Coordinating Editor</i> Anil Rijasinghani, Richard Hausmann, Michele Wright, Paul Langille, P. J. Singh , <i>Editorial Team</i>
IEEE Std 802.1u-2001	17 March 2001	Tony Jeffree , <i>Chair</i> Neil Jarvis , <i>Vice Chair</i> Mick Seaman , <i>Chair, Interworking Task Group</i>
IEEE Std 802.1v-2001	17 March 2001	Tony Jeffree , <i>Chair</i> Neil Jarvis , <i>Vice Chair</i> Mick Seaman , <i>Chair, Interworking Task Group</i> David Delany , <i>Editor</i> Andrew Smith , <i>Editor</i>
IEEE Std 802.1s-2002	11 December 2002	Tony Jeffree , <i>Chair</i> Neil Jarvis , <i>Vice Chair</i> Mick Seaman , <i>Chair, Interworking Task Group</i> Norman W. Finn , <i>Editor</i>
IEEE Std 802.1ad-2005	28 March 2005	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Mick Seaman , <i>Chair, Interworking Task Group</i> Stephen R. Haddock , <i>Editor</i>
IEEE Std 802.1Q-2005	7 December 2005	Tony Jeffree , <i>Chair and Editor</i> Paul Congdon , <i>Vice Chair</i> Mick Seaman , <i>Chair, Interworking Task Group</i>
IEEE Std 802.1ak-2007	22 March 2007	Tony Jeffree , <i>Chair and Editor</i> Paul Congdon , <i>Vice Chair</i> Mick Seaman , <i>Chair, Interworking Task Group</i>

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Letter Ballot
IEEE Std 802.1ag-2007	27 September 2007	Tony Jeffree, Chair Paul Congdon, Vice Chair Stephen R. Haddock, Chair, Interworking Task Group Norman W. Finn, Editor-in-Chief David V. Elie-Dit-Cosaque, Dinesh Mohan, Oscar Rodriguez, and Ali Sajassi, Assistant Editors
IEEE Std 802.1ah-2008	12 June 2008	Tony Jeffree, Chair Paul Congdon, Vice Chair Stephen R. Haddock, Chair, Interworking Task Group Paul Bottorff, Stephen Haddock, and Muneyoshi Suzuki, Editors
IEEE Std 802.1Q-2005/Cor-1-2008	26 September 2008	Tony Jeffree, Chair and Editor Paul Congdon, Vice Chair Stephen R. Haddock, Chair, Interworking Task Group
IEEE Std 802.1ap-2008	10 December 2008	Tony Jeffree, Chair Paul Congdon, Vice Chair Stephen R. Haddock, Chair, Interworking Task Group Glenn Parsons, Editor David Levi, Assistant Editor
IEEE Std 802.1Qaw-2009	17 June 2009	Tony Jeffree, Chair Paul Congdon, Vice Chair Stephen R. Haddock, Chair, Interworking Task Group Linda Dunbar, Editor
IEEE Std 802.1Qay-2009	17 June 2009	Tony Jeffree, Chair Paul Congdon, Vice Chair Stephen R. Haddock, Chair, Interworking Task Group Panagiotis Saltsidis, Editor
IEEE Std 802.1aj-2009	9 December 2009	Tony Jeffree, Chair Paul Congdon, Vice Chair Stephen R. Haddock, Chair, Interworking Task Group John Messenger, Editor Brian Hassink, MIB Editor

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Letter Ballot
IEEE Std 802.1Qav-2009	9 November 2009	Tony Jeffree , <i>Chair and Editor</i> Paul Congdon , <i>Vice Chair</i> Michael Johas Teener , <i>Chair, Audio Video Bridging Task Group</i>
IEEE Std 802.1Qau-2010	25 March 2010	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Patricia Thaler , <i>Chair, Data Center Bridging Task Group</i> Norman W. Finn , <i>Editor</i>
IEEE Std 802.1Qat-2010	30 September 2010	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Michael Johas Teener , <i>Chair, Audio Video Bridging Task Group</i> Craig Gunther , <i>Editor</i>
IEEE Std 802.1Qbe-2011	16 June 2011	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Stephen Haddock , <i>Chair, Interworking Task Group</i> Norman Finn , <i>Editor</i>
IEEE Std 802.1Qbc-2011	16 June 2011	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Stephen Haddock , <i>Chair, Interworking Task Group</i> Thomas Mack-Crane , <i>Editor</i>
IEEE Std 802.1Qbb-2011	16 June 2011	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Patricia Thaler , <i>Chair, Data Center Bridging Task Group</i> Claudio DeSanti , <i>Editor</i>
IEEE Std 802.1Qaz-2011	7 December 2011	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Patricia Thaler , <i>Chair, Data Center Bridging Task Group</i> Craig W. Carlson , <i>Editor</i>

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Letter Ballot
IEEE Std 802.1Qbf-2011	7 December 2011	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Stephen Haddock , <i>Chair, Interworking Task Group</i> Robert Sultan , <i>Editor</i>
IEEE Std 802.1aq-2012	29th March 2012	Tony Jeffree , <i>Chair</i> Glenn Parsons , <i>Vice Chair</i> Stephen Haddock , <i>Chair, Interworking Task Group</i> Donald Fedyk , <i>Editor</i>
IEEE Std 802.1Qbg-2012	14 May 2012	Tony Jeffree , <i>Chair and Editor</i> Paul Congdon , <i>Vice Chair</i> Patricia Thaler , <i>Chair, Data Center Bridging Task Group</i> Paul Borttorff , <i>Editor, Clauses 12 and 17</i>
IEEE Std 802.1Q-2011/ Cor-2-2012	19 October 2012	Tony Jeffree , <i>Chair and Editor</i> Glenn Parsons , <i>Vice Chair and Chair, Maintenance Task Group</i>

Osama Aboul-Magd
 Steve Adams
 Stephen Ades
 Zehavit Alon
 Ken Alonge
 Yafan An
 Ting Ao
 Peter Ashwood-Smith
 Siamack Ayandeh
 Floyd Backes
 John Bartlett
 Alexei Beliaev
 Les Bell
 Avner Ben-Dor
 Michael Berger
 Caitlin Bestler
 Jan Bialkowski
 James S. Binder
 Rob Boatright
 Christian Boiger
 Brad Booth
 Jean-Michel Bonnamy
 Mike Borza
 Paul Bottorff
 David Brady
 Rudolf Brandner
 Martin Brewer
 Bill Bunch
 Jim Burns
 Bob Cardinal
 Craig W. Carlson
 Paul Carroll
 Jeffrey Catlin
 Dennis Cave
 Dirceu Cavendish
 Alan Chambers
 Steve Chan
 David W. Chang
 Xin Chang
 Frank Chao
 Ken Chapman
 Weiying Cheng
 Rao Cherukuri
 Taesik Cheung
 Hon Wah Chin
 Jin-Seek Choi
 Chi Chong
 Chris Christ
 Marc Cochran
 Paul Congdon
 Glenn Connery
 Alex Conta
 Diego Crupnicoff
 David Cullerot
 Rodney Cummings
 Uri Cummings
 Ted Davies
 Andy Davis
 Arjan de Heer
 Prakash Desai

Claudio DeSanti
 Jeffrey Dietz
 Russell Dietz
 Zhemin Ding
 Kurt Dobbins
 Linda Dunbar
 Craig Easley
 Donald Eastlake, III
 Peter Ecclesine
 J. J. Ekstrom
 Anush Elangovan
 Hesham M. Elbakoury
 David Elie-Dit-Cosaque
 Janos Farkas
 Donald W. Fedyk
 Felix Feifei Feng
 Norman Finn
 Yishai Fraenkel
 Paul Frantz
 David Frattura
 Robert Frazier
 Lars Henrik Frederiksen
 Andre Fredette
 John Fuller
 Ilango Ganga
 Geoffrey Garner
 Anoop Ghanwani
 Franz Goetz
 Mark Gravel
 Eric Gray
 Karanvir Grewal
 John Grinham
 Yingjie Gu
 Craig Gunther
 Mitch Gusat
 Stephen Haddock
 Sharam Hakimi
 John Hart
 Scott Harvell
 Takashi Hasegawa
 Brian Hassink
 Wayne Hathaway
 Brian Hausauer
 Hitoshi Hayakawa
 Vic Hayes
 Asif Hazarika
 David Head
 Gaby Hecht
 Deepak Hegde
 Ariel Hendel
 John Hickey
 David Hollender
 Steve Horowitz
 Bob Hott
 Michelle Hsiung
 Charles Hudson
 Rita Hunt
 David Husak
 Altaf Hussain
 Romain Insler

Ran Ish-Shalom
 Vipin K. Jain
 Tony Jeffree
 Paul Hongkyu Jeong
 Pankaj Jha
 Markus Jochim
 Michael Johas Teener
 Girault Jones
 Shyam Kaluve
 Daya Kamath
 Abhay Karandikar
 Allen Kasey
 Prakash Kashyap
 Toyayuki Kato
 Hal Keen
 Srikanth Keesara
 Daniel Kelley
 Kevin Ketchum
 Ketil Kilcrease
 Doyeon Kim
 Yongbum Kim
 Keith Klamm
 Philippe Klein
 Oliver Kleinberg
 Bruce Kling
 Walter Knitl
 Mike Ko
 Raghu Kondapalli
 Michael Krause
 Dan Krent
 Vinod Kumar
 Paul Kummer
 Bruce Kwan
 Paul Lachapelle
 Kari Laihonen
 Ashvin Lakshmikantha
 Bill Lane
 Lin Li
 Loren Larsen
 Yannick Le Goff
 John Lemon
 Michael Lerer
 Johann Lindmeyr
 Marina Lipshteyn
 Gary Littleton
 Yuanqui Luo
 Robert D. Love
 Andy Luque
 Jeff Lynch
 Gael Mace
 Thomas Mack-Crane
 David Martin
 Peter Martini
 Riccardo Martinotti
 Marco Mascitto
 Keith McCloghrie
 Alan McGuire

James McIntosh
 Martin McNealis
 Menucher Menuchery
 Milan Merhar
 John Messenger
 Colin Mick
 Amol Mitra
 Dinesh Mohan
 Gabriel Montenegro
 Matthew Mora
 John Morris
 Bob Moskowitz
 Eric Multanen
 Yaron Nachman
 Yukihiro Nakagawa
 Krishna Narayanaswamy
 Lawrence Ng
 Henry Ngai
 Paul Nikolich
 Kevin Nolish
 Don O'Connor
 Karen O'Donoghue
 Eugene O'Neil
 Satoshi Obara
 Hiroshi Ohta
 David Olsen
 Toshio Ooka
 Jörg Ottensmeyer
 Shlomo Ovadia
 Vijoy Pandey
 Don Pannell
 Luc Pariseau
 Glenn W. Parsons
 Ken Patton
 Mark Pearson
 Joseph Pelissier
 Yonadav Perry
 David Peterson
 John Pickens
 Hayim Porat
 Gideon Prat
 Kirk Preiss
 Max Pritikin
 Ray Qiu
 Rene Raeber
 Ananda Rajagopal
 Steve Ramberg
 Karen Randall
 Shlomo Reches

Frank Reichstein
 Dick Reohr
 James Richmond
 Robert Roden
 Guenter Roeck
 John J. Roesse
 Josef Roesse
 Derek J. Rohde
 Allyn Romanow
 Dan Romascanu
 Moran Roth
 Jessy V. Rouyer
 Doug Ruby
 Eric Ryu
 Jonathan Sadler
 Ali Sajassi
 Joseph Salowey
 Panagiotis Saltsidis
 Sam Sambasivan
 Ray Samora
 Satish Sathe
 John M. Sauer
 Ayman Sayed
 Ted Schroeder
 Benjamin Schultz
 Michael J. Seaman
 Rich Seifert
 Lee Sendelbach
 Koichiro Seto
 Himanshu Shah
 Rakesh Sharma
 Ravi Shenoy
 K. Karl Shimada
 Fred Shu
 Taeshi Shimizu
 Phil Simmons
 Curtis Simonson
 Rosemary V. Slager
 Alexander Smith
 Michel Soerensen
 Stuart Soloway
 Nurit Sprecher
 Kevin B. Stanton
 Larry Stefani
 Sundar Subramaniam
 Robert Sultan
 Muneyoshi Suzuki
 Yoshihiro Suzuki
 George Swallow

Richard Sweatt
 Attila Takacs
 Francois Tallet
 Robin Tasker
 John Terry
 Patricia A. Thaler
 Geoff Thompson
 Oliver Thorp
 Michel Thorsen
 Fouad Tobagi
 Jeremy Touve
 Naoki Tsukutari
 Fred Tuck
 Chait Tumuluri
 Paul Unbehagen
 Dhadesugoor Vaman
 Steve Van Seters
 Dono van-Mierop
 John Viega
 Maarten Vissers
 Dennis Volpano
 Manoj Wadekar
 Yuehua Wei
 John Wakerly
 Peter Wang
 Philip Wang
 Y. C. Wang
 Yan Wang
 Trevor Warwick
 Bob Watson
 Karl Weber
 Brian Weis
 Alan Weissberger
 Glenn Wenig
 Martin White
 Bert Wijnen
 Keith Willette
 Robert Williams
 Ludwig Winkel
 Robert Winter
 Michael Witkowski
 Edward Wong
 Michael D. Wright
 Chien-Hsien Wu
 Min Xiao
 Ken Young
 Allen Yu
 Wayne Zakowski
 Glen Zorn

Contents

1. Overview.....	1
1.1 Scope.....	2
1.2 Purpose.....	2
1.3 Introduction.....	2
1.4 VLAN aims and benefits	8
2. Normative references	10
3. Definitions	14
4. Abbreviations.....	32
5. Conformance.....	37
5.1 Requirements terminology.....	37
5.2 Conformant components and equipment	37
5.3 Protocol Implementation Conformance Statement (PICS).....	38
5.4 VLAN-aware Bridge component requirements	38
5.4.1 VLAN-aware Bridge component options	39
5.4.2 Multiple VLAN Registration Protocol (MVRP) requirements.....	43
5.4.3 VLAN-aware Bridge requirements for congestion notification	43
5.4.4 Multiple Stream Registration Protocol (MSRP) requirements	44
5.4.5 Shortest Path Bridging operation (optional)	44
5.5 C-VLAN component conformance.....	45
5.5.1 C-VLAN component options	45
5.6 S-VLAN component conformance	45
5.6.1 S-VLAN component options	46
5.6.2 S-VLAN component requirements for PBB-TE.....	46
5.6.3 S-VLAN component requirements for PBB-TE IPS	46
5.7 I-component conformance	46
5.7.1 I-component options	47
5.8 B-component conformance.....	47
5.8.1 B-component options.....	47
5.8.2 B-component requirements for PBB-TE	48
5.8.3 B-component requirements for PBB-TE IPS.....	48
5.9 VLAN Bridge conformance.....	48
5.9.1 VLAN Bridge options.....	48
5.10 Provider Bridge conformance	48
5.10.1 S-VLAN Bridge conformance	49
5.10.2 Provider Edge Bridge conformance.....	49
5.11 System requirements for Priority-based Flow Control	49
5.12 Backbone Edge Bridge conformance	50
5.12.1 Backbone Edge Bridge requirements for PBB-TE	50
5.13 VLAN-unaware Bridge component requirements	50
5.14 TPMR component conformance.....	50
5.14.1 TPMR component options.....	51
5.15 TPMR conformance.....	51
5.15.1 TPMR options.....	51
5.16 T-component conformance	52
5.16.1 T-component options	52
5.17 End station requirements for MMRP, MVRP, and MSRP	52
5.17.1 MMRP requirements and options	52

5.17.2	MVRP requirements and options.....	53
5.17.3	MSRP requirements and options	53
5.18	VLAN-aware end station requirements for Connectivity Fault Management.....	54
5.19	End station requirements—forwarding and queuing for time-sensitive streams	54
5.20	End station requirements for congestion notification	55
5.21	MAC-specific bridging methods	55
5.22	Edge Virtual Bridging (EVB) Bridge requirements	56
5.23	Edge Virtual Bridging (EVB) station requirements	56
5.23.1	Edge relay requirements	57
6.	Support of the MAC Service	59
6.1	Basic architectural concepts and terms	60
6.1.1	Protocol entities, peers, layers, services, and clients	60
6.1.2	Service interface primitives, parameters, and frames	60
6.1.3	Layer management interfaces	61
6.1.4	Service access points, interface stacks, and ports	61
6.1.5	MAC method independent protocols and shims	62
6.1.6	MAC Service clients	62
6.1.7	Stations and systems	63
6.1.8	Connectionless connectivity	63
6.2	Provision of the MAC service	63
6.2.1	Point-to-point, multipoint-to-multipoint, and rooted-multipoint connectivity	64
6.3	Support of the MAC service	64
6.4	Preservation of the MAC service	65
6.5	Quality of service maintenance.....	65
6.5.1	Service availability	65
6.5.2	Frame loss	66
6.5.3	Frame misordering.....	67
6.5.4	Frame duplication	67
6.5.5	Transit delay	68
6.5.6	Frame lifetime.....	69
6.5.7	Undetected frame error rate	69
6.5.8	Maximum Service Data Unit Size	69
6.5.9	Priority	69
6.5.10	Throughput.....	70
6.6	Internal Sublayer Service	71
6.6.1	Service primitives and parameters	71
6.6.2	Status parameters	73
6.6.3	Point-to-point parameters	73
6.6.4	Stream Reservation Protocol (SRP) Domain status parameters	73
6.6.5	Control primitives and parameters.....	74
6.6.6	EVB status parameters.....	74
6.7	Support of the Internal Sublayer Service by specific MAC procedures.....	75
6.7.1	Support of the Internal Sublayer Service by IEEE Std 802.3 (CSMA/CD)	76
6.7.2	Support by IEEE Std 802.11 (Wireless LAN)	77
6.7.3	Support by IEEE Std 802.17 (RPR).....	78
6.7.4	Support by IEEE 802.20 Mobile Broadband Wireless Access Method (MBWA)	80
6.8	Enhanced Internal Sublayer Service	81
6.8.1	Service primitives	82
6.8.2	Status parameters	82
6.8.3	Point-to-point parameters	82
6.9	Support of the EISS	83
6.9.1	Data indications	84

6.9.2	Data requests.....	85
6.9.3	Priority Code Point encoding.....	85
6.9.4	Regenerating priority	87
6.10	Support of the ISS/EISS by Provider Instance Ports	88
6.10.1	Data indications	90
6.10.2	Data requests.....	91
6.10.3	Priority Code Point encoding.....	92
6.11	Support of the EISS by Customer Backbone Ports.....	92
6.11.1	Data indications	93
6.11.2	Data requests.....	94
6.11.3	Priority Code Point decoding.....	95
6.11.4	Regenerating priority	95
6.12	Protocol VLAN classification.....	95
6.12.1	Protocol Templates	97
6.12.2	Protocol Group Identifiers	97
6.12.3	Protocol Group Database.....	98
6.13	Support of the ISS for attachment to a Provider Bridged Network.....	98
6.13.1	Data requests.....	99
6.13.2	Data indications	100
6.14	Support of the ISS within a system.....	100
6.15	Support of the ISS by additional technologies.....	101
6.16	Filtering services in Bridged Local Area Networks	101
6.16.1	Purpose(s) of filtering service provision.....	101
6.16.2	Goals of filtering service provision	102
6.16.3	Users of filtering services	102
6.16.4	Basis of service	102
6.16.5	Categories of service.....	102
6.16.6	Service configuration.....	103
6.16.7	Service definition for Extended Filtering Services.....	103
6.17	EISS Multiplex Entity.....	104
6.18	Backbone Service Instance Multiplex Entity.....	105
6.18.1	Demultiplexing direction	107
6.18.2	Multiplexing direction	108
6.18.3	Priority Code Point encoding.....	108
6.18.4	Status parameters	108
6.19	TESI Multiplex Entity	109
6.20	Support of the ISS with signaled priority	110
6.20.1	Data indications	110
6.20.2	Data requests.....	111
6.21	Infrastructure Segment Multiplex Entity	111
7.	Principles of network operation.....	113
7.1	Network overview.....	113
7.2	Use of VLANs	114
7.3	Active topology.....	114
7.4	VLAN topology	115
7.5	Locating end stations	116
7.6	Ingress, forwarding, and egress rules.....	116
8.	Principles of bridge operation.....	118
8.1	Bridge operation	118
8.1.1	Relay	118
8.1.2	Filtering and relaying information.....	119

8.1.3	Duplicate frame prevention	119
8.1.4	Traffic segregation	119
8.1.5	Traffic reduction	120
8.1.6	Traffic expediting	120
8.1.7	Conversion of frame formats	120
8.2	Bridge architecture	121
8.3	Model of operation	122
8.4	Active topologies, learning, and forwarding	125
8.5	Bridge Port Transmit and Receive	126
8.5.1	Bridge Port connectivity	127
8.5.2	TPMR Port connectivity	128
8.5.3	Support of Higher Layer Entities	128
8.6	The Forwarding Process	129
8.6.1	Active topology enforcement	130
8.6.2	Ingress filtering	131
8.6.3	Frame filtering	131
8.6.4	Egress	134
8.6.5	Flow classification and metering	135
8.6.6	Queuing frames	135
8.6.7	Queue management	136
8.6.8	Transmission selection	137
8.7	The Learning Process	140
8.7.1	Default filtering utility criteria	140
8.7.2	Enhanced filtering utility criteria	140
8.7.3	Ageing of Dynamic Filtering Entries	140
8.8	The Filtering Database	141
8.8.1	Static Filtering Entries	144
8.8.2	Static VLAN Registration Entries	145
8.8.3	Dynamic Filtering Entries	146
8.8.4	MAC Address Registration Entries	146
8.8.5	Dynamic VLAN Registration Entries	147
8.8.6	Default Group filtering behavior	147
8.8.7	Dynamic Reservation Entries	148
8.8.8	Allocation of VIDs to FIDs	149
8.8.9	Querying the Filtering Database	150
8.8.10	Determination of the member set for a VID	153
8.8.11	Permanent Database	153
8.8.12	Connection_Identifier	154
8.9	MST, SPB, and ESP configuration information	154
8.9.1	MST Configuration Table	155
8.9.2	MST configuration identification	155
8.9.3	FID to MSTI Allocation Table	155
8.9.4	SPT Configuration Identification	156
8.10	Spanning Tree Protocol Entity	156
8.11	MRP Entities	157
8.12	Bridge Management Entity	157
8.13	Addressing	157
8.13.1	End stations	157
8.13.2	Bridge Ports	157
8.13.3	Use of LLC by Spanning Tree Protocol Entities	158
8.13.4	Reserved MAC Addresses	158
8.13.5	Group MAC Addresses for spanning tree entity	158
8.13.6	Group MAC Addresses for MRP Applications	160
8.13.7	Bridge Management Entities	161

8.13.8	Unique identification of a Bridge	161
8.13.9	Points of attachment and connectivity for Higher Layer Entities.....	161
8.13.10	VLAN attachment and connectivity for Higher Layer Entities	164
8.13.11	Connectivity Fault Management entities	166
9.	Tagged frame format	168
9.1	Purpose of tagging	168
9.2	Representation and encoding of tag fields	168
9.3	Tag format.....	169
9.4	Tag Protocol Identifier (TPID) formats	169
9.5	Tag Protocol Identification	169
9.6	VLAN Tag Control Information.....	170
9.7	Backbone Service Instance Tag Control Information.....	171
10.	Multiple Registration Protocol (MRP) and Multiple MAC Registration Protocol (MMRP)	173
10.1	MRP overview	173
10.2	MRP architecture	176
10.3	MRP Attribute Propagation (MAP).....	177
10.3.1	MAP Context	178
10.4	Requirements to be met by MRP	179
10.5	Requirements for interoperability between MRP Participants	179
10.6	Protocol operation.....	181
10.7	Protocol specification	185
10.7.1	Notational conventions and abbreviations	186
10.7.2	Registrar Administrative Controls	187
10.7.3	Applicant Administrative Controls	188
10.7.4	Protocol timers	188
10.7.5	Protocol event definitions	189
10.7.6	Protocol Action definitions	192
10.7.7	Applicant state machine.....	194
10.7.8	Registrar state machine.....	196
10.7.9	LeaveAll state machine.....	196
10.7.10	PeriodicTransmission state machine.....	196
10.7.11	Timer values	197
10.7.12	Operational reporting and statistics	198
10.7.13	Interoperability considerations	198
10.8	Structure and encoding of MRP Protocol Data Units	199
10.8.1	Structure	199
10.8.2	Encoding of MRPDU parameters	201
10.8.3	Packing and parsing MRPDUs	204
10.9	Multiple MAC Registration Protocol (MMRP)—Purpose	206
10.10	Model of operation.....	207
10.10.1	Propagation of Group Membership information	208
10.10.2	Propagation of Group service requirement information	209
10.10.3	Source pruning	209
10.10.4	Use of Group service requirement registration by end stations	209
10.11	Default Group filtering behavior and MMRP propagation	210
10.12	Definition of the MMRP application	211
10.12.1	Definition of MRP elements	211
10.12.2	Provision and support of Extended Filtering Services.....	213
10.12.3	Use of “new” declaration capability	215
10.12.4	Attribute value support requirements	215
10.12.5	Registrar Administrative Controls	215

11. VLAN topology management.....	216
11.1 Static and dynamic VLAN configuration	216
11.2 Multiple VLAN Registration Protocol	217
11.2.1 MVRP overview	217
11.2.2 VLAN registration service definition	219
11.2.3 Definition of the MVRP application.....	220
11.2.4 VID translation table.....	223
11.2.5 Use of “new” declaration capability	223
11.2.6 New-only Participant and Registrar Administrative Controls	223
11.2.7 Attribute value support requirements	224
12. Bridge management	225
12.1 Management functions.....	225
12.1.1 Configuration Management	225
12.1.2 Fault Management	226
12.1.3 Performance Management	226
12.1.4 Security Management	226
12.1.5 Accounting Management.....	226
12.2 VLAN-aware bridge objects	226
12.3 Data types	227
12.4 Bridge Management Entity	228
12.4.1 Bridge Configuration	228
12.4.2 Port configuration	231
12.5 MAC entities	233
12.5.1 ISS Port Number table managed object (optional)	233
12.6 Forwarding process.....	233
12.6.1 The Port Counters	234
12.6.2 Priority handling	234
12.6.3 Traffic Class Table.....	242
12.7 Filtering Database	243
12.7.1 The Filtering Database	243
12.7.2 A Static Filtering Entry.....	244
12.7.3 A Dynamic Filtering Entry	244
12.7.4 A MAC Address Registration Entry	245
12.7.5 A VLAN Registration Entry	245
12.7.6 Permanent Database.....	245
12.7.7 General Filtering Database operations.....	246
12.8 Bridge Protocol Entity	248
12.8.1 The Protocol Entity	248
12.8.2 Bridge Port.....	251
12.9 MRP Entities.....	255
12.9.1 The MRP Timer object	255
12.9.2 The MRP Attribute Type object	256
12.9.3 Periodic state machine objects	257
12.10 Bridge VLAN managed objects.....	257
12.10.1 Bridge VLAN Configuration managed object.....	258
12.10.2 VLAN Configuration managed object.....	263
12.10.3 The VLAN Learning Constraints managed object	264
12.11 MMRP entities	269
12.11.1 MMRP Configuration managed object.....	269
12.12 MST configuration entities	270
12.12.1 The MSTI List	271
12.12.2 The FID to MSTID Allocation Table	272

12.12.3	The MST Configuration Table	273
12.13	Provider Bridge management	275
12.13.1	Provider Bridge Port Type managed object.....	276
12.13.2	Customer Edge Port Configuration managed object	277
12.13.3	Remote Customer Access Port Configuration managed object.....	280
12.14	CFM entities	282
12.14.1	Maintenance Domain list managed object.....	282
12.14.2	CFM Stack managed object.....	284
12.14.3	Default MD Level managed object.....	285
12.14.4	Configuration Error List managed object	286
12.14.5	Maintenance Domain managed object.....	287
12.14.6	Maintenance Association managed object.....	289
12.14.7	Maintenance association End Point managed object.....	292
12.15	Backbone Core Bridge management	299
12.16	Backbone Edge Bridge management.....	299
12.16.1	BEB configuration managed object.....	300
12.16.2	BEB/PB/VLAN Bridge Port configuration managed object	304
12.16.3	VIP configuration managed object	305
12.16.4	PIP configuration managed object.....	306
12.16.5	CBP Configuration managed object	312
12.17	DDCFM entities.....	314
12.17.1	DDCFM Stack managed object	314
12.17.2	Reflection Responder managed object	315
12.17.3	RFM Receiver managed object.....	318
12.17.4	Decapsulator Responder managed object	319
12.17.5	SFM Originator managed object.....	322
12.18	PBB-TE Protection Switching managed objects	325
12.18.1	TE protection group list managed object.....	325
12.18.2	TE protection group managed object.....	326
12.19	TPMR managed objects.....	328
12.19.1	TPMR management entity	328
12.19.2	MAC and PHY entities	330
12.19.3	Forwarding Process.....	331
12.19.4	MAC status propagation entity	336
12.20	Management entities for forwarding and queueing for time-sensitive streams.....	338
12.20.1	The Bandwidth Availability Parameter Table	338
12.20.2	The Transmission Selection Algorithm Table	339
12.20.3	The Priority Regeneration Override Table	339
12.21	Congestion notification managed objects	339
12.21.1	CN component managed object.....	340
12.21.2	CN component priority managed object.....	340
12.21.3	CN Port priority managed object.....	341
12.21.4	Congestion Point managed object.....	342
12.21.5	Reaction Point port priority managed object	342
12.21.6	Reaction Point group managed object	344
12.22	SRP entities.....	344
12.22.1	SRP Bridge Base Table.....	344
12.22.2	SRP Bridge Port Table.....	344
12.22.3	SRP Latency Parameter Table	345
12.22.4	SRP Stream Table.....	346
12.22.5	SRP Reservations Table.....	346
12.23	Priority-based Flow Control objects	346
12.24	1:1 PBB-TE Infrastructure Protection Switching (IPS) managed objects	347
12.24.1	IPG list managed object.....	347

12.24.2	IPG managed object.....	349
12.25	Shortest Path Bridging managed objects	351
12.25.1	The SPB System managed object	352
12.25.2	The SPB MTID Static managed object.....	354
12.25.3	The SPB Topology Instance Dynamic managed object	356
12.25.4	The SPB ECT Static Entry managed object	356
12.25.5	The SPB ECT Dynamic Entry managed object	358
12.25.6	The SPB Adjacency Static Entry managed object.....	359
12.25.7	The SPB Adjacency Dynamic Entry managed object	360
12.25.8	The SPB Topology Node Table managed object.....	360
12.25.9	The SPB Topology ECT Table managed object.....	361
12.25.10	The SPB Topology Edge Table managed object.....	362
12.25.11	The SPBM Topology Service Table managed object.....	363
12.25.12	The SPBV Topology Service Table managed object	364
12.26	Edge Virtual Bridging management	365
12.26.1	EVB system base table	368
12.26.2	SBP table entry	370
12.26.3	VSI table entry	371
12.26.4	S-channel configuration and management.....	374
12.26.5	Edge relay management.....	377
12.27	Edge Control Protocol management	378
12.27.1	ECP table entry	378
13.	Spanning Tree Protocols	379
13.1	Protocol design requirements.....	380
13.2	Protocol support requirements	381
13.2.1	MSTP support requirements	381
13.2.2	SPB support requirements	381
13.3	Protocol design goals	382
13.4	RSTP overview	382
13.4.1	Computation of the active topology.....	383
13.4.2	Example topologies.....	385
13.5	MSTP overview	388
13.5.1	Example topologies.....	389
13.5.2	Relationship of MSTP to RSTP	392
13.5.3	Modeling an MST or SPT Region as a single bridge	392
13.6	SPB overview	393
13.7	Compatibility and interoperability	394
13.7.1	Designated Port selection.....	394
13.7.2	Force Protocol Version	394
13.8	MST Configuration Identifier	395
13.9	Spanning Tree Priority Vectors	396
13.10	CIST Priority Vector calculations.....	398
13.11	MST Priority Vector calculations	400
13.12	Port Role assignments.....	402
13.13	Stable connectivity	403
13.14	Communicating Spanning Tree information	404
13.15	Changing Spanning Tree information.....	405
13.16	Changing Port States with RSTP or MSTP	406
13.16.1	Subtree connectivity and priority vectors	407
13.16.2	Root Port transition to Forwarding	407
13.16.3	Designated Port transition to Forwarding	407
13.16.4	Master Port transition to Forwarding.....	408

13.17	Changing Port States with SPB	411
13.17.1	Agreement Digest	413
13.18	Managing spanning tree topologies	413
13.19	Updating learned station location information	415
13.20	Managing reconfiguration	417
13.21	Partial and disputed connectivity	418
13.22	In-service upgrades	418
13.23	Fragile bridges	419
13.24	Spanning tree protocol state machines	420
13.25	State machine timers	422
13.25.1	edgeDelayWhile	423
13.25.2	fdWhile	423
13.25.3	helloWhen	423
13.25.4	mdelayWhile	423
13.25.5	rbWhile	423
13.25.6	rcvdInfoWhile	423
13.25.7	rrWhile	424
13.25.8	tcDetected	424
13.25.9	tcWhile	424
13.25.10	pseudoInfoHelloWhen	424
13.26	Per bridge variables	424
13.26.1	agreementDigest	425
13.26.2	BridgeIdentifier	425
13.26.3	BridgePriority	425
13.26.4	BridgeTimes	425
13.26.5	ForceProtocolVersion	426
13.26.6	MigrateTime	426
13.26.7	MstConfigId	426
13.26.8	AuxMstConfigId	426
13.26.9	rootPortId	426
13.26.10	rootPriority	426
13.26.11	rootTimes	426
13.26.12	TxHoldCount	426
13.27	Per port variables	426
13.27.1	AdminEdge	429
13.27.2	ageingTime	429
13.27.3	agree	429
13.27.4	agreed	429
13.27.5	agreedAbove	429
13.27.6	agreedDigest	429
13.27.7	agreedDigestValid	429
13.27.8	agreeDigest	429
13.27.9	agreeDigestValid	429
13.27.10	agreedMisorder	429
13.27.11	agreedN	430
13.27.12	agreedND	430
13.27.13	agreedPriority	430
13.27.14	agreedTopology	430
13.27.15	agreementOutstanding	430
13.27.16	agreeN	430
13.27.17	agreeND	430
13.27.18	AutoEdge	430
13.27.19	AutoIsolate	430
13.27.20	designatedPriority	431

13.27.21	designatedTimes	431
13.27.22	disputed	431
13.27.23	enableBPDUrx	431
13.27.24	enableBPDUtx	431
13.27.25	ExternalPortPathCost	431
13.27.26	isL2gp	431
13.27.27	isolate	431
13.27.28	fdbFlush	432
13.27.29	forward	432
13.27.30	forwarding	432
13.27.31	infoInternal	432
13.27.32	infoIs	432
13.27.33	InternalPortPathCost	432
13.27.34	learn	433
13.27.35	learning	433
13.27.36	master	433
13.27.37	mastered	433
13.27.38	mcheck	433
13.27.39	msgPriority	433
13.27.40	msgTimes	433
13.27.41	neighbourPriority	434
13.27.42	newInfo	434
13.27.43	newInfoMsti	434
13.27.44	operEdge	434
13.27.45	portEnabled	434
13.27.46	portId	434
13.27.47	portPriority	434
13.27.48	portTimes	435
13.27.49	proposed	435
13.27.50	proposing	435
13.27.51	pseudoRootId	435
13.27.52	rcvdBPDU	435
13.27.53	rcvdInfo	435
13.27.54	rcvdInternal	435
13.27.55	rcvdMsg	435
13.27.56	rcvdRSTP	435
13.27.57	rcvdSTP	435
13.27.58	rcvdTc	435
13.27.59	rcvdTcAck	435
13.27.60	rcvdTen	436
13.27.61	reRoot	436
13.27.62	reselect	436
13.27.63	restrictedDomainRole	436
13.27.64	restrictedRole	436
13.27.65	restrictedTcn	436
13.27.66	role	436
13.27.67	selected	436
13.27.68	selectedRole	436
13.27.69	sendRSTP	437
13.27.70	sync	437
13.27.71	synced	437
13.27.72	tcAck	437
13.27.73	tcProp	437
13.27.74	tick	437

13.27.75	txCount.....	437
13.27.76	updtInfo.....	437
13.28	State machine conditions and parameters.....	437
13.28.1	allSptAgree.....	438
13.28.2	allSynced.....	438
13.28.3	allTransmitReady.....	438
13.28.4	BestAgreementPriority.....	438
13.28.5	cist.....	438
13.28.6	cistRootPort.....	438
13.28.7	cistDesignatedPort.....	439
13.28.8	EdgeDelay.....	439
13.28.9	forwardDelay.....	439
13.28.10	FwdDelay.....	439
13.28.11	HelloTime.....	439
13.28.12	MaxAge.....	439
13.28.13	msti.....	439
13.28.14	mstiDesignatedOrTCpropagatingRootPort.....	439
13.28.15	mstiMasterPort.....	439
13.28.16	operPointToPoint.....	439
13.28.17	rcvdAnyMsg.....	439
13.28.18	rcvdCistMsg.....	439
13.28.19	rcvdMstiMsg.....	440
13.28.20	reRooted.....	440
13.28.21	rstpVersion.....	440
13.28.22	spt.....	440
13.28.23	stpVersion.....	440
13.28.24	updtCistInfo.....	440
13.28.25	updtMstiInfo.....	440
13.29	State machine procedures.....	440
13.29.1	betterorsameInfo(newInfoIs).....	441
13.29.2	clearAllRcvdMsgs().....	441
13.29.3	clearReselectTree().....	441
13.29.4	disableForwarding().....	442
13.29.5	disableLearning().....	442
13.29.6	enableForwarding().....	442
13.29.7	enableLearning().....	442
13.29.8	fromSameRegion().....	442
13.29.9	newTcDetected().....	442
13.29.10	newTcWhile().....	442
13.29.11	pseudoRcvMsgs().....	443
13.29.12	rcvInfo().....	443
13.29.13	rcvMsgs().....	444
13.29.14	rcvAgreements().....	444
13.29.15	recordAgreement().....	444
13.29.16	recordDispute().....	445
13.29.17	recordMastered().....	445
13.29.18	recordPriority().....	445
13.29.19	recordProposal().....	445
13.29.20	recordTimes().....	445
13.29.21	setReRootTree().....	446
13.29.22	setSelectedTree().....	446
13.29.23	setSyncTree().....	446
13.29.24	setTcFlags().....	446
13.29.25	setTcPropTree().....	446

13.29.26	syncMaster()	446
13.29.27	txConfig()	446
13.29.28	txRstp()	447
13.29.29	txTcn()	447
13.29.30	updtAgreement()	447
13.29.31	updtBPDUVersion()	448
13.29.32	updtDigest()	448
13.29.33	updtRcvdInfoWhile()	449
13.29.34	updtRolesTree()	450
13.29.35	uptRolesDisabledTree()	451
13.30	The Port Timers state machine	451
13.31	Port Receive state machine	452
13.32	Port Protocol Migration state machine	453
13.33	Bridge Detection state machine	453
13.34	Port Transmit state machine	453
13.35	Port Information state machine	455
13.36	Port Role Selection state machine	456
13.37	Port Role Transitions state machine	456
13.38	Port State Transition state machine	460
13.38.1	Port State transitions for the CIST and MSTIs	460
13.38.2	Port State transitions for SPTs	460
13.39	Topology Change state machine	462
13.40	Layer 2 Gateway Port Receive state machine	463
13.41	Customer Edge Port Spanning Tree operation	463
13.41.1	Provider Edge Port operPointToPointMAC and operEdge	463
13.41.2	updtRolesTree()	464
13.41.3	setReRootTree(), setSyncTree(), setTcPropTree()	464
13.41.4	allSynced, reRooted	464
13.41.5	Configuration parameters	464
13.42	Virtual Instance Port Spanning Tree operation	465
14.	Encoding of Bridge Protocol Data Units (BPDUs)	466
14.1	BPDUs Structure	466
14.1.1	Transmission and representation of octets	466
14.1.2	Common BPDU fields	468
14.2	Encoding of parameter types	468
14.2.1	Encoding of Protocol Identifiers	468
14.2.2	Encoding of Protocol Version Identifiers	468
14.2.3	Encoding of BPDU types	468
14.2.4	Encoding of flags	468
14.2.5	Encoding of Bridge Identifiers	468
14.2.6	Encoding of External Root Path Cost and Internal Root Path Cost	469
14.2.7	Encoding of Port Identifiers	469
14.2.8	Encoding of Timer Values	470
14.2.9	Encoding of Port Role values	470
14.2.10	Encoding of Length Values	470
14.2.11	Encoding of Hop Counts	470
14.3	Transmission of BPDUs	470
14.4	Encoding and decoding of STP Configuration, RST, MST, and SPT BPDUs	471
14.4.1	MSTI Configuration Messages	472
14.5	Validation of received BPDUs	473
14.6	Validation and interoperability	474

15. Support of the MAC Service by Provider Bridged Networks	476
15.1 Service transparency	476
15.2 Customer service interfaces	477
15.3 Port-based service interface	477
15.4 C-tagged service interface	478
15.5 S-tagged service interface	479
15.6 Remote customer service interfaces	480
15.7 Service instance segregation	483
15.8 Service instance selection and identification	483
15.9 Service priority selection	484
15.10 Service access protection	485
15.11 Connectivity Fault Management.....	485
15.12 Data-driven and data-dependent connectivity fault management (DDCFM).....	485
16. Principles of Provider Bridged Network operation	486
16.1 Provider Bridged Network overview	486
16.2 Provider Bridged Network.....	487
16.3 Service instance connectivity.....	490
16.4 Service provider learning of customer end station addresses	491
16.5 Detection of connectivity loops through attached networks.....	491
16.6 Network management	492
17. Management Information Base (MIB)	493
17.1 Internet Standard Management Framework	493
17.2 Structure of the MIB	493
17.2.1 Structure of the IEEE8021-TC MIB.....	494
17.2.2 Structure of the IEEE8021-BRIDGE MIB	496
17.2.3 Structure of the IEEE8021-SPANNING-TREE MIB	501
17.2.4 Structure of the IEEE8021-Q-BRIDGE MIB	503
17.2.5 Structure of the IEEE8021-PB MIB	510
17.2.6 Structure of the IEEE8021-MSTP MIB.....	513
17.2.7 Structure of the IEEE8021-CFM MMIB	516
17.2.8 Structure of the IEEE8021-PBB MIB	521
17.2.9 Structure of the IEEE8021-DDCFM MIBs	524
17.2.10 Structure of the IEEE8021-PBBTE MIB.....	527
17.2.11 Structure of the TPMR MIB	529
17.2.12 Structure of the IEEE8021-FQTSS MIB	532
17.2.13 Structure of the Congestion Notification MIB	533
17.2.14 Structure of the IEEE8021-SRP MIB	535
17.2.15 Structure of the MVRP extension MIB	537
17.2.16 Structure of the MIRP MIB	537
17.2.17 Structure of the Priority-based Flow Control MIB	538
17.2.18 Structure of the IEEE80221-TEIPS MIB	538
17.2.19 Structure of the IEEE8021-SPB-MIB.....	540
17.2.20 Structure of the IEEE8021-EVB MIB	544
17.3 Relationship to other MIBs Relationship to other MIBs	547
17.3.1 Relationship of the IEEE8021-TC MIB to other MIB modules	547
17.3.2 Relationship of the IEEE8021-BRIDGE MIB to other MIB modules	548
17.3.3 Relationship of the IEEE8021-RSTP MIB to other MIB modules	550
17.3.4 Relationship of the IEEE8021-Q-BRIDGE MIB to other MIB modules	550
17.3.5 Relationship of the IEEE8021-PB-BRIDGE MIB to other MIB modules	552
17.3.6 Relationship of the IEEE8021-MSTP MIB to other MIB modules.....	552

17.3.7	Relationship of the IEEE8021-CFM MIB to other MIB modules.....	552
17.3.8	Relationship of the IEEE8021-PBB MIB to other MIB modules	553
17.3.9	Relationship of the IEEE8021-DDCFM to other MIB modules	555
17.3.10	Relationship of the IEEE8021-PBBTE MIB to other MIB modules.....	555
17.3.11	Relationship of the TPMR MIB to other MIB modules	555
17.3.12	Relationship of the IEEE8021-FQTSS MIB to other MIB modules	556
17.3.13	Relationship of the Congestion Notification MIB to other MIB modules	556
17.3.14	Relationship of the IEEE8021-SRP MIB to other MIB modules	556
17.3.15	Relationship of the IEEE8021-MVRPX-MIB to other MIB modules	557
17.3.16	Relationship of the IEEE8021-MIRP-MIB to other MIB modules	557
17.3.17	Relationship of the Priority-based Flow Control MIB to other MIB modules....	557
17.3.18	Relationship of the IEEE8021-TEIPS MIB to other MIB modules	557
17.3.19	Relationship of the of the IEEE8021-SPB-MIB to other MIB modules	557
17.3.20	Relationship of the IEEE8021-EVB MIB to other MIB modules	557
17.4	Security considerations	558
17.4.1	Security considerations of the IEEE8021-TC MIB	558
17.4.2	Security considerations of the IEEE8021-BRIDGE MIB	558
17.4.3	Security considerations of the IEEE8021-SPANNING-TREE MIB.....	559
17.4.4	Security considerations of the IEEE8021-Q-BRIDGE MIB	560
17.4.5	Security considerations of the IEEE8021-PB MIB	561
17.4.6	Security considerations of the IEEE8021-MSTP MIB	561
17.4.7	Security considerations of the IEEE8021-CFM MIB.....	561
17.4.8	Security considerations of the IEEE8021-PBB MIB.....	563
17.4.9	Security considerations of the IEEE8021-DDCFM MIB	564
17.4.10	Security considerations of the IEEE8021-PBBTE MIB	564
17.4.11	Security considerations of the TPMR MIB	566
17.4.12	Security considerations of the IEEE8021-FQTSS MIB	566
17.4.13	Security considerations of the Congestion Notification MIB.....	567
17.4.14	Security considerations of the IEEE8021-SRP MIB	568
17.4.15	Security considerations of the IEEE8021-MVRPX-MIB.....	569
17.4.16	Security considerations of the IEEE8021-MIRP-MIB	569
17.4.17	Security considerations for the Priority-based Flow Control MIB	569
17.4.18	Security considerations of the IEEE8021-TEIPS MIB.....	570
17.4.19	Security considerations of the IEEE8021-SPB MIB	570
17.4.20	Security considerations of the IEEE8021-EVB MIB	571
17.5	Dynamic component and Port creation.....	572
17.5.1	Overview of the dynamically created Bridge entities.....	572
17.5.2	Component creation	574
17.5.3	Port creation	575
17.6	MIB operations for service interface configuration.....	585
17.6.1	Provisioning Provider Bridged Network service interfaces	585
17.6.2	Provisioning Backbone Bridged Network service interfaces	588
17.7	MIB modules	595
17.7.1	Definitions for the IEEE8021-TC MIB module	595
17.7.2	Definitions for the IEEE8021-BRIDGE MIB module	606
17.7.3	Definitions for the IEEE8021-SPANNING-TREE MIB module.....	646
17.7.4	Definitions for the IEEE8021-Q-BRIDGE MIB module	663
17.7.5	Definitions for the IEEE8021-PB MIB module	706
17.7.6	Definitions for the IEEE8021-MSTP MIB module	723
17.7.7	Definitions for the IEEE8021-CFM MIB module.....	751
17.7.8	Definitions for the IEEE8021-PBB MIB module.....	835
17.7.9	Definitions for the IEEE8021-DDCFM MIB module	857
17.7.10	Definitions for the IEEE8021-PBBTE MIB module.....	874
17.7.11	Definitions for the TPMR MIB module	891

17.7.12	Definitions for the IEEE8021-FQTSS MIB module	905
17.7.13	Congestion Notification MIB module	916
17.7.14	Definitions of the IEEE8021-SRP MIB module.....	952
17.7.15	MVRP extension MIB module	968
17.7.16	MIRP MIB module	972
17.7.17	Priority-based Flow Control MIB module.....	978
17.7.18	Definitions for the IEEE8021-TEIPS MIB module.....	982
17.7.19	SPB MIB module.....	996
17.7.20	Definitions of the IEEE8021-EVB MIB module.....	1025
18.	Principles of Connectivity Fault Management operation	1050
18.1	Maintenance Domains and Domain Service Access Points	1051
18.2	Service instances and Maintenance Associations	1053
18.3	Maintenance Domain Levels	1054
19.	Connectivity Fault Management Entity operation.....	1058
19.1	Maintenance Points.....	1058
19.2	Maintenance association End Point	1058
19.2.1	MEP identification.....	1059
19.2.2	MEP functions	1060
19.2.3	MEP architecture	1060
19.2.4	MP Type Demultiplexer	1060
19.2.5	MP Multiplexer.....	1062
19.2.6	MP Level Demultiplexer	1062
19.2.7	MP OpCode Demultiplexer	1062
19.2.8	MEP Continuity Check Receiver.....	1062
19.2.9	MEP Continuity Check Initiator	1063
19.2.10	MP Loopback Responder.....	1063
19.2.11	MEP Loopback Initiator	1063
19.2.12	MEP Linktrace Initiator	1063
19.2.13	MEP LTI SAP.....	1064
19.2.14	MEP Linktrace SAP.....	1064
19.2.15	MEP CCM Database.....	1064
19.2.16	MEP Fault Notification Generator.....	1064
19.2.17	MEP Decapsulator Responder	1064
19.2.18	MEP RFM Receiver.....	1064
19.3	MIP Half Function	1065
19.3.1	MHF identification	1065
19.3.2	MHF functions	1065
19.3.3	MHF architecture.....	1066
19.3.4	MHF Level Demultiplexer.....	1066
19.3.5	MHF Type Demultiplexer	1067
19.3.6	MHF OpCode Demultiplexer	1067
19.3.7	MHF Multiplexer.....	1067
19.3.8	MHF Loopback Responder.....	1067
19.3.9	MHF Continuity Check Receiver	1067
19.3.10	MIP CCM Database.....	1067
19.3.11	MHF Linktrace SAP	1067
19.3.12	MHF Decapsulator Responder.....	1067
19.3.13	MHF RFM Receiver	1067
19.4	Maintenance Point addressing	1068
19.5	Linktrace Output Multiplexer	1068
19.6	Linktrace Responder	1069

20. Connectivity Fault Management protocols	1071
20.1 Continuity Check protocol	1072
20.1.1 MAC status reporting in the CCM	1073
20.1.2 Defects and Fault Alarms	1074
20.1.3 CCM reception	1074
20.2 Loopback protocol	1075
20.2.1 Loopback Message transmission	1075
20.2.2 Loopback Message reception and Loopback Reply transmission	1076
20.2.3 Loopback Reply reception	1077
20.3 Linktrace protocol	1077
20.3.1 Linktrace Message origination	1078
20.3.2 Linktrace Message reception, forwarding, and replying	1078
20.3.3 Linktrace Reply reception	1080
20.4 Connectivity Fault Management state machines	1081
20.5 CFM state machine timers	1081
20.5.1 LTFwhile	1081
20.5.2 CCIwhile	1081
20.5.3 errorCCMwhile	1081
20.5.4 xconCCMwhile	1082
20.5.5 LBIwhile	1083
20.5.6 FNGwhile	1083
20.5.7 mmCCMwhile	1083
20.5.8 mmLocwhile	1083
20.5.9 mmFNGwhile	1083
20.5.10 rMEPwhile	1083
20.6 CFM procedures	1083
20.6.1 CCMtime()	1083
20.7 Maintenance Domain variable	1084
20.7.1 mdLevel	1084
20.8 Maintenance Association variables	1084
20.8.1 CCMinterval	1084
20.9 MEP variables	1084
20.9.1 MEPactive	1084
20.9.2 enableRmepDefect	1085
20.9.3 MAdefectIndication	1085
20.9.4 allRMEPsDead	1085
20.9.5 lowestAlarmPri	1086
20.9.6 presentRDI	1086
20.9.7 MEPprimaryVID	1086
20.9.8 presentTraffic	1086
20.9.9 presentmmLoc	1086
20.9.10 ISpresentTraffic	1086
20.9.11 ISpresentmmLoc	1086
20.10 MEP Continuity Check Initiator variables	1086
20.10.1 CCIenabled	1087
20.10.2 CCI sentCCMs	1087
20.10.3 MACstatusChanged	1087
20.11 MEP Continuity Check Initiator procedures	1087
20.11.1 xmitCCM()	1087
20.12 MEP Continuity Check Initiator state machine	1088
20.13 MHF Continuity Check Receiver variables	1088
20.13.1 MHFrecvdCCM	1088
20.13.2 MHFCCMPDU	1088

20.14	MHF Continuity Check Receiver procedures	1089
20.14.1	MHFprocessCCM()	1089
20.15	MHF Continuity Check Receiver state machine	1089
20.16	MEP Continuity Check Receiver variables	1090
20.16.1	CCMreceivedEqual	1090
20.16.2	CCMequalPDU	1090
20.16.3	CCMreceivedLow	1091
20.16.4	CCMlowPDU	1091
20.16.5	recvdMacAddress	1091
20.16.6	recvdRDI	1091
20.16.7	recvdInterval	1091
20.16.8	recvdPortState	1091
20.16.9	recvdInterfaceStatus	1091
20.16.10	recvdSenderId	1091
20.16.11	recvdFrame	1091
20.16.12	CCMsequenceErrors	1091
20.16.13	rcvdTrafficBit	1092
20.17	MEP Continuity Check Receiver procedures	1092
20.17.1	MEPprocessEqualCCM()	1092
20.17.2	MEPprocessLowCCM()	1093
20.18	MEP Continuity Check Receiver state machine	1093
20.19	Remote MEP variables	1093
20.19.1	rMEPCCMdefect	1094
20.19.2	rMEPlastRDI	1094
20.19.3	rMEPlastPortState	1094
20.19.4	rMEPlastInterfaceStatus	1094
20.19.5	rMEPlastSenderId	1094
20.19.6	rCCMreceived	1094
20.19.7	rMEPmacAddress	1094
20.19.8	rMEPportStatusDefect	1094
20.19.9	rMEPinterfaceStatusDefect	1095
20.20	Remote MEP state machine	1095
20.21	Remote MEP Error variables	1095
20.21.1	errorCCMreceived	1096
20.21.2	errorCCMlastFailure	1096
20.21.3	errorCCMdefect	1096
20.22	Remote MEP Error state machine	1096
20.23	MEP Cross Connect variables	1096
20.23.1	xconCCMreceived	1097
20.23.2	xconCCMlastFailure	1097
20.23.3	xconCCMdefect	1097
20.24	MEP Cross Connect state machine	1097
20.25	MEP Mismatch variables	1097
20.25.1	mmCCMreceived	1098
20.25.2	mmCCMdefect	1098
20.25.3	mmCCMTime	1098
20.25.4	disableLocdefect	1098
20.25.5	mmLocdefect	1098
20.26	MEP Mismatch state machines	1098
20.27	MP Loopback Responder variables	1098
20.27.1	LBMreceived	1099
20.27.2	LBMPDU	1100
20.28	MP Loopback Responder procedures	1100
20.28.1	ProcessLBM()	1100

20.28.2	xmitLBR()	1100
20.29	MP Loopback Responder state machine	1101
20.30	MEP Loopback Initiator variables	1101
20.30.1	LBMSToSend	1102
20.30.2	nextLBMtransID	1102
20.30.3	expectedLBRtransID	1102
20.30.4	LBIactive	1102
20.30.5	xmitReady	1102
20.30.6	LBRreceived	1102
20.30.7	LBRPDU	1102
20.31	MEP Loopback Initiator transmit procedures	1102
20.31.1	xmitLBM()	1102
20.32	MEP Loopback Initiator transmit state machine	1103
20.33	MEP Loopback Initiator receive procedures	1103
20.33.1	ProcessLBR()	1103
20.34	MEP Loopback Initiator receive state machine	1104
20.35	MEP Fault Notification Generator variables	1104
20.35.1	fngPriority	1105
20.35.2	fngDefect	1105
20.35.3	fngAlarmTime	1105
20.35.4	fngResetTime	1105
20.35.5	someRMEPCCMdefect	1105
20.35.6	someMACstatusDefect	1106
20.35.7	someRDId defect	1106
20.35.8	highestDefectPri	1106
20.35.9	highestDefect	1106
20.36	MEP Fault Notification Generator procedures	1106
20.36.1	xmitFaultAlarm()	1106
20.37	MEP Fault Notification Generator state machine	1106
20.38	MEP Mismatch Fault Notification Generator variables	1107
20.38.1	mfngAllowed	1107
20.38.2	mmdefectIndication	1107
20.38.3	mfngAlarmTime	1108
20.38.4	mfngResetTime	1108
20.39	MEP Mismatch Fault Notification Generator procedures	1108
20.39.1	xmitFaultAlarm()	1108
20.40	MEP Mismatch Fault Notification Generator state machine	1108
20.41	MEP Linktrace Initiator variables	1108
20.41.1	nextLTMtransID	1108
20.41.2	ltmReplyList	1108
20.42	MEP Linktrace Initiator procedures	1111
20.42.1	xmitLTM()	1111
20.43	MEP Linktrace Initiator receive variables	1112
20.43.1	LTRreceived	1112
20.43.2	LTRPDU	1112
20.44	MEP Linktrace Initiator receive procedures	1112
20.44.1	ProcessLTR()	1112
20.45	MEP Linktrace Initiator receive state machine	1113
20.46	Linktrace Responder variables	1113
20.46.1	nPendingLTRs	1113
20.46.2	LTMreceived	1113
20.46.3	LTMPDU	1113
20.47	LTM Receiver procedures	1114
20.47.1	ProcessLTM()	1114

20.47.2	clearPendingLTRs()	1118
20.47.3	ForwardLTM()	1118
20.47.4	enqueueLTR()	1118
20.48	LTM Receiver state machine	1120
20.49	LTR Transmitter procedure	1120
20.49.1	xmitOldestLTR()	1120
20.50	LTR Transmitter state machine	1120
20.51	CFM PDU validation and versioning	1121
20.51.1	Goals of CFM PDU versioning	1121
20.51.2	PDU transmission	1121
20.51.3	PDU validation	1122
20.51.4	Validation pass	1122
20.51.5	Execution pass	1123
20.51.6	Future extensions	1124
20.52	PDU identification	1124
20.53	Use of transaction IDs and sequence numbers	1125
21.	Encoding of CFM Protocol Data Units	1126
21.1	Structure, representation, and encoding	1126
21.2	CFM encapsulation	1126
21.3	CFM request and indication parameters	1127
21.3.1	destination_address parameter	1127
21.3.2	source_address parameter	1127
21.4	Common CFM Header	1128
21.4.1	MD Level	1128
21.4.2	Version	1128
21.4.3	OpCode	1128
21.4.4	Flags	1128
21.4.5	First TLV Offset	1128
21.5	TLV Format	1129
21.5.1	General format for CFM TLVs	1129
21.5.2	Organization-Specific TLV	1130
21.5.3	Sender ID TLV	1131
21.5.4	Port Status TLV	1132
21.5.5	Interface Status TLV	1133
21.5.6	Data TLV	1134
21.5.7	End TLV	1134
21.6	Continuity Check Message format	1134
21.6.1	Flags	1135
21.6.2	First TLV Offset	1136
21.6.3	Sequence Number	1136
21.6.4	Maintenance association End Point Identifier	1136
21.6.5	Maintenance Association Identifier	1136
21.6.6	Defined by ITU-T Y.1731 (02/2008)	1139
21.6.7	Optional CCM TLVs	1139
21.7	Loopback Message and Loopback Reply formats	1139
21.7.1	Flags	1140
21.7.2	First TLV Offset	1140
21.7.3	Loopback Transaction Identifier	1140
21.7.4	Additional LBM/LBR TLVs	1140
21.7.5	PBB-TE MIP TLV	1140
21.8	Linktrace Message Format	1141
21.8.1	Flags	1142

21.8.2	First TLV Offset	1142
21.8.3	LTM Transaction Identifier	1142
21.8.4	LTM TTL.....	1142
21.8.5	Original MAC Address.....	1142
21.8.6	Target MAC Address.....	1142
21.8.7	Additional LTM TLVs.....	1142
21.8.8	LTM Egress Identifier TLV.....	1143
21.9	Linktrace Reply Format	1143
21.9.1	Flags.....	1143
21.9.2	First TLV Offset	1143
21.9.3	LTR Transaction Identifier	1144
21.9.4	Reply TTL.....	1144
21.9.5	Relay Action	1144
21.9.6	Additional LTR TLVs	1144
21.9.7	LTR Egress Identifier TLV.....	1145
21.9.8	Reply Ingress TLV.....	1146
21.9.9	Reply Egress TLV	1147
22	Connectivity Fault Management in systems	1149
22.1	CFM shims in Bridges	1149
22.1.1	Preliminary positioning of Maintenance Points.....	1149
22.1.2	CFM and the Forwarding Process	1150
22.1.3	Up/Down separation of Maintenance Points	1151
22.1.4	Service instances over multiple Bridges.....	1154
22.1.5	Multiple VID service instances.....	1156
22.1.6	Untagged CFM PDUs.....	1156
22.1.7	Maintenance Points and non-VLAN aware Bridges.....	1156
22.1.8	Maintenance Points and other standards.....	1157
22.1.9	CFM and IEEE 802.3 Clause 57 OAM	1159
22.2	Maintenance Entity creation	1159
22.2.1	Creating Maintenance Domains and Maintenance Associations.....	1160
22.2.2	Creating MEPs.....	1160
22.2.3	Creating MIPs.....	1162
22.2.4	CFM configuration errors	1163
22.3	MPs, Ports, and MD Level assignment.....	1164
22.4	Stations and Connectivity Fault Management	1164
22.5	Scalability of Connectivity Fault Management	1165
22.6	CFM in Provider Bridges.....	1166
22.6.1	Maintenance Points and C-VLAN components.....	1166
22.6.2	Maintenance C-VLAN on a Port-based service interface	1167
22.6.3	Maintenance C-VLAN on a C-tagged service interface	1168
22.6.4	Maintenance Points and Port-mapping S-VLAN components	1168
22.7	Management Port MEPs and CFM in the enterprise environment	1169
22.8	Implementing CFM on existing Bridges	1171
23	MAC status propagation	1173
23.1	Model of operation.....	1174
23.1.1	MAC Status Shim	1175
23.1.2	Relationship of Connectivity Fault Management to the MAC Status Shim.....	1176
23.2	MAC status protocol (MSP) overview	1176
23.3	MAC status protocol state machines	1180
23.4	State machine timers	1182
23.4.1	linkNotifyWhen	1182

23.4.2	linkNotifyWhile	1182
23.4.3	macNotifyWhile	1182
23.4.4	macRecoverWhile	1182
23.5	MSP performance parameters	1182
23.5.1	LinkNotify	1182
23.5.2	LinkNotifyWait	1183
23.5.3	LinkNotifyRetry	1183
23.5.4	MACNotify	1183
23.5.5	MACNotifyTime	1183
23.5.6	MACRecoverTime	1183
23.6	State machine variables	1183
23.6.1	BEGIN	1183
23.6.2	addConfirmed	1183
23.6.3	disableMAC	1183
23.6.4	disabledMAC	1183
23.6.5	disableMSS	1183
23.6.6	lossConfirmed	1183
23.6.7	macOperational	1184
23.6.8	mssOperational	1184
23.6.9	prop	1184
23.6.10	rxAck	1184
23.6.11	rxAdd	1184
23.6.12	rxAddConfirm	1184
23.6.13	rxLoss	1184
23.6.14	rxLossConfirm	1184
23.6.15	txAck	1184
23.6.16	txAdd	1184
23.6.17	txAddConfirm	1184
23.6.18	txLoss	1184
23.6.19	txLossConfirm	1185
23.7	State machine procedures	1185
23.8	Status Transition state machine	1185
23.9	Status Notification state machine	1185
23.10	Receive Process	1185
23.11	Transmit Process	1186
23.12	Management of MSP	1186
23.13	MSPDU transmission, addressing, and protocol identification	1187
23.13.1	Destination MAC Address	1187
23.13.2	Source MAC Address	1187
23.13.3	Priority	1187
23.13.4	EtherType use and encoding	1188
23.14	Representation and encoding of octets	1188
23.15	MSPDU structure	1188
23.15.1	Protocol Version	1188
23.15.2	Packet Type	1189
23.16	Validation of received MSPDUs	1189
23.17	Other MSP participants	1189
24.	<Reserved for a future amendment>	1190
25.	Support of the MAC Service by Provider Backbone Bridged Networks	1191
25.1	Service transparency	1193
25.2	Customer service interface	1193

25.3	Port-based service interface	1194
25.4	S-tagged service interface	1195
25.5	I-tagged service interface	1197
25.6	Service instance segregation	1199
25.7	Service instance selection and identification	1199
25.8	Service priority and drop eligibility selection	1200
25.9	Service access protection	1200
25.9.1	Class II redundant LANs access protection	1202
25.9.2	Class III simple redundant LANs and nodes access protection	1203
25.10	Support of the MAC Service by a PBB-TE Region	1204
25.10.1	Provisioning TESI	1205
25.10.2	ESP forwarding behavior	1206
25.11	Transparent service interface	1207
26.	Principles of Provider Backbone Bridged Network operation	1209
26.1	Provider Backbone Bridged Network overview	1209
26.2	Provider Backbone Bridged Network example	1210
26.3	Backbone VLAN connectivity	1212
26.4	Backbone addressing	1213
26.4.1	Learning individual backbone addresses at a PIP	1213
26.4.2	Translating backbone destination addresses at a CBP	1214
26.4.3	Backbone addressing considerations for CFM Maintenance Points	1214
26.5	Detection of connectivity loops through attached networks	1215
26.6	Scaling of Provider Backbone Bridges	1215
26.6.1	Hierarchal PBBNs	1215
26.6.2	Peer PBBNs	1216
26.7	Network Management	1216
26.8	Connectivity Fault Management in Provider Backbone Bridges	1216
26.8.1	CFM over Port-based and S-tagged Service Interfaces	1222
26.8.2	Connectivity Fault Management over I-tagged Service Interfaces	1223
26.8.3	Connectivity Fault Management over hierarchal E-NNI	1223
26.8.4	Connectivity Fault Management over peer E-NNI	1223
26.9	Connectivity Fault Management in a PBB-TE Region	1224
26.9.1	Addressing PBB-TE MEPs	1224
26.9.2	TESI identification	1224
26.9.3	PBB-TE MEP placement in a Bridge Port	1225
26.9.4	PBB-TE MIP placement in a Bridge Port	1225
26.9.5	TESI Maintenance Domains	1225
26.9.6	PBB-TE enhancements of the CFM protocols	1226
26.9.7	Addressing Infrastructure Segment MEPs	1228
26.9.8	Infrastructure Segment identification	1228
26.9.9	Infrastructure Segment MEP placement in a Bridge Port	1229
26.9.10	Infrastructure Segment Maintenance Domains	1229
26.9.11	IPS extensions to Continuity Check operation	1229
26.10	Protection switching for point-to-point TESI	1231
26.10.1	Introduction	1231
26.10.2	1:1 point-to-point TESI protection switching	1232
26.10.3	Protection Switching state machines	1234
26.11	Infrastructure Protection Switching in PBB-TE Region	1240
26.11.1	Infrastructure Segment monitoring	1241
26.11.2	1:1 IPS	1242
26.11.3	IPS Control entity	1245
26.11.4	1:1 IPS state machines	1246

26.11.5	M:1 IPS	1246
26.12	Mismatch defect.....	1252
26.13	Signaling VLAN registrations among I-components	1253
27.	Shortest Path Bridging (SPB)	1254
27.1	Protocol design requirements.....	1256
27.2	Protocol support.....	1257
27.3	Protocol design goals	1257
27.4	ISIS-SPB VLAN configuration	1257
27.4.1	SPT Region and ISIS-SPB adjacency determination	1258
27.5	ISIS-SPB information	1261
27.6	Calculating CIST connectivity.....	1261
27.7	Connectivity between regions in the same domain	1262
27.8	Calculating SPT connectivity	1263
27.8.1	ISIS-SPB overload.....	1263
27.9	Loop prevention.....	1264
27.10	SPVID and SPSourceID allocation.....	1264
27.11	Allocation of VIDs to FIDs	1266
27.12	SPBV SPVID translation	1266
27.13	VLAN topology management.....	1267
27.14	Individual addresses and SPBM	1268
27.14.1	Loop mitigation.....	1268
27.14.2	Loop prevention.....	1269
27.15	SPBM group addressing	1269
27.16	Backbone service instance topology management	1270
27.17	Equal cost shortest paths, ECTs, and load spreading	1271
27.18	Using SPBV and SPBM	1271
27.18.1	Shortest Path Bridging—VID	1271
27.18.2	Shortest Path Bridging—MAC	1273
27.19	Security considerations	1275
28.	ISIS-SPB Link State Protocol.....	1276
28.1	ISIS-SPB control plane MAC	1276
28.2	Formation and maintenance of ISIS-SPB adjacencies	1277
28.3	Loop prevention	1278
28.4	The Agreement Digest	1278
28.4.1	Agreement Digest Format Identifier	1279
28.4.2	Agreement Digest Format Capabilities.....	1279
28.4.3	Agreement Digest Convention Identifier	1279
28.4.4	Agreement Digest Convention Capabilities	1279
28.4.5	Agreement Digest Edge Count	1280
28.4.6	The Computed Topology Digest.....	1280
28.5	Symmetric shortest path tie breaking.....	1281
28.6	Symmetric ECT framework.....	1282
28.7	Symmetric ECT	1283
28.8	Predefined ECT Algorithm details	1284
28.9	ECT Migration	1285
28.9.1	Use of a new ECT Algorithm in SPBV	1285
28.9.2	Use of a new ECT Algorithm in SPBM	1286
28.10	MAC Address registration	1286
28.11	Circuit IDs and Port Identifiers.....	1287
28.12	ISIS-SPB TLVs.....	1287
28.12.1	MT-Capability TLV.....	1288

28.12.2	SPB MCID sub-TLV	1288
28.12.3	SPB Digest sub-TLV	1289
28.12.4	SPB Base VLAN-Identifiers sub-TLV	1289
28.12.5	SPB Instance sub-TLV	1291
28.12.6	SPB Instance Opaque ECT Algorithm sub-TLV	1292
28.12.7	SPB Link Metric sub-TLV	1293
28.12.8	SPB Adjacency Opaque ECT Algorithm sub-TLV	1294
28.12.9	SPBV MAC address sub-TLV	1294
28.12.10	SPBM Service Identifier and Unicast Address (ISID-ADDR) sub-TLV	1296
29.	DDCFM operations and protocols	1298
29.1	Principles of DDCFM operation	1298
29.1.1	Data-driven and data-dependent faults (DDFs)	1298
29.1.2	Basic principle to diagnose and isolate DDFs	1298
29.2	DDCFM Entity operation	1301
29.2.1	DDCFM implementation	1301
29.2.2	Forward Path Test Reflection Responder	1302
29.2.3	Reflection Responder related parameters	1303
29.2.4	Reflection Target and RFM Receiver	1304
29.2.5	Return path test related parameters	1304
29.2.6	Decapsulator Responder	1305
29.2.7	SFM Originator	1306
29.3	DDCFM protocols	1306
29.3.1	Reflection Responder variables	1306
29.3.2	RR Filter Procedures	1308
29.3.3	RR Encapsulation Procedures	1309
29.3.4	RR Transmit procedure	1310
29.3.5	Reflection Responder related state machines	1311
29.3.6	RFM Receiver variables	1312
29.3.7	RFM Receiver procedure	1313
29.3.8	Decapsulator Responder variables	1314
29.3.9	Decapsulator Responder procedures	1314
29.3.10	Decapsulator Responder state machine	1316
29.4	Encoding of DDCFM Protocol Data Units	1316
29.4.1	RFM and SFM Header	1316
29.4.2	RFM format	1316
29.4.3	SFM format	1317
30.	Principles of congestion notification	1319
30.1	Congestion notification design requirements	1319
30.2	Quantized Congestion Notification protocol	1321
30.2.1	The CP Algorithm	1322
30.2.2	Basic Reaction Point algorithm	1323
30.2.3	RP algorithm with timer	1324
30.3	Congestion Controlled Flow	1325
30.4	Congestion Notification Priority Value	1326
30.5	Congestion Notification Tag	1326
30.6	Congestion Notification Domain	1326
30.7	Multicast data	1327
30.8	Congestion notification and additional tags	1328
31.	Congestion notification entity operation	1329

31.1	Congestion aware Bridge Forwarding Process	1329
31.1.1	Congestion Point	1329
31.1.2	Congestion Point ingress multiplexer	1330
31.2	Congestion aware end station functions	1330
31.2.1	Output flow segregation	1331
31.2.2	Per-CNPV station function	1332
31.2.3	Flow Select Database	1334
31.2.4	Flow multiplexer	1334
31.2.5	CNM demultiplexer	1334
31.2.6	Input flow segregation	1334
31.2.7	End station input queue	1335
31.2.8	Reception selection	1335
32.	Congestion notification protocol	1336
32.1	Congestion Notification Domain operations	1336
32.1.1	Congestion Notification Domain defense	1336
32.1.2	Automatic Congestion Notification Domain recognition	1338
32.1.3	Variables controlling Congestion Notification Domain defense	1338
32.2	CN component variables	1339
32.2.1	cngMasterEnable	1340
32.2.2	cngCnmTransmitPriority	1340
32.2.3	cngDiscardedFrames	1340
32.2.4	cngErroredPortList	1340
32.3	Congestion notification per-CNPV variables	1340
32.3.1	cncpDefModeChoice	1340
32.3.2	cncpAlternatePriority	1341
32.3.3	cncpAutoAltPri	1341
32.3.4	cncpAdminDefenseMode	1341
32.3.5	cncpCreation	1341
32.3.6	cncpLldpInstanceChoice	1341
32.3.7	cncpLldpInstanceSelector	1341
32.4	CND defense per-Port per-CNPV variables	1342
32.4.1	cnpdDefModeChoice	1342
32.4.2	cnpdAdminDefenseMode	1342
32.4.3	cnpdAutoDefenseMode	1343
32.4.4	cnpdLldpInstanceChoice	1343
32.4.5	cnpdLldpInstanceSelector	1343
32.4.6	cnpdAlternatePriority	1343
32.4.7	cnpdXmitCnpvCapable	1343
32.4.8	cnpdXmitReady	1343
32.4.9	cncpDoesEdge	1344
32.4.10	cnpdAcceptsCnTag	1344
32.4.11	cnpdRcvdCnpv	1344
32.4.12	cnpdRcvdReady	1344
32.4.13	cnpdIsAdminDefMode	1344
32.4.14	cnpdDefenseMode	1345
32.5	Congestion Notification Domain defense procedures	1345
32.5.1	DisableCnpvRemapping()	1345
32.5.2	TurnOnCnDefenses()	1345
32.5.3	TurnOffCnDefenses()	1345
32.6	Congestion Notification Domain defense state machine	1346
32.7	Congestion notification protocol	1346
32.8	Congestion Point variables	1347

32.8.1	cpMacAddress	1348
32.8.2	cpId	1348
32.8.3	cpQSp.....	1348
32.8.4	cpQLen.....	1348
32.8.5	cpQLenOld.....	1348
32.8.6	cpW	1348
32.8.7	cpQOffset.....	1348
32.8.8	cpQDelta	1348
32.8.9	cpFb	1349
32.8.10	cpEnqueued	1349
32.8.11	cpSampleBase.....	1349
32.8.12	cpDiscardedFrames.....	1349
32.8.13	cpTransmittedFrames.....	1349
32.8.14	cpTransmittedCnms	1349
32.8.15	cpMinHeaderOctets	1349
32.9	Congestion Point procedures	1349
32.9.1	Random.....	1350
32.9.2	NewCpSampleBase().....	1350
32.9.3	EM_UNITDATA.request (parameters).....	1350
32.9.4	GenerateCnmPdu()	1351
32.10	Reaction Point per-Port per-CNPV variables	1352
32.10.1	rpppMaxRps.....	1352
32.10.2	rpppCreatedRps	1352
32.10.3	rpppRpCentiseconds	1352
32.11	Reaction Point group variables	1352
32.11.1	rpgEnable	1353
32.11.2	rpgTimeReset.....	1353
32.11.3	rpgByteReset.....	1353
32.11.4	rpgThreshold	1353
32.11.5	rpgMaxRate	1353
32.11.6	rpgAiRate.....	1353
32.11.7	rpgHaiRate	1353
32.11.8	rpgGd	1353
32.11.9	rpgMinDecFac	1353
32.11.10	rpgMinRate	1354
32.12	Reaction Point timer	1354
32.12.1	RpWhile	1354
32.13	Reaction Point variables	1354
32.13.1	rpEnabled	1354
32.13.2	rpByteCount.....	1354
32.13.3	rpByteStage.....	1354
32.13.4	rpTimeStage.....	1355
32.13.5	rpTargetRate	1355
32.13.6	rpCurrentRate.....	1355
32.13.7	rpFreeze	1355
32.13.8	rpLimiterRate.....	1355
32.13.9	rpFb	1355
32.14	Reaction Point procedures	1355
32.14.1	ResetCnm.....	1356
32.14.2	TestRpTerminate	1356
32.14.3	TransmitDataFrame	1356
32.14.4	ReceiveCnm.....	1356
32.14.5	ProcessCnm	1357
32.14.6	AdjustRates.....	1357

32.15	RP rate control state machine	1357
32.16	Congestion notification and encapsulation interworking function	1359
33.	Encoding of congestion notification Protocol Data Units	1361
33.1	Structure, representation, and encoding.....	1361
33.2	Congestion Notification Tag format	1361
33.2.1	Flow Identifier	1362
33.3	Congestion Notification Message.....	1362
33.4	Congestion Notification Message PDU format	1363
33.4.1	Version.....	1363
33.4.2	ReservedV.....	1363
33.4.3	Quantized Feedback.....	1364
33.4.4	Congestion Point Identifier	1364
33.4.5	cnmQOffset.....	1364
33.4.6	cnmQDelta	1364
33.4.7	Encapsulated priority	1364
33.4.8	Encapsulated destination MAC address	1364
33.4.9	Encapsulated MSDU length.....	1364
33.4.10	Encapsulated MSDU.....	1364
33.4.11	CNM Validation	1365
34.	Forwarding and queuing for time-sensitive streams.....	1366
34.1	Overview.....	1366
34.2	Detection of SRP domains	1366
34.3	The bandwidth availability parameters.....	1367
34.3.1	Relationships among bandwidth availability parameters	1367
34.3.2	Bandwidth availability parameter management	1368
34.4	Deriving actual bandwidth requirements from the size of the MSDU	1368
34.5	Mapping priorities to traffic classes for time-sensitive streams	1369
34.6	End station behavior	1371
34.6.1	Talker behavior.....	1371
34.6.2	Listener behavior	1372
35.	Stream Registration Protocol (SRP)	1373
35.1	Multiple Stream Registration Protocol (MSRP).....	1374
35.1.1	MSRP and Shared Media.....	1375
35.1.2	Behavior of end stations	1375
35.1.3	Behavior of Bridges	1377
35.2	Definition of the MSRP application	1377
35.2.1	Definition of internal state variables.....	1377
35.2.2	Definition of MRP elements	1379
35.2.3	Provision and support of Stream registration service	1390
35.2.4	MSRP Attribute Propagation	1394
35.2.5	Operational reporting and statistics	1399
35.2.6	Encoding	1399
35.2.7	Attribute value support requirements	1399
36.	Priority-based Flow Control	1401
36.1	Priority-based Flow Control operation	1401
36.1.1	Overview.....	1401
36.1.2	PFC primitives	1402
36.1.3	Detailed specification of PFC operation.....	1403

36.2	PFC aware system queue functions	1404
36.2.1	PFC Initiator	1405
36.2.2	PFC Receiver	1405
37.	Enhanced Transmission Selection (ETS)	1141
37.1	Overview	1141
37.1.1	Relationship to other transmission selection algorithms	1141
37.2	ETS configuration parameters	1141
37.3	ETS algorithm	1141
37.4	Legacy configuration	1142
38.	Data Center Bridging eXchange Protocol (DCBX)	1143
38.1	Overview	1143
38.2	Goals	1143
38.3	Types of DCBX attributes	1143
38.3.1	Informational attributes	1143
38.4	DCBX and LLDP	1143
38.4.1	Asymmetric attribute passing	1144
38.4.2	Symmetric attribute passing	1145
39.	Multiple I-SID Registration Protocol	1147
39.1	MIRP overview	1147
39.1.1	Behavior of I-components	1148
39.1.2	Behavior of B-components	1149
39.2	Definition of the MIRP application	1149
39.2.1	Definition of MRP protocol elements	1149
39.2.2	Alternate MIRP model for B-components	1152
39.2.3	Use of “new” declaration capability	1154
39.2.4	Attribute value support requirements	1154
39.2.5	MRP Message filtering	1154
40.	Edge Virtual Bridging (EVB)	1155
40.1	EVB architecture without S-channels	1157
40.2	EVB architecture with S-channels	1158
40.3	Asymmetric EVB architecture without S-channels	1160
41.	VSI discovery and configuration protocol (VDP)	1162
41.1	VSI manager ID TLV definition	1162
41.1.1	TLV type	1162
41.1.2	TLV information string length	1162
41.1.3	VSI Manager ID	1163
41.2	VDP association TLV definitions	1163
41.2.1	TLV type	1163
41.2.2	TLV information string length	1164
41.2.3	Status	1164
41.2.4	VSI Type ID (VTID)	1164
41.2.5	VSI Type Version	1164
41.2.6	VSIID format	1164
41.2.7	VSIID	1165
41.2.8	Filter Info format	1165
41.2.9	Filter Info field	1166

41.2.10	VDP TLV type and Status semantics	1169
41.3	Organizationally defined TLV definitions	1170
41.3.1	TLV type	1170
41.3.2	TLV information string length	1170
41.3.3	Organizationally unique identifier (OUI)	1170
41.3.4	Organizationally defined information	1170
41.4	Validation rules for VDP TLVs	1170
41.5	VDP state machines	1171
41.5.1	State machine conventions	1171
41.5.2	Bridge VDP state machine	1171
41.5.3	Station VDP state machine	1172
41.5.4	VDP state machine timers	1173
41.5.5	VDP state machine variables and parameters	1173
41.5.6	Command-Response TLV field references in state machines	1175
41.5.7	VDP state machine procedures	1176
42.	S-Channel Discovery and Configuration Protocol (CDCP)	1178
42.1	CDCP discovery and configuration	1178
42.2	CDCP state machine overview	1178
42.3	CDCP configuration state machine	1179
42.4	CDCP configuration variables	1180
42.4.1	AdminChnCap	1180
42.4.2	AdminRole	1181
42.4.3	AdminSVIDWants	1181
42.4.4	LastLocalSVIDPool	1181
42.4.5	LastRemoteSVIDList	1181
42.4.6	LastSVIDWants	1181
42.4.7	LocalSVIDPool	1181
42.4.8	OperChnCap	1181
42.4.9	OperRole	1181
42.4.10	OperSVIDList	1182
42.4.11	RemoteChnCap	1182
42.4.12	RemoteRole	1182
42.4.13	RemoteSVIDList	1182
42.4.14	RemoteVersion	1182
42.4.15	schState	1182
42.5	CDCP configuration procedures	1182
42.5.1	SetSVIDRequest (OperRole, AdminSVIDWants, OperSVIDList)	1182
42.5.2	RxSVIDConfig (OperSVIDList, LastRemoteSVIDList)	1183
42.5.3	TxSVIDConfig (OperChnCap, RemoteChnCap, LastLocalSVIDPool, RemoteSVIDList, OperSVIDList)	1183
43.	Edge Control Protocol (ECP)	1184
43.1	Edge control protocol operation	1184
43.2	Edge Control Sublayer Service (ECSS)	1185
43.3	Edge control protocol (ECP) and state machine	1185
43.3.1	State machine conventions	1185
43.3.2	Overview	1185
43.3.3	Edge control protocol data unit (ECPDU)	1186
43.3.4	ECP transmit state machine	1187
43.3.5	ECP receive state machine	1187
43.3.6	ECP state machine timers	1188
43.3.7	ECP state machine variables and parameters	1189

43.3.8	ECP state machine procedures.....	1190
Annex A		1191
(normative)PICS proforma—Bridge implementations.....		1191
A.1	Introduction.....	1191
A.2	Abbreviations and special symbols.....	1191
A.3	Instructions for completing the PICS proforma.....	1192
A.4	PICS proforma for IEEE Std 802.1Q—Bridge implementations	1194
A.5	Major capabilities	1195
A.6	Media Access Control methods	1199
A.7	Relay and filtering of frames	1200
A.8	Basic Filtering Services	1201
A.9	Addressing	1202
A.10	Rapid Spanning Tree Protocol	1204
A.11	BPDU encoding	1206
A.12	Implementation parameters.....	1206
A.13	Performance	1207
A.14	Bridge management	1208
A.15	Remote management.....	1217
A.16	Expedited traffic classes	1218
A.17	Extended Filtering Services	1218
A.18	Multiple Spanning Tree Protocol.....	1218
A.19	VLAN support	1220
A.20	MMRP	1224
A.21	MVRP	1225
A.22	MRP	1226
A.23	Connectivity Fault Management.....	1227
A.24	Management Information Base (MIB)	1233
A.25	Protection Switching.....	1235
A.26	Data-driven and data-dependent connectivity fault management.....	1236
A.27	TPMR.....	1236
A.29	Forwarding and queuing for time-sensitive streams	1237
A.28	MSP	1237
A.30	Congestion notification.....	1238
A.31	Stream Reservation Protocol	1239
A.32	MIRP	1242
A.33	Priority-based Flow Control	1243
A.34	Enhanced Transmission Selection	1243
A.35	DCBX	1244
A.36	Shortest Path Bridging.....	1244
A.37	EVB Bridge.....	1245
A.38	EVB station.....	1246
A.39	Edge relay	1248
A.40	VEB and VEPA edge relay components	1250
A.41	VDP, CDCP, and ECP	1251
Annex B		1252
(normative)PICS proforma—End station implementations		1252
B.1	Introduction.....	1252
B.2	Abbreviations and special symbols.....	1252
B.3	Instructions for completing the PICS proforma.....	1253

B.4	PICS proforma for IEEE Std 802.1Q—End station implementations	1255
B.5	Major capabilities	1256
B.6	MMRP	1256
B.7	MVRP	1257
B.8	MRP	1258
B.9	Forwarding and queuing for time-sensitive streams	1259
B.10	SRP (Stream Reservation Protocol).....	1259
B.11	Congestion notification.....	1262
Annex C		1264
(normative)DMN (Designated MSRP Node) Implementations		1264
C.1	Designated MSRP nodes on CSNs	1264
C.2	Designated MSRP Node on MoCA	1267
C.3	Designated MSRP Nodes on IEEE 802.11 media	1272
Annex D		1281
(normative)IEEE 802.1 Organizationally Specific TLVs.....		1281
D.1	Requirements of the IEEE 802.1 Organizationally Specific TLV sets.....	1281
D.2	Organizationally Specific TLV definitions.....	1282
D.3	IEEE 802.1 Organizationally Specific TLV management.....	1298
D.4	IEEE 802.1/LLDP extension MIB	1299
D.5	PICS proforma for IEEE 802.1 Organizationally Specific TLV extensions	1382
Annex E		1385
(normative)Notational conventions used in state diagrams.....		1385
Annex F		1387
(informative)Shared and Independent VLAN Learning.....		1387
F.1	Requirements for Shared and Independent Learning	1387
F.2	Configuring the Global VLAN Learning Constraints	1396
F.3	Interoperability.....	1397
Annex G		1399
(informative)MAC method dependent aspects of VLAN support.....		1399
G.1	Example tagged IEEE 802.3 Ethertype-encoded frame format.....	1399
G.2	Padding and frame size considerations	1399
Annex H		1401
(informative)Interoperability considerations		1401
H.1	Requirements for interoperability	1401
H.2	Homogenous IEEE 802.1Q networks	1402
H.3	Heterogeneous networks: Intermixing IEEE 802.1D (D) and IEEE 802.1Q (Q) Bridges	1404
H.4	Heterogeneous networks: GARP and MRP issues	1405
H.5	Intermixing Port-based classification and Port-and-Protocol-based classification or future enhancements in IEEE Std 802.1Q1407	

Annex I	1409
(informative)Priority and drop precedence	1409
I.1 Traffic types	1409
I.2 Managing latency and throughput	1410
I.3 Traffic type to traffic class mapping	1410
I.4 Traffic types and priority values	1412
I.5 Supporting the credit-based shaper algorithm	1413
I.6 Supporting drop precedence	1414
I.7 Priority code point allocation	1415
I.8 Interoperability	1415
Annex J	1417
(informative)Connectivity Fault Management protocol design and use	1417
J.1 Origin of Connectivity Fault Management	1417
J.2 Deployment of Connectivity Fault Management	1417
J.3 MD Level allocation alternative	1418
J.4 Relationship of IEEE Std 802.1Q CFM to other standards	1418
J.5 Interpreting Linktrace results	1419
J.6 MP addressing: Individual and Shared MP addresses	1420
Annex K	1425
(informative)TPMR use cases	1425
K.1 Use case 1—TPMR as User to Network Interface (UNI) demarcation device	1425
K.2 Use case 2—TPMRs with aggregated links	1426
K.3 Use case 3—Multiple TPMRs	1426
K.4 Special cases	1427
Annex L	1430
(informative)Operation of the credit-based shaper algorithm	1430
L.1 Overview of credit-based shaper operation	1430
L.2 “Class measurement intervals” in Bridges	1433
L.3 Determining worst-case latency contribution and buffering requirements	1435
L.4 Operation of the credit-based shaper in a coordinated shared network	1445
Annex M	1447
(normative)Support for PFC in link layers without MAC Control	1447
M.1 Overview	1447
M.2 PFC PDU Format	1447
Annex N	1448
(informative)Buffer requirements for Priority-based Flow Control	1448
N.1 Overview	1448
N.2 Delay model	1449
N.3 Interface Delay	1451
N.4 Cable Delay	1451

N.5	Higher Layer Delay	1451
N.6	Computation example	1452
Annex O		1453
(informative)	Bibliography	1453

Figures

Figure 6-1	Internal organization of the MAC sublayer	59
Figure 6-2	MAC entities, the MAC Service, and MAC Service users (clients).....	61
Figure 6-3	An interface stack.....	62
Figure 6-4	Provider Instance Ports	89
Figure 6-5	B-Component Customer Backbone Port.....	92
Figure 6-6	Example of operation of Port-and-Protocol-based classification	96
Figure 6-7	Service access priority selection	99
Figure 6-8	Two back-to-back EISS Multiplex Entities	105
Figure 6-9	Two back-to-back Backbone Service Instance Multiplex Entities	106
Figure 6-10	Backbone Service Instance Multiplex Entities with example CFM shims	106
Figure 6-11	Two back-to-back Up and Down TESI Multiplex Entities.....	109
Figure 6-12	Supporting the ISS with signaled priority.....	110
Figure 6-13	Two back-to-back Up and Down Infrastructure Segment Multiplex Entities	111
Figure 7-1	VLAN Bridging overview	114
Figure 8-1	A Bridged Local Area Network	119
Figure 8-2	VLAN-aware Bridge architecture.....	121
Figure 8-3	Relaying MAC frames	123
Figure 8-4	Observation of network traffic.....	123
Figure 8-5	Operation of Spanning Tree protocol.....	123
Figure 8-6	Operation of MRP	124
Figure 8-7	Management Port transmission and reception	124
Figure 8-8	Infrastructure Segment MEP placement in a PNP	125
Figure 8-9	Bridge Port Transmit and Receive	127
Figure 8-10	TPMR Port Transmit and Receive	128
Figure 8-11	Forwarding Process functions	129
Figure 8-12	Logical points of attachment of the Higher Layer and Relay Entities.....	162
Figure 8-13	Effect of control information on the forwarding path.....	162
Figure 8-14	Per-Port points of attachment.....	163
Figure 8-15	Single point of attachment—relay permitted.....	163
Figure 8-16	Single point of attachment—relay not permitted.....	163
Figure 8-17	Effect of Port State	164
Figure 8-18	Controlled and Uncontrolled Port connectivity	165
Figure 8-19	Ingress/egress control information in the forwarding path	165
Figure 9-1	VLAN TCI format	170
Figure 9-3	I-TAG TCI format.....	171
Figure 10-1	Example—Attribute value propagation from one station	174
Figure 10-2	Example—Attribute value propagation from two stations	174
Figure 10-3	Example—Registrations as pointers to the sources of declarations	175
Figure 10-4	MRP architecture	177
Figure 10-5	Format of the major components of an MRPDU	201
Figure 10-6	Operation of MMRP for a single VLAN Context.....	207
Figure 10-7	Example Directed Graph.....	208
Figure 10-8	Example of MMRP propagation in a VLAN Context	210
Figure 11-1	Operation of MVRP	218
Figure 12-1	Relationships among CFM managed objects.....	283
Figure 12-2	Relationship among BEB managed objects	299
Figure 12-3	SPB Management objects	352
Figure 12-4	Relationships among EVB Bridge managed objects	365
Figure 12-5	Relationship among EVB station managed objects	366
Figure 13-1	Diagrammatic conventions for spanning tree topologies.....	385
Figure 13-2	Physical topology and active topology	386
Figure 13-3	Port Roles and Port States.....	386

Figure 13-4	A Backup Port	387
Figure 13-5	“Ring Backbone” example	387
Figure 13-6	An MST Bridge network	389
Figure 13-7	CIST Priority Vectors, Port Roles, and MST Regions	390
Figure 13-8	MSTI Active Topology in Region 2	391
Figure 13-9	CIST and MSTI active topologies in Region 1 of the example network	404
Figure 13-10	Agreements and Proposals	408
Figure 13-11	CIST and MSTI Active Topologies in Region 2 of Figure 13-6	409
Figure 13-12	Enhanced Agreements	410
Figure 13-13	Spanning tree protocol state machines—overview and relationships	421
Figure 13-14	MSTP overview notation	422
Figure 13-15	Port Timers state machine	452
Figure 13-16	Port Receive state machine	452
Figure 13-17	Port Protocol Migration state machine	453
Figure 13-18	Bridge Detection state machine	453
Figure 13-19	Port Transmit state machine	454
Figure 13-20	Port Information state machine	455
Figure 13-21	Port Role Selection state machine	456
Figure 13-22	Disabled Port role transitions	457
Figure 13-23	Port Role Transitions state machine—MasterPort	457
Figure 13-24	Port Role Transitions state machine—RootPort	458
Figure 13-25	Port Role Transitions state machine—DesignatedPort	459
Figure 13-26	Port Role Transitions state machine—AlternatePort and BackupPort	459
Figure 13-27	Port State Transition state machine	460
Figure 13-28	Topology Change state machine	462
Figure 13-29	L2 Gateway Port Receive state machine	463
Figure 14-1	RST, MST, SPT, and STP Configuration BPDU format	467
Figure 14-2	STP TCN BPDU format	467
Figure 14-3	MSTI Configuration Message parameters and format	473
Figure 15-1	Internal organization of the MAC sublayer in a Provider Bridged Network	476
Figure 15-2	Port-based service interface to a Provider Bridged Network	477
Figure 15-3	Port-based service interface to a Provider Bridged Network	478
Figure 15-4	C-tagged service interface to a Provider Bridged Network	478
Figure 15-5	C-tagged service interface to a Provider Bridged Network	478
Figure 15-6	Customer Edge Ports	479
Figure 15-7	S-tagged service interface to a Provider Bridged Network	479
Figure 15-8	S-tagged interface to a Provider Bridged Network	480
Figure 15-9	RCSIs to a Provider Bridged Network	480
Figure 15-10	Remote Customer Access Ports	481
Figure 15-11	C-tagged RCSI to a Provider Bridged Network	482
Figure 15-12	Port-based RCSI to a Provider Bridged Network	482
Figure 15-13	Provider Network Port interface	483
Figure 16-1	Provider Bridged Network with interface examples	487
Figure 16-2	Examples of remote customer service access via a second PBN	489
Figure 16-3	Access service separation and “Hairpin Switching”	490
Figure 17-1	C-VLAN component internal LAN managed system	550
Figure 17-2	I/B-component internal LAN managed system	554
Figure 18-1	One Maintenance Domain: operator’s view	1052
Figure 18-2	One service instance: operator’s view	1053
Figure 18-3	One service instance: customer’s view	1053
Figure 18-4	MEP and MIP Symbols	1054
Figure 18-5	Maintenance Associations: one service instance in a provider network	1055
Figure 18-6	Maintenance Associations: Expansion of Figure 18-5	1056
Figure 18-7	MEPs, MIPs, and MD Levels	1057

Figure 19-1	CFM Protocol shims	1058
Figure 19-2	Maintenance association End Point (MEP)	1061
Figure 19-3	MIP Half Function	1066
Figure 19-4	Linktrace Output Multiplexer shim.....	1068
Figure 19-5	Linktrace Output Multiplexer architecture	1069
Figure 20-1	MEP state machines—overview and relationships	1082
Figure 20-2	MEP Continuity Check Initiator state machine	1088
Figure 20-3	MHF Continuity Check Receiver state machine.....	1090
Figure 20-4	MEP Continuity Check Receiver state machine	1093
Figure 20-5	Remote MEP state machine	1095
Figure 20-6	Remote MEP Error state machine.....	1096
Figure 20-7	MEP Cross Connect state machine	1097
Figure 20-8	MEP Traffic Field Mismatch state machine	1099
Figure 20-9	MEP Local Mismatch state machine	1099
Figure 20-10	MP Loopback Responder state machine.....	1101
Figure 20-11	MEP Loopback Initiator transmit state machine.....	1104
Figure 20-12	MEP Loopback Initiator receive state machine	1105
Figure 20-13	MEP Fault Notification Generator state machine.....	1107
Figure 20-14	MEP Mismatch Fault Notification Generator state machine.....	1109
Figure 20-15	MEP Linktrace Initiator receive state machine.....	1113
Figure 20-16	Linktrace Responder, MEPs, MHFs, and LOMs	1115
Figure 20-17	LTM Receiver state machine	1120
Figure 20-18	LTR Transmitter state machine.....	1121
Figure 22-1	MEPs and MIPs distinguished by VID (incomplete picture)	1150
Figure 22-2	Alternate view of Forwarding process	1151
Figure 22-3	Combining per-VLAN Maintenance Points into two shims	1152
Figure 22-4	More complete picture of Maintenance Point placement in a Bridge Port	1153
Figure 22-5	Service instance spanning two Bridges protected by Up MPs.....	1155
Figure 22-6	Service instance spanning two Bridges protected by Down MPs.....	1155
Figure 22-7	Maintenance Point placement in a non-VLAN aware Bridge Port.....	1157
Figure 22-8	Maintenance Point placement relative to other standards.....	1158
Figure 22-9	Creating MEPs and MIPs.....	1161
Figure 22-10	CFM in a Provider Edge Bridge C-tagged service interface	1167
Figure 22-11	CFM in a Provider Edge Bridge C-tagged RCSI	1169
Figure 22-12	Up MEPs in a Management Port.....	1170
Figure 22-13	CFM in the enterprise environment	1171
Figure 22-14	CFM on a Bridge conformant to IEEE Std 802.1Q-2005.....	1172
Figure 23-1	TPMR connecting two Bridge Ports	1173
Figure 23-2	TPMR chain connecting Bridge Ports	1173
Figure 23-3	MAC Status Shims and the MAC Status Propagation Entity	1175
Figure 23-4	Adding connectivity	1177
Figure 23-5	Losing connectivity	1178
Figure 23-6	TPMR recovery	1179
Figure 23-7	Notification from one end of the link to the other	1180
Figure 23-8	Immediate MAC status notification at the end of a link	1180
Figure 23-9	MSPE state machine overview	1181
Figure 23-10	Status Transition state machine.....	1185
Figure 23-11	Status Notification state machine.....	1186
Figure 23-12	MSPDU structure.....	1188
Figure 25-1	Internal organization of the MAC sublayer in a PBBN	1191
Figure 25-2	Provider Backbone Bridge terminology	1192
Figure 25-3	Customer service interface types	1193
Figure 25-4	Port-based service interface	1194
Figure 25-5	Port-based interface equipment.....	1195