



BSI Standards Publication

Telecommunications and exchange between information technology systems — Requirements for local and metropolitan area networks

Part 1Q: Bridges and bridged networks

National foreword

This British Standard is the UK implementation of ISO/IEC/IEEE 8802-1Q:2020. It supersedes BS ISO/IEC/IEEE 8802-1Q:2016, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee IST/6, Data communications.

A list of organizations represented on this committee can be obtained on request to its committee manager.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2020
Published by BSI Standards Limited 2020

ISBN 978 0 539 04332 7

ICS 35.110

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2020.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

INTERNATIONAL
STANDARD

ISO/IEC/
IEEE
8802-1Q

Second edition
2020-08

**Telecommunications and exchange
between information technology
systems — Requirements for local and
metropolitan area networks —**

**Part 1Q:
Bridges and bridged networks**

*Télécommunications et échange entre systèmes informatiques —
Exigences pour les réseaux locaux et métropolitains —*

Partie 1Q: Ponts et réseaux pontés



Reference number
ISO/IEC/IEEE 8802-1Q:2020(E)
Documents
© IEEE 2018
Document Sharing Hub



COPYRIGHT PROTECTED DOCUMENT

© IEEE 2018

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO or IEEE at the respective address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Institute of Electrical and Electronics Engineers, Inc
3 Park Avenue, New York
NY 10016-5997, USA

Email: stds.ipr@ieee.org
Website: www.ieee.org

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted (see www.iso.org/directives).

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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see <http://patents.iec.ch>).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

ISO/IEC/IEEE 8802-1Q was prepared by the LAN/MAN of the IEEE Computer Society (as IEEE Std 802.1Q-2018) and drafted in accordance with its editorial rules. It was adopted, under the “fast-track procedure” defined in the Partner Standards Development Organization cooperation agreement between ISO and IEEE, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

This second edition cancels and replaces the first edition (ISO/IEC/IEEE 8802-1Q:2016), which has been technically revised. It also incorporates the Amendments ISO/IEC/IEEE 8802-1Q:2016/Amd.1:2017, ISO/IEC/IEEE 8802-1Q:2016/Amd.2:2018, ISO/IEC/IEEE 8802-1Q:2016/Amd.3:2017, ISO/IEC/IEEE 8802-1Q:2016/Amd.4:2017, ISO/IEC/IEEE 8802-1Q:2016/Amd.5:2017, ISO/IEC/IEEE 8802-1Q:2016/Amd.6:2019, ISO/IEC/IEEE 8802-1Q:2016/Amd.7:2019 and the Corrigendum ISO/IEC/IEEE 8802-1Q:2016/Cor.1:2017.

A list of all parts in the ISO/IEC/IEEE 8802 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

IEEE Std 802.1Q™-2018
(Revision of
IEEE Std 802.1Q-2014)

**IEEE Standard for
Local and Metropolitan Area Networks—
Bridges and Bridged Networks**

Sponsor

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

Approved 7 May 2018

IEEE-SA Standards Board

Abstract: This standard specifies how the Media Access Control (MAC) Service is supported by Bridged Networks, the principles of operation of those networks, and the operation of MAC Bridges and VLAN Bridges, including management, protocols, and algorithms.

Keywords: Bridged Network, IEEE 802.1Q™, LAN, local area network, MAC Bridge, metropolitan area network, MSTP, Multiple Spanning Tree Protocol, Rapid Spanning Tree Protocol, RSTP, PBN, Provider Bridged Network, Shortest Path Bridging Protocol, SPB Protocol, Time-Sensitive Networking, TSN, Virtual Bridged Network, virtual LAN, VLAN Bridge

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2018 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 6 July 2018. Printed in the United States of America.

IEEE and IEEE 802 are registered trademarks in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

PDF:	ISBN 978-1-5044-4929-8	STD23139
Print:	ISBN 978-1-5044-4930-4	STDPD23139

IEEE prohibits discrimination, harassment and bullying.
For more information, visit <https://www.ieee.org/about/corporate/governance/p9-26.html>.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading “Important Notices and Disclaimers Concerning IEEE Standards Documents.” They can also be obtained on request from IEEE or viewed at <https://standards.ieee.org/IPR/disclaimers.html>.

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (“IEEE-SA”) Standards Board. IEEE (“the Institute”) develops its standards through a consensus development process, approved by the American National Standards Institute (“ANSI”), which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards are documents developed through scientific, academic, and industry-based technical working groups. Volunteers in IEEE working groups are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers and users of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied “AS IS” and “WITH ALL FAULTS.”

Use of an IEEE standard is wholly voluntary. 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.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own 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.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of 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 of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive 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 comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

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

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document 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

IEEE draft and approved standards are copyrighted by IEEE under U.S. and international copyright laws. They are made available by IEEE and are adopted 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 these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents 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. A current 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.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, 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 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-SA Website at <https://ieeexplore.ieee.org> or contact IEEE at the address listed previously. For more information about the IEEE SA or IEEE's standards development process, visit the IEEE-SA Website at <https://standards.ieee.org>.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: <https://standards.ieee.org/findstds/errata/index.html>. Users are encouraged to check this URL for errata periodically.

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 by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at <https://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

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

Glenn Parsons, Chair

John Messenger, Vice Chair, Chair of Maintenance Task Group, Editor

Ralf Assmann	Craig Gunther	Karen Randall
Shenghua Bao	Marina Gutierrez	Maximilian Riegel
Gordon Bechtel	Stephen Haddock	Jessy Rouyer
Jens Bierschenk	Mark Hantel	Soheil Samii
Steinar Bjornstad	Marc Holness	Atsushi Sato
Christian Boiger	Lokesh Kabra	Frank Schewe
Paul Bottorff	Michael Karl	Mick Seaman
Radhakrishna Canchi	Stephan Kehrer	Johannes Specht
David Chen	Hajime Koto	Patricia Thaler
Feng Chen	Yizhou Li	Paul Unbehagen
Weiyang Cheng	Christophe Mangin	Hao Wang
Paul Congdon	Scott Mansfield	Tongtong Wang
Rodney Cummings	James McIntosh	Xinyuan Wang
Hesham Elbakoury	Robert Moskowitz	Karl Weber
János Farkas	Tero Mustala	Brian Weis
Norman Finn	Tomoki Ohsawa	Jordon Woods
Mickael Fontaine	Donald R. Pannell	Takahiro Yamaura
Geoffrey Garner	Walter Pieniac	Xiang Yu
Eric W. Gray	Michael Potts	Nader Zein
	Wei Qiu	

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

Thomas Alexander	Mark Hantel	John Messenger
Butch Anton	Marco Hernandez	Michael Montemurro
Stefan Aust	Guido Hiertz	Charles Moorwood
Gordon Bechtel	Werner Hoelzl	Michael Newman
Harry Bims	Rita Horner	Nicks A. Nikjoo
Steinar Bjørnstad	David Hunter	Paul Nikolich
Christian Boiger	C. Huntley	Robert O'Hara
Nancy Bravin	Noriyuki Ikeuchi	Satoshi Obara
Demetrio Bucaneg	Sergiu Iordanescu	Bansi Patel
William Byrd	Osamu Ishida	Arumugam Paventhan
Juan Carreon	Atsushi Ito	Clinton Powell
David Chalupsky	Raj Jain	Alon Regev
Keith Chow	Tony Jeffree	Maximilian Riegel
Charles Cook	Sangkwon Jeong	Robert Robinson
Rodney Cummings	Piotr Karocki	Reinhard Schrage
Patrick Diamond	Stuart Kerry	Mick Seaman
Richard Doyle	Yongbum Kim	Takeshi Shimizu
Sourav Dutta	Jeff Koftinoff	Veselin Skendzic
Donald Eastlake	Jouni Korhonen	Daniel Smith
János Farkas	Hyeong Ho Lee	Thomas Starai
Norman Finn	John Lemon	Walter Struppler
Michael Fischer	James Lepp	Mark-Rene Uchida
Avraham Freedman	Jon Lewis	Lorenzo Vangelista
Matthias Fritsche	Arthur H. Light	George Vlantis
Yukihiro Fujimoto	Elvis Maculuba	Khurram Waheed
Eric W. Gray	Roger Marks	Stephen Webb
Randall Groves	Arthur Marris	Karl Weber
Michael Gundlach	Jeffery Masters	Andreas Wolf
Craig Gunther	Brett McClellan	Michael D. Wright
Stephen Haddock	Michael McInnis	Oren Yuen
Mark Hamilton	Richard Mellitz	Zhen Zhou

When the IEEE-SA Standards Board approved this standard on 7 May 2018, it had the following membership:

Jean-Philippe Faure, *Chair*
Gary Hoffman, *Vice Chair*
John D. Kulick, *Past Chair*
Konstantinos Karachalios, *Secretary*

Ted Burse
Guido R. Hiertz
Christel Hunter
Joseph L. Koepfinger*
Thomas Koshy
Hung Ling
Dong Liu

Xiaohui Liu
Kevin Lu
Daleep Mohla
Andrew Myles
Paul Nikolich
Ronald C. Petersen
Annette D. Reilly

Robby Robson
Dorothy Stanley
Mehmet Ulema
Phil Wennblom
Philip Winston
Howard Wolfman
Jingyi Zhou

*Member Emeritus

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 Std 802.1ag-2007	27 September 2007	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Stephen R. Haddock , <i>Chair, Interworking Task Group</i> Norman W. Finn , <i>Editor-in-Chief</i> David V. Elie-Dit-Cosaque , Dinesh Mohan , Oscar Rodriguez , and Ali Sajassi , <i>Assistant Editors</i>

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Letter Ballot
IEEE Std 802.1ah-2008	12 June 2008	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Stephen R. Haddock , <i>Chair, Interworking Task Group</i> Paul Bottorff , Stephen Haddock , and Muneyoshi Suzuki , <i>Editors</i>
IEEE Std 802.1Q-2005/Cor-1-2008	26 September 2008	Tony Jeffree , <i>Chair and Editor</i> Paul Congdon , <i>Vice Chair</i> Stephen R. Haddock , <i>Chair, Interworking Task Group</i>
IEEE Std 802.1ap-2008	10 December 2008	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Stephen R. Haddock , <i>Chair, Interworking Task Group</i> Glenn Parsons , <i>Editor</i> David Levi , <i>Assistant Editor</i>
IEEE Std 802.1Qaw-2009	17 June 2009	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Stephen R. Haddock , <i>Chair, Interworking Task Group</i> Linda Dunbar , <i>Editor</i>
IEEE Std 802.1Qay-2009	17 June 2009	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Stephen R. Haddock , <i>Chair, Interworking Task Group</i> Panagiotis Saltsidis , <i>Editor</i>
IEEE Std 802.1aj-2009	9 December 2009	Tony Jeffree , <i>Chair</i> Paul Congdon , <i>Vice Chair</i> Stephen R. Haddock , <i>Chair, Interworking Task Group</i> John Messenger , <i>Editor</i> Brian Hassink , <i>MIB Editor</i>
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 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Letter Ballot
IEEE Std 802.1Q-2011	16 May 2011	Tony Jeffree , <i>Chair and Editor</i> Paul Congdon , <i>Vice Chair</i> Stephen Haddock , <i>Chair, Interworking Task Group</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	16 June 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 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	29 March 2012	Tony Jeffree , <i>Chair</i> Glenn Parsons , <i>Vice Chair</i> Stephen Haddock , <i>Chair, Interworking Task Group</i> Donald Fedyk and Mick Seaman , <i>Editors</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 Bottorff , <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>
IEEE Std 802.1Qbp-2014	27 March 2014	Tony Jeffree , <i>Chair</i> Glenn Parsons , <i>Vice Chair</i> Stephen Haddock , <i>Chair, Interworking Task Group</i> Ben Mack-Crane , <i>Editor</i>

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Letter Ballot
IEEE Std 802.1D-2004	9 February 2004	Tony Jeffree , <i>Chair and Editor</i> Paul Congdon , <i>Vice Chair</i> Mick Seaman , <i>Chair, Interworking Task Group and Editor</i>
IEEE Std 802.1D-2004	3 November 2014	Glenn Parsons , <i>Chair</i> John Messenger , <i>Vice-Chair</i> Tony Jeffree , <i>Editor</i> Stephen Haddock , <i>Chair, Interworking Task Group</i>
IEEE Std 802.1Qcd-2015	16 February 2015	Glenn Parsons , <i>Chair</i> John Messenger , <i>Vice Chair</i> Patricia Thaler , <i>Chair, Data Center Bridging Task Group</i> Eric Multanen , <i>Editor</i>
IEEE Std 802.1Qca-2015	3 September 2015	Glenn Parsons , <i>Chair</i> John Messenger , <i>Vice-Chair</i> János Farkas , <i>Editor</i> Stephen Haddock , <i>Chair, Interworking Task Group</i>
IEEE Std 802.1Q-2014/ Cor 1-2015	5 December 2015	Glenn Parsons , <i>Chair</i> John Messenger , <i>Vice-Chair and Chair, Maintenance Task Group</i> Tony Jeffree , <i>Editor</i>
IEEE Std 802.1Qbv-2015	5 December 2015	Glenn Parsons , <i>Chair</i> John Messenger , <i>Vice-Chair</i> Michael Johas Teener , <i>Chair, Time Sensitive Networking Task Group</i> Tony Jeffree , <i>Editor</i>
IEEE Std 802.1Qbu-2016	30 June 2016	Glenn Parsons , <i>Chair</i> John Messenger , <i>Vice-Chair</i> Michael Johas Teener , <i>Chair, Time Sensitive Networking Task Group</i> Tony Jeffree , <i>Editor</i>
IEEE Std 802.1Qbz-2016	30 June 2016	Glenn Parsons , <i>Chair</i> John Messenger , <i>Vice-Chair</i> Michael Johas Teener , <i>Chair, Time Sensitive Networking Task Group</i> Norm Finn , <i>Editor</i>
IEEE Std 802.1Qci-2017	14 February 2017	Glenn Parsons , <i>Chair</i> John Messenger , <i>Vice-Chair</i> János Farkas , <i>Chair, Time Sensitive Networking Task Group</i> Tony Jeffree , <i>Editor</i>
IEEE Std 802.1Qch-2017	15 May 2017	Glenn Parsons , <i>Chair</i> John Messenger , <i>Vice-Chair</i> János Farkas , <i>Chair, Time Sensitive Networking Task Group</i> Tony Jeffree , <i>Editor</i>

Osama Aboul-Magd	Rao Cherukuri	Gerrard Goubert
Steve Adams	Taesik Cheung	Richard Graham
Stephen Ades	Jade Chien	Mark Gravel
Fumio Akashi	Hon Wah Chin	Michael A. Gravel
Zehavit Alon	Jin-Seek Choi	Eric W. Gray
Ken Alonge	Chi Chong	Karanvir Grewal
Ann Ambler	Chris Christ	John Grinham
Paul D. Amer	Marc Cochran	Yingjie Gu
Yafan An	Paul Congdon	Craig Gunther
Ting Ao	Glenn Connery	Mitch Gusat
Charles Arnold	Alex Conta	Marina Gutierrez
Peter Ashwood-Smith	Jim Corrigan	Stephen Haddock
Siamack Ayandeh	Diego Crupnicoff	Sharam Hakimi
Floyd Backes	David Cullerot	Mogens Hansen
SeoYoung Baek	Rodney Cummings	Mark Hantel
Ann Ballard	Uri Cummings	Harold Harrington
Richard Bantel	Ted Davies	John Hart
Shenghua Bao	Andy Davis	Scott Harvell
John Bartlett	Peter Dawe	Mike Harvey
Sy Bederman	Stan Degen	Takashi Hasegawa
Alexei Beliaev	Arjan de Heer	Brian Hassink
Les Bell	Frank Deignan	Wayne Hathaway
Amatzia Ben-Artzi	David Delaney	Brian Hausauer
Avner Ben-Dor	Prakash Desai	Richard Hausman
Michael Berger	Claudio DeSanti	Hitoshi Hayakawa
Caitlin Bestler	Ron Dhondy	Vic Hayes
Jan Bialkowski	Patrick Diamond	Asif Hazarika
Jens Bierschenk	Aboubacar Kader Diarra	David Head
James S. Binder	Jeffrey Dietz	Gaby Hecht
Steinar Bjørnstad	Russell Dietz	Patrick Heffernan
Robert Bledsoe	Zheming Ding	Deepak Hegde
Rob Boatright	Kurt Dobbins	Ariel Hendel
Kwami Boakaye	Eiji Doi	Bob Herbst
Christian Boiger	Barbara J. Don Carlos	John Hickey
Brad Booth	Linda Dunbar	Jeremy Hitt
Jean-Michel Bonnamy	Craig Easley	David Hollender
Mike Borza	Donald Eastlake	Marc Holness
Paul Bottorff	Peter Ecclesine	Steve Horowitz
David Brady	J. J. Ekstrom	Bob Hott
Rudolf Brandner	Anush Elangovan	Michelle Hsiung
Martin Brewer	Hesham M. Elbakoury	Lu Huang
Frank Bruns	Walter Eldon	Charles Hudson
Juan Bulnes	David Elie-Dit-Cosaque	Jack R. Hung
Bill Bunch	János Farkas	Rita Hunt
Jim Burns	Donald W. Fedyk	David Husak
Peter Carbone	Eldon D. Feist	Altaf Hussain
Bob Cardinal	Felix Feifei Feng	Rahil Hussain
Craig W. Carlson	Norman Finn	Thomas Hytry
Paul Carroll	Len Fishler	Romain Insler
Marco Carugi	Kevin Flanagan	Ran Ish-Shalom
Jeffrey Catlin	Mickael Fontaine	Jay Israel
Dennis Cave	Yishai Fraenkel	Atsushi Iwata
Dirceu Cavendish	Paul Frantz	Vipin K. Jain
Alan Chambers	David Frattura	Neil Jarvis
Steve Chan	Robert Frazier	Tony Jeffree
David W. Chang	Lars Henrik Frederiksen	Paul Hongkyu Jeong
Xin Chang	Andre Fredette	Pankaj Jha
Frank Chao	John Fuller	Markus Jochim
Ken Chapman	Ilango Ganga	Michael Johas Teener
Alice Chen	Geoffrey Garner	Girault Jones
David Chen	Anoop Ghanwani	Peter Jones
Feng Chen	Franz Goetz	Shyam Kaluve
Weiying Cheng	Pat Gonia	Daya Kamath

Abhay Karandikar
 Allen Kasey
 Prakash Kashyap
 Toyayuki Kato
 Manu Kaycee
 Hal Keen
 Srikanth Keesara
 Stephan Kehrer
 Daniel Kelley
 Kevin Ketchum
 Ketil Kilcrease
 Doyeon Kim
 Yongbum Kim
 Alan Kirby
 Kimberly Kirkpatrick
 Keith Klamm
 Steve Kleiman
 Philippe Klein
 Oliver Kleinberg
 Marcel Kiessling
 Yongbum Kim
 Philippe Klein
 Bruce Kling
 Walter Knitl
 Mike Ko
 Raghu Kondapalli
 Jouni Korhonen
 Michael Krause
 Dan Krent
 James Kristof
 Vinod Kumar
 Paul Kummer
 Bruce Kwan
 Paul Lachapelle
 Kari Laihonen
 Ashvin Lakshmikantha
 Bill Lane
 Paul Langille
 Roger Lapuh
 H. Eugene Latham
 Loren Larsen
 Yannick Le Goff
 Marcus Leech
 John Lemon
 Michael Lerer
 Lin Li
 Yizhou Li
 Bing Liao
 George Lin
 William P Lidinsky
 Johann Lindmeyr
 Marina Lipshteyn
 Gary Littleton
 Robert D. Love
 Yuanqui Luo
 Andy Luque
 Jeff Lynch
 Gael Mace
 Thomas Mack-Crane
 Phillip Magnuson

Christophe Mangin
 Mahalingam Mani
 David Martin
 Peter Martini
 Riccardo Martinotti
 Marco Mascitto
 Tom McBeath
 Keith McCloghrie
 Bruce McClure
 Tom McGowan
 Alan McGuire
 James McIntosh
 Martin McNealis
 Menucher Menuchery
 Milan Merhar
 Margaret A. Merrick
 John Messenger
 Colin Mick
 Amol Mitra
 Dinesh Mohan
 Gabriel Montenegro
 Jim Montrose
 Matthew Mora
 John Morris
 Bob Moskowitz
 Eric Multanen
 Tero Mustala
 Yaron Nachman
 Yukihiro Nakagawa
 Hiroki Nakano
 Krishna Narayanaswamy
 Lawrence Ng
 Henry Ngai
 Paul Nikolich
 Kevin Nolish
 Bob Noseworthy
 Don O'Connor
 Karen O'Donoghue
 Jerry O'Keefe
 Eugene O'Neil
 Satoshi Obara
 Hiroshi Ohta
 David Olsen
 Toshio Ooka
 Jörg Ottensmeyer
 Shlomo Ovardia
 Vijoy Pandey
 Donald R. Pannell
 Luc Pariseau
 Glenn W. Parsons
 Richard Patti
 Ken Patton
 Mark Pearson
 Joseph Pelissier
 Yonadav Perry
 David Peterson
 Roger Pfister
 Thomas L. Phinney
 John Pickens
 Walter Pieniac

Daniel Pitt
 Hayim Porat
 Michael Potts
 Gideon Prat
 Kirk Preiss
 Ron L. G. Prince
 Max Pritikin
 Ray Qiu
 Rene Raeber
 Ananda Rajagopal
 Steve Ramberg
 Nigel Ramsden
 Karen Randall
 Shlomo Reches
 Frank Reichstein
 Dick Reohr
 Trudy Reusser
 James Richmond
 Maximilian Riegel
 Anil Rijasinghani
 Robert Roden
 Edouard Rocher
 Guenter Roeck
 John J. Roese
 Josef Roese
 Derek J. Rohde
 Allyn Romanow
 Dan Romascanu
 Paul Rosenblum
 Moran Roth
 Jessie V. Rouyer
 Doug Ruby
 Eric Ryu
 Ero Ryytty
 Jonathan Sadler
 Ali Sajassi
 Dolores Sala
 Joseph Salowey
 John Salter
 Panagiotis Saltisidis
 Sam Sambasivan
 Soheil Samii
 Ray Samora
 Behcet Sarikaya
 Alan Sarsby
 Satish Sathe
 John M. Sauer
 Ayman Sayed
 Susan Schanning
 Frank Schewe
 Ted Schroeder
 Benjamin Schultz
 Mick Seaman
 Gerry Segal
 Rich Seifert
 Lee Sendelbach
 Koichiro Seto
 Daniel Sexton
 Himanshu Shah
 Rakesh Sharma

Ravi Shenoy
Howard Sherry
K. Karl Shimada
Taeshi Shimizu
Fred Shu
Wu-Shi Shung
Phil Simmons
Curtis Simonson
Paramjeet Singh
Rosemary V. Slager
Alexander Smith
Andrew Smith
Michel Soerensen
M. Soha
Stuart Soloway
Johannes Specht
Nurit Sprecher
Kevin B. Stanton
Larry Stefani
Wilfried Steiner
Dan Stokesberry
Sundar Subramaniam
Robert Sultan
Muneyoshi Suzuki
Yoshihiro Suzuki
George Swallow
Lennart Swartz
Richard Sweatt
Vahid Tabatabaee
Attila Takacs
Kenta Takumi
Francois Tallet
Robin Tasker

Angus Telfer
John Terry
Patricia A. Thaler
Jonathan Thatcher
Dave Thompson
Geoff Thompson
David Thornburg
Oliver Thorp
Michel Thorsen
Fouad Tobagi
Nathan Tobol
Jeremy Touve
Naoki Tsukutari
Fred Tuck
Chait Tumuluri
Wendell Turner
Paul Unbehagen
Dhadesugoor Vaman
Steve Van Seters
Dono van-Mierop
Peter Videcranz
John Viega
Maarten Vissers
Dennis Volpano
Manoj Wadekar
Paul Wainwright
Scott Wasson
Daniel Watts
Yuehua Wei
John Wakerly
Hao Wang
Peter Wang
Philip Wang
Y. C. Wang

Yan Wang
Trevor Warwick
Bob Watson
Karl Weber
Yuehua Wei
Brian Weis
Alan Weissberger
Glenn Wenig
Martin White
Bert Wijnen
Deborah Wilbert
Keith Willette
Robert Williams
Val Wilson
Ludwig Winkel
Robert Winter
Michael Witkowski
Edward Wong
Jordon Woods
Michael D. Wright
Michele Wright
Chien-Hsien Wu
Min Xiao
Ken Young
Allen Yu
Wayne Zakowski
Nader Zein
Igor Zhovnirovsky
Carolyn Zimmer
Helge Zinner
Glen Zorn
Nick Zuccherro
Juan-Carlos Zuniga

Introduction

This introduction is not part of IEEE Std 802.1Q-2018, IEEE Standard for Local and metropolitan area networks—Bridges and Bridged Networks.

IEEE Std 802.1Q-2018 incorporates the text of the following amendments into IEEE Std 802.1Q-2014.

IEEE Std 802.1Qcd™-2015	Application Virtual Local Area Network (VLAN) Type, Length, Value (TLV)
IEEE Std 802.1Qca™-2015	Path Control and Reservation
IEEE Std 802.1Q-2014 Cor 1-2015	Technical and editorial corrections
IEEE Std 802.1Qbv™-2015	Enhancements for scheduled traffic
IEEE Std 802.1Qbu™-2016	Frame preemption
IEEE Std 802.1Qbz™-2016	Enhancements to Bridging of IEEE 802.11 Media
IEEE Std 802.1Qci™-2017	Per-Stream Filtering and Policing
IEEE Std 802.1Qch™-2017	Cyclic Queuing and Forwarding

The 2014 revision of this standard incorporated the text of the following amendments into IEEE Std 802.1Q-2011.

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™-2012	Edge Virtual Bridging
IEEE Std 802.1aq™-2012	Shortest Path Bridging
IEEE Std 802.1Q-2011/Cor 2-2012	Technical and editorial corrections
IEEE Std 802.1Qbp™-2014	Equal Cost Multiple Paths (ECMP)

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

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 Algorithm and Protocol (RSTP), superseding references to IEEE Std 802.1D™-2004 [B17].¹

The 2005 revision of this standard incorporated the text of the following amendments into 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 Networks.

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

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
USA

Grateful acknowledgment

The working group would like to acknowledge and thank Diane Lacey for her invaluable work on the final publication of this standard.

¹ Numbers in brackets correspond to the numbers in the bibliography in Annex U.

Contents

1.	Overview	61
1.1	Scope	61
1.2	Purpose	61
1.3	Introduction	62
2.	Normative references	69
3.	Definitions	73
4.	Abbreviations	95
5.	Conformance	101
5.1	Requirements terminology	101
5.2	Conformant components and equipment	101
5.3	Protocol Implementation Conformance Statement (PICS)	102
5.4	VLAN Bridge component requirements	102
5.4.1	VLAN Bridge component options	103
5.4.2	Multiple VLAN Registration Protocol (MVRP) requirements	108
5.4.3	VLAN Bridge requirements for congestion notification	108
5.4.4	Multiple Stream Registration Protocol (MSRP) requirements	109
5.4.5	Shortest Path Bridging (SPB) operation (optional)	109
5.4.6	Path Control and Reservation (PCR) (optional)	110
5.5	C-VLAN component conformance	111
5.5.1	C-VLAN component options	111
5.6	S-VLAN component conformance	111
5.6.1	S-VLAN component options	112
5.6.2	S-VLAN component requirements for Provider Backbone Bridge Traffic Engineering (PBB-TE)	112
5.6.3	S-VLAN component requirements for PBB-TE IPS	112
5.6.4	S-VLAN component requirements for ECMP with flow filtering	113
5.7	I-component conformance	113
5.7.1	I-component options	113
5.8	B-component conformance	113
5.8.1	B-component options	114
5.8.2	B-component requirements for PBB-TE	114
5.8.3	B-component requirements for PBB-TE IPS	114
5.8.4	B-component requirements for ECMP with flow filtering	115
5.9	C-VLAN Bridge conformance	115
5.9.1	C-VLAN Bridge options	115
5.10	Provider Bridge conformance	115
5.10.1	S-VLAN Bridge conformance	115
5.10.2	Provider Edge Bridge conformance	116
5.11	System requirements for Priority-based Flow Control (PFC)	116
5.12	Backbone Edge Bridge (BEB) conformance	116
5.12.1	BEB requirements for PBB-TE	117
5.13	MAC Bridge component requirements	117
5.13.1	MAC Bridge component options	117
5.14	MAC Bridge conformance	118
5.14.1	MAC Bridge options	118
5.15	TPMR component conformance	118

5.15.1	TPMR component options	119
5.16	TPMR conformance	119
5.16.1	TPMR options	119
5.17	T-component conformance	119
5.17.1	T-component options	120
5.18	End station requirements for MMRP, MVRP, and MSRP	120
5.18.1	MMRP requirements and options	120
5.18.2	MVRP requirements and options	121
5.18.3	MSRP requirements and options	121
5.19	VLAN-aware end station requirements for CFM	122
5.20	End station requirements—FQTSS	122
5.21	End station requirements for congestion notification	123
5.22	MAC-specific bridging methods	123
5.23	EVB Bridge requirements	123
5.24	EVB station requirements	124
5.24.1	Edge relay (ER) requirements	125
5.25	End station requirements—enhancements for scheduled traffic	126
5.26	End station requirements—enhancements for frame preemption	126
5.27	End-station requirements—PSFP	127
5.28	End station requirements—Cyclic queuing and forwarding	127
6.	Support of the MAC Service	128
6.1	Basic architectural concepts and terms	129
6.2	Provision of the MAC Service	129
6.2.1	Point-to-point, multipoint-to-multipoint, and rooted-multipoint connectivity ...	130
6.3	Support of the MAC Service	130
6.4	Preservation of the MAC Service	131
6.5	Quality of service (QoS) maintenance	131
6.5.1	Service availability	131
6.5.2	Frame loss	132
6.5.3	Frame misordering	132
6.5.4	Frame duplication	133
6.5.5	Transit delay	134
6.5.6	Frame lifetime	135
6.5.7	Undetected frame error rate	135
6.5.8	Maximum Service Data Unit Size	135
6.5.9	Priority	135
6.5.10	Throughput	136
6.6	Internal Sublayer Service (ISS)	137
6.7	Support of the ISS by specific MAC procedures	137
6.7.1	Support of the ISS by IEEE Std 802.3 (Ethernet)	137
6.7.2	Frame preemption	137
6.8	Enhanced Internal Sublayer Service (EISS)	138
6.8.1	Service primitives	138
6.8.2	Status parameters	139
6.8.3	Point-to-point parameters	139
6.8.4	Control primitives and parameters	139
6.9	Support of the EISS	140
6.9.1	Data indications	141
6.9.2	Data requests	142
6.9.3	Priority Code Point encoding	142
6.9.4	Regenerating priority	144
6.10	Support of the ISS/EISS by PIPs	145

6.10.1	Data indications	147
6.10.2	Data requests	148
6.10.3	Priority Code Point encoding	148
6.11	Support of the EISS by CBPs	149
6.11.1	Data indications	150
6.11.2	Data requests	151
6.11.3	Priority Code Point decoding	152
6.11.4	Regenerating priority	152
6.12	Protocol VLAN classification	152
6.12.1	Protocol Templates	154
6.12.2	Protocol Group Identifiers	154
6.12.3	Protocol Group Database	154
6.13	Support of the ISS for attachment to a PBN	155
6.13.1	Data requests	156
6.13.2	Data indications	157
6.14	Support of the ISS within a system	157
6.15	Support of the ISS by additional technologies	157
6.16	Filtering services in Bridged Networks	158
6.16.1	Purpose(s) of filtering service provision	158
6.16.2	Goals of filtering service provision	158
6.16.3	Users of filtering services	159
6.16.4	Basis of service	159
6.16.5	Categories of service	159
6.16.6	Service configuration	159
6.16.7	Service definition for Extended Filtering Services	160
6.17	EISS Multiplex Entity	161
6.18	Backbone Service Instance Multiplex Entity	162
6.18.1	Demultiplexing direction	163
6.18.2	Multiplexing direction	164
6.18.3	Priority Code Point encoding	165
6.18.4	Status parameters	165
6.19	TESI Multiplex Entity	165
6.20	Support of the ISS with signaled priority	166
6.20.1	Data indications	167
6.20.2	Data requests	167
6.21	Infrastructure Segment Multiplex Entity	167
6.22	PDU and protocol discrimination and media	169
7.	Principles of Virtual Bridged Network operation	170
7.1	Network overview	170
7.2	Use of VLANs	171
7.3	Active topology	171
7.4	VLAN topology	172
7.5	Locating end stations	173
7.6	Ingress, forwarding, and egress rules	174
8.	Principles of Bridge operation	175
8.1	Bridge operation	175
8.1.1	Relay	175
8.1.2	Filtering and relaying information	176
8.1.3	Duplicate frame prevention	176
8.1.4	Traffic segregation	176
8.1.5	Traffic reduction	177

8.1.6	Traffic expediting	177
8.1.7	Conversion of frame formats	177
8.2	Bridge architecture.....	178
8.3	Model of operation.....	180
8.4	Active topologies, learning, and forwarding	184
8.5	Bridge Port Transmit and Receive.....	185
8.5.1	Bridge Port connectivity	185
8.5.2	TPMR Port connectivity	186
8.5.3	Support of Higher Layer Entities	187
8.6	The Forwarding Process	187
8.6.1	Active topology enforcement	188
8.6.2	Ingress filtering	190
8.6.3	Frame filtering	190
8.6.4	Egress filtering	193
8.6.5	Flow classification and metering	193
8.6.6	Queuing frames	197
8.6.7	Queue management	199
8.6.8	Transmission selection	199
8.6.9	Scheduled traffic state machines	205
8.6.10	Stream gate control state machines	213
8.7	The Learning Process.....	215
8.7.1	Default filtering utility criteria	215
8.7.2	Enhanced filtering utility criteria	216
8.7.3	Ageing of Dynamic Filtering Entries	216
8.8	The Filtering Database (FDB)	217
8.8.1	Static Filtering Entries	220
8.8.2	Static VLAN Registration Entries	221
8.8.3	Dynamic Filtering Entries	221
8.8.4	MAC Address Registration Entries	222
8.8.5	Dynamic VLAN Registration Entries	223
8.8.6	Default Group filtering behavior	223
8.8.7	Dynamic Reservation Entries	224
8.8.8	Allocation of VIDs to FIDs	225
8.8.9	Querying the FDB	225
8.8.10	Determination of the member set for a VID	229
8.8.11	Permanent Database	230
8.8.12	Connection Identifier	230
8.9	MST, SPB, and ESP configuration information.....	230
8.9.1	MST Configuration Table	231
8.9.2	MST configuration identification	231
8.9.3	FID to MSTI Allocation Table	232
8.9.4	SPT Configuration Identification	232
8.10	Spanning Tree Protocol Entity.....	233
8.11	MRP entities	233
8.12	Bridge Management Entity	233
8.13	Addressing	233
8.13.1	End stations	233
8.13.2	Bridge Ports	234
8.13.3	Use of LLC by Spanning Tree Protocol Entities	234
8.13.4	Reserved MAC addresses	234
8.13.5	Group MAC addresses for spanning tree entity	235
8.13.6	Group MAC addresses for MRP Applications	237
8.13.7	Bridge Management Entities	237
8.13.8	Unique identification of a Bridge	237

8.13.9	Points of attachment and connectivity for Higher Layer Entities	238
8.13.10	VLAN attachment and connectivity for Higher Layer Entities	241
8.13.11	CFM entities	242
9.	Tagged frame format	244
9.1	Purpose of tagging	244
9.2	Representation and encoding of tag fields	244
9.3	Tag format.....	245
9.4	TPID formats	245
9.5	Tag Protocol identification	245
9.6	VLAN Tag Control Information (TCI).....	246
9.7	Backbone Service Instance Tag Control Information (I-TAG TCI).....	247
10.	Multiple Registration Protocol (MRP) and Multiple MAC Registration Protocol (MMRP)	249
10.1	MRP overview	249
10.2	MRP architecture	252
10.3	MRP Attribute Propagation (MAP).....	253
10.3.1	MAP Context	254
10.4	Requirements to be met by MRP	255
10.5	Requirements for interoperability between MRP Participants	256
10.6	Protocol operation.....	257
10.7	Protocol specification	261
10.7.1	Notational conventions and abbreviations	262
10.7.2	Registrar Administrative Controls	264
10.7.3	Applicant Administrative Controls	264
10.7.4	Protocol timers	264
10.7.5	Protocol event definitions	265
10.7.6	Protocol Action definitions	268
10.7.7	Applicant state machine	270
10.7.8	Registrar state machine	271
10.7.9	LeaveAll state machine	271
10.7.10	PeriodicTransmission state machine	272
10.7.11	Timer values	272
10.7.12	Operational reporting and statistics	273
10.7.13	Interoperability considerations	273
10.8	Structure and encoding of Multiple Registration Protocol Data Units (MRPDUs)	274
10.8.1	Structure	274
10.8.2	Encoding of MRPDU parameters	276
10.8.3	Packing and parsing MRPDUs	279
10.9	Multiple MAC Registration Protocol (MMRP)—Purpose	281
10.10	Model of operation.....	282
10.10.1	Propagation of Group Membership information	283
10.10.2	Propagation of Group service requirement information	284
10.10.3	Source pruning	284
10.10.4	Use of Group service requirement registration by end stations	284
10.11	Default Group filtering behavior and MMRP propagation	284
10.12	Definition of the MMRP application	286
10.12.1	Definition of MRP elements	286
10.12.2	Provision and support of Extended Filtering Services	288
10.12.3	Use of “new” declaration capability	290
10.12.4	Attribute value support requirements	290
10.12.5	Registrar Administrative Controls	290

11.	VLAN topology management.....	291
11.1	Static and dynamic VLAN configuration	291
11.2	Multiple VLAN Registration Protocol (MVRP)	292
11.2.1	MVRP overview	292
11.2.2	VLAN registration service definition	294
11.2.3	Definition of the MVRP application	295
11.2.4	VID translation table	298
11.2.5	Use of “new” declaration capability	298
11.2.6	New-Only Participant and Registrar Administrative Controls	298
11.2.7	Attribute value support requirements	298
12.	Bridge management	299
12.1	Management functions.....	299
12.1.1	Configuration Management	299
12.1.2	Fault Management	300
12.1.3	Performance Management	300
12.1.4	Security Management	300
12.1.5	Accounting Management	300
12.2	VLAN Bridge objects	300
12.3	Data types	301
12.4	Bridge Management Entity	302
12.4.1	Bridge Configuration	302
12.4.2	Port configuration	305
12.5	MAC entities.....	307
12.5.1	ISS Port Number table managed object (optional)	307
12.6	Forwarding process.....	307
12.6.1	The Port Counters	307
12.6.2	Priority handling	308
12.6.3	Traffic Class Table	316
12.7	Filtering Database (FDB).....	317
12.7.1	The Filtering Database object	317
12.7.2	A Static Filtering Entry object	318
12.7.3	A Dynamic Filtering Entry object	318
12.7.4	A MAC Address Registration Entry object	318
12.7.5	A VLAN Registration Entry object	319
12.7.6	Permanent Database object	319
12.7.7	General FDB operations	320
12.8	Bridge Protocol Entity	321
12.8.1	The Protocol Entity	322
12.8.2	Bridge Port	325
12.9	MRP Entities.....	329
12.9.1	The MRP Timer object	329
12.9.2	The MRP Attribute Type object	330
12.9.3	Periodic state machine objects	331
12.10	Bridge VLAN managed objects.....	331
12.10.1	Bridge VLAN Configuration managed object	332
12.10.2	VLAN Configuration managed object	337
12.10.3	The VID to FID allocation managed object	338
12.11	MMRP entities.....	341
12.11.1	MMRP Configuration managed object	341
12.12	MST configuration entities	342
12.12.1	The MSTI List	342
12.12.2	The FID to MSTID Allocation Table	344

12.12.3	The MST Configuration Table	345
12.13	Provider Bridge management	346
12.13.1	Provider Bridge Port Type managed object	348
12.13.2	Customer Edge Port Configuration managed object	349
12.13.3	Remote Customer Access Port Configuration managed object	352
12.14	CFM entities	354
12.14.1	Maintenance Domain list managed object	355
12.14.2	CFM Stack managed object	356
12.14.3	Default MD Level managed object	357
12.14.4	Configuration Error List managed object	358
12.14.5	Maintenance Domain managed object	358
12.14.6	Maintenance Association managed object	361
12.14.7	Maintenance association Endpoint managed object	364
12.15	Backbone Core Bridge (BCB) management	371
12.16	Backbone Edge Bridge (BEB) management	371
12.16.1	BEB configuration managed object	372
12.16.2	BEB/PB/VLAN Bridge Port configuration managed object	376
12.16.3	VIP configuration managed object	377
12.16.4	PIP configuration managed object	378
12.16.5	CBP Configuration managed object	384
12.17	DDCFM entities	387
12.17.1	DDCFM Stack managed object	387
12.17.2	Reflection Responder managed object	388
12.17.3	RFM Receiver managed object	391
12.17.4	Decapsulator Responder managed object	392
12.17.5	SFM Originator managed object	395
12.18	PBB-TE Protection Switching managed objects	398
12.18.1	TE protection group list managed object	398
12.18.2	TE protection group managed object	399
12.19	TPMR managed objects	401
12.19.1	TPMR management entity	402
12.19.2	MAC and PHY entities	404
12.19.3	Forwarding Process	404
12.19.4	MAC Status Propagation Entity (MSPE)	409
12.20	Management entities for FQTSS	411
12.20.1	The Bandwidth Availability Parameter Table	411
12.20.2	The Transmission Selection Algorithm Table	412
12.20.3	The Priority Regeneration Override Table	412
12.21	Congestion Notification managed objects	412
12.21.1	CN component managed object	413
12.21.2	CN component priority managed object	413
12.21.3	CN Port priority managed object	414
12.21.4	Congestion Point managed object	415
12.21.5	Reaction Point port priority managed object	416
12.21.6	Reaction Point group managed object	416
12.22	Stream Reservation Protocol (SRP) entities	417
12.22.1	SRP Bridge Base Table	417
12.22.2	SRP Bridge Port Table	417
12.22.3	SRP Latency Parameter Table	418
12.22.4	SRP Stream Table	418
12.22.5	SRP Reservations Table	419
12.23	Priority-based Flow Control objects	419
12.24	1:1 PBB-TE IPS managed objects	420
12.24.1	IPG list managed object	420

12.24.2	IPG managed object	422
12.25	Shortest Path Bridging managed objects	424
12.25.1	The SPB System managed object	425
12.25.2	The SPB MTID Static managed object	428
12.25.3	The SPB Topology Instance Dynamic managed object	429
12.25.4	The SPB ECT Static Entry managed object	430
12.25.5	The SPB ECT Dynamic Entry managed object	431
12.25.6	The SPB Adjacency Static Entry managed object	432
12.25.7	The SPB Adjacency Dynamic Entry managed object	433
12.25.8	The SPBM BSI Static Entry managed object	434
12.25.9	The SPB Topology Node Table managed object	435
12.25.10	The SPB Topology ECT Table managed object	436
12.25.11	The SPB Topology Edge Table managed object	436
12.25.12	The SPBM Topology Service Table managed object	437
12.25.13	The SPBV Topology Service Table managed object	438
12.25.14	The ECMP ECT Static Entry managed object	439
12.26	Edge Virtual Bridging (EVB) management.....	440
12.26.1	EVB system base table	444
12.26.2	SBP table entry	445
12.26.3	VSI table entry	446
12.26.4	S-channel configuration and management	448
12.26.5	ER management	450
12.27	Edge Control Protocol (ECP) management.....	451
12.27.1	ECP table entry	451
12.28	Path Control and Reservation (PCR) management.....	451
12.28.1	The PCR ECT Static Entry managed object	452
12.28.2	The PCR Topology ECT Table managed object	455
12.29	Managed objects for scheduled traffic.....	455
12.29.1	The Gate Parameter Table	455
12.29.2	Timing points for scheduled traffic	458
12.30	Managed objects for frame preemption	459
12.30.1	Frame Preemption Parameter table	459
12.31	Managed objects for per-stream filtering and policing.....	460
12.31.1	The Stream Parameter Table	460
12.31.2	The Stream Filter Instance Table	461
12.31.3	The Stream Gate Instance Table	463
12.31.4	The Flow Meter Instance Table	466
13.	Spanning tree protocols	467
13.1	Protocol design requirements.....	468
13.2	Protocol support requirements.....	469
13.2.1	MSTP support requirements	469
13.2.2	SPB support requirements	469
13.3	Protocol design goals	470
13.4	RSTP overview	470
13.4.1	Computation of the active topology	471
13.4.2	Example topologies	472
13.5	MSTP overview	475
13.5.1	Example topologies	476
13.5.2	Relationship of MSTP to RSTP	479
13.5.3	Modeling an MST or SPT Region as a single Bridge	479
13.6	SPB overview	480
13.7	Compatibility and interoperability.....	481

13.7.1	Designated Port selection	481
13.7.2	Force Protocol Version	481
13.8	MST Configuration Identifier (MCID).....	482
13.9	Spanning tree priority vectors.....	483
13.10	CIST Priority Vector calculations.....	485
13.11	MST Priority Vector calculations.....	487
13.12	Port Role assignments.....	489
13.13	Stable connectivity.....	490
13.14	Communicating spanning tree information	491
13.15	Changing spanning tree information.....	492
13.16	Changing Port States with RSTP or MSTP	493
13.16.1	Subtree connectivity and priority vectors	494
13.16.2	Root Port transition to Forwarding	494
13.16.3	Designated Port transition to Forwarding	494
13.16.4	Master Port transition to Forwarding	496
13.17	Changing Port States with SPB	498
13.17.1	Agreement Digest	500
13.18	Managing spanning tree topologies	501
13.19	Updating learned station location information	502
13.20	Managing reconfiguration.....	504
13.21	Partial and disputed connectivity	505
13.22	In-service upgrades.....	505
13.23	Fragile Bridges.....	507
13.24	Spanning tree protocol state machines.....	507
13.25	State machine timers.....	509
13.25.1	edgeDelayWhile	510
13.25.2	fdWhile	510
13.25.3	helloWhen	510
13.25.4	mdelayWhile	510
13.25.5	rbWhile	510
13.25.6	rcvdInfoWhile	510
13.25.7	rrWhile	511
13.25.8	tcDetected	511
13.25.9	tcWhile	511
13.25.10	pseudoInfoHelloWhen	511
13.26	Per Bridge variables.....	511
13.26.1	agreementDigest	512
13.26.2	BridgeIdentifier	512
13.26.3	BridgePriority	512
13.26.4	BridgeTimes	512
13.26.5	ForceProtocolVersion	513
13.26.6	MigrateTime	513
13.26.7	MstConfigId	513
13.26.8	AuxMstConfigId	513
13.26.9	rootPortId	513
13.26.10	rootPriority	513
13.26.11	rootTimes	513
13.26.12	TxHoldCount	513
13.27	Per port variables	513
13.27.1	AdminEdge	516
13.27.2	ageingTime	516
13.27.3	agree	516
13.27.4	agreed	516
13.27.5	agreedAbove	516

13.27.6	agreedDigest	516
13.27.7	agreedDigestValid	516
13.27.8	agreeDigest	516
13.27.9	agreeDigestValid	516
13.27.10	agreedMisorder	517
13.27.11	agreedN	517
13.27.12	agreedND	517
13.27.13	agreedPriority	517
13.27.14	agreedTopology	517
13.27.15	agreementOutstanding	517
13.27.16	agreeN	517
13.27.17	agreeND	517
13.27.18	AutoEdge	517
13.27.19	AutoIsolate	518
13.27.20	designatedPriority	518
13.27.21	designatedTimes	518
13.27.22	disputed	518
13.27.23	enableBPDURx	518
13.27.24	enableBPDUTx	518
13.27.25	ExternalPortPathCost	518
13.27.26	isL2gp	518
13.27.27	isolate	519
13.27.28	fdbFlush	519
13.27.29	forward	519
13.27.30	forwarding	519
13.27.31	infoInternal	519
13.27.32	infols	519
13.27.33	InternalPortPathCost	519
13.27.34	learn	520
13.27.35	learning	520
13.27.36	master	520
13.27.37	mastered	520
13.27.38	mcheck	520
13.27.39	msgPriority	520
13.27.40	msgTimes	520
13.27.41	neighbourPriority	521
13.27.42	newInfo	521
13.27.43	newInfoMsti	521
13.27.44	operEdge	521
13.27.45	portEnabled	521
13.27.46	portId	521
13.27.47	portPriority	521
13.27.48	portTimes	522
13.27.49	proposed	522
13.27.50	proposing	522
13.27.51	pseudoRootId	522
13.27.52	rcvdBPDU	522
13.27.53	rcvdInfo	522
13.27.54	rcvdInternal	522
13.27.55	rcvdMsg	522
13.27.56	rcvdRSTP	522
13.27.57	rcvdSTP	522
13.27.58	rcvdTc	522
13.27.59	rcvdTcAck	522

13.27.60	rcvdTcn	523
13.27.61	reRoot	523
13.27.62	reselect	523
13.27.63	restrictedDomainRole	523
13.27.64	restrictedRole	523
13.27.65	restrictedTcn	523
13.27.66	role	523
13.27.67	selected	523
13.27.68	selectedRole	523
13.27.69	sendRSTP	524
13.27.70	sync	524
13.27.71	synced	524
13.27.72	tcAck	524
13.27.73	tcProp	524
13.27.74	tick	524
13.27.75	txCount	524
13.27.76	updtInfo	524
13.28	State machine conditions and parameters	524
13.28.1	allSptAgree	525
13.28.2	allSynced	525
13.28.3	allTransmitReady	525
13.28.4	BestAgreementPriority	525
13.28.5	cist	525
13.28.6	cistRootPort	525
13.28.7	cistDesignatedPort	526
13.28.8	EdgeDelay	526
13.28.9	forwardDelay	526
13.28.10	FwdDelay	526
13.28.11	HelloTime	526
13.28.12	MaxAge	526
13.28.13	msti	526
13.28.14	mstiDesignatedOrTCpropagatingRootPort	526
13.28.15	mstiMasterPort	526
13.28.16	operPointToPoint	526
13.28.17	rcvdAnyMsg	526
13.28.18	rcvdCistMsg	526
13.28.19	rcvdMstiMsg	527
13.28.20	reRooted	527
13.28.21	rstpVersion	527
13.28.22	spt	527
13.28.23	stpVersion	527
13.28.24	updtCistInfo	527
13.28.25	updtMstiInfo	527
13.29	State machine procedures	527
13.29.1	betterorsameInfo(newInfoIs)	528
13.29.2	clearAllRcvdMsgs()	528
13.29.3	clearReselectTree()	528
13.29.4	disableForwarding()	529
13.29.5	disableLearning()	529
13.29.6	enableForwarding()	529
13.29.7	enableLearning()	529
13.29.8	fromSameRegion()	529
13.29.9	newTcDetected()	529
13.29.10	newTcWhile()	529

13.29.11	pseudoRcvMsgs()	530
13.29.12	rcvInfo()	530
13.29.13	rcvMsgs()	531
13.29.14	rcvAgreements()	531
13.29.15	recordAgreement()	531
13.29.16	recordDispute()	532
13.29.17	recordMastered()	532
13.29.18	recordPriority()	532
13.29.19	recordProposal()	532
13.29.20	recordTimes()	532
13.29.21	setReRootTree()	533
13.29.22	setSelectedTree()	533
13.29.23	setSyncTree()	533
13.29.24	setTcFlags()	533
13.29.25	setTcPropTree()	533
13.29.26	syncMaster()	533
13.29.27	txConfig()	533
13.29.28	txRstp()	534
13.29.29	txTcn()	534
13.29.30	updtAgreement()	534
13.29.31	updtBPDUVersion()	535
13.29.32	updtDigest()	535
13.29.33	updtRcvdInfoWhile()	536
13.29.34	updtRolesTree()	537
13.29.35	updtRolesDisabledTree()	538
13.30	The Port Timers state machine	538
13.31	Port Receive state machine	539
13.32	Port Protocol Migration state machine	540
13.33	Bridge Detection state machine	540
13.34	Port Transmit state machine	541
13.35	Port Information state machine	542
13.36	Port Role Selection state machine	543
13.37	Port Role Transitions state machine	543
13.38	Port State Transition state machine	548
13.38.1	Port State transitions for the CIST and MSTIs	549
13.38.2	Port State transitions for SPTs	549
13.39	Topology Change state machine	550
13.40	Layer 2 Gateway Port Receive state machine	551
13.41	CEP spanning tree operation	551
13.41.1	PEP operPointToPointMAC and operEdge	551
13.41.2	updtRolesTree()	552
13.41.3	setReRootTree(), setSyncTree(), setTcPropTree()	552
13.41.4	allSynced, reRooted	552
13.41.5	Configuration parameters	552
13.42	Virtual Instance Port (VIP) spanning tree operation	553
14.	Encoding of Bridge Protocol Data Units (BPDUs)	554
14.1	BPDUs Structure	554
14.1.1	Transmission and representation of octets	554
14.1.2	Common BPDU fields	554
14.2	Encoding of parameter types	556
14.2.1	Encoding of Protocol Identifiers	556
14.2.2	Encoding of Protocol Version Identifiers	556

14.2.3	Encoding of BPDU types	556
14.2.4	Encoding of flags	556
14.2.5	Encoding of Bridge Identifiers	556
14.2.6	Encoding of External Root Path Cost and Internal Root Path Cost	557
14.2.7	Encoding of Port Identifiers	557
14.2.8	Encoding of Timer Values	557
14.2.9	Encoding of Port Role values	557
14.2.10	Encoding of Length Values	558
14.2.11	Encoding of Hop Counts	558
14.3	Transmission of BPDUs	558
14.4	Encoding and decoding of STP Configuration, RST, MST, and SPT BPDUs.....	558
14.4.1	MSTI Configuration Messages	560
14.5	Validation of received BPDUs	561
14.6	Validation and interoperability	562
15.	Support of the MAC Service by PBNs	563
15.1	Service transparency	563
15.2	Customer service interfaces	564
15.3	Port-based service interface	564
15.4	C-tagged service interface	565
15.5	S-tagged service interface	566
15.6	Remote customer service interfaces (RCSIs)	567
15.7	Service instance segregation	570
15.8	Service instance selection and identification	570
15.9	Service priority selection	571
15.10	Service access protection	571
16.	Principles of Provider Bridged Network (PBN) operation	572
16.1	PBN overview	572
16.2	Provider Bridged Network (PBN)	573
16.3	Service instance connectivity	576
16.4	Service provider learning of customer end station addresses	577
16.5	Detection of connectivity loops through attached networks	577
16.6	Network management	578
17.	Management Information Base (MIB)	579
17.1	Internet Standard Management Framework	579
17.2	Structure of the MIB	579
17.2.1	Structure of the IEEE8021-TC-MIB	580
17.2.2	Structure of the IEEE8021-BRIDGE-MIB	582
17.2.3	Structure of the IEEE8021-SPANNING-TREE MIB	586
17.2.4	Structure of the IEEE8021-Q-BRIDGE-MIB	589
17.2.5	Structure of the IEEE8021-PB-MIB	594
17.2.6	Structure of the IEEE8021-MSTP-MIB	596
17.2.7	Structure of the IEEE8021-CFM-MIB	599
17.2.8	Structure of the IEEE8021-PBB-MIB	605
17.2.9	Structure of the IEEE8021-DDCFM-MIBs	607
17.2.10	Structure of the IEEE8021-PBBTE-MIB	610
17.2.11	Structure of the TPMR MIB	612
17.2.12	Structure of the IEEE8021-FQTSS-MIB	614
17.2.13	Structure of the Congestion Notification MIB	615
17.2.14	Structure of the IEEE8021-SRP-MIB	617

17.2.15	Structure of the MVRP extension MIB	619
17.2.16	Structure of the MIRP MIB	619
17.2.17	Structure of the PFC MIB	620
17.2.18	Structure of the IEEE80221-TEIPS MIB	620
17.2.19	Structure of the IEEE8021-SPB-MIB	622
17.2.20	Structure of the IEEE8021-EVB-MIB	626
17.2.21	Structure of the IEEE8021-ECMP-MIB	630
17.2.22	Structure of the IEEE8021-ST-MIB	631
17.2.23	Structure of the IEEE8021-Preemption-MIB	632
17.2.24	Structure of the IEEE8021-PSFP-MIB	633
17.3	Relationship to other MIBs.....	636
17.3.1	Relationship of the IEEE8021-TC-MIB to other MIB modules	636
17.3.2	Relationship of the IEEE8021-BRIDGE-MIB to other MIB modules	636
17.3.3	Relationship of the IEEE8021-RSTP MIB to other MIB modules	639
17.3.4	Relationship of the IEEE8021-Q-BRIDGE-MIB to other MIB modules	639
17.3.5	Relationship of the IEEE8021-PB-BRIDGE MIB to other MIB modules	641
17.3.6	Relationship of the IEEE8021-MSTP-MIB to other MIB modules	641
17.3.7	Relationship of the IEEE8021-CFM-MIB to other MIB modules	641
17.3.8	Relationship of the IEEE8021-PBB-MIB to other MIB modules	642
17.3.9	Relationship of the IEEE8021-DDCFM to other MIB modules	643
17.3.10	Relationship of the IEEE8021-PBBTE-MIB to other MIB modules	643
17.3.11	Relationship of the TPMR MIB to other MIB modules	644
17.3.12	Relationship of the IEEE8021-FQTSS-MIB to other MIB modules	644
17.3.13	Relationship of the IEEE802-CN-MIB to other MIB modules	644
17.3.14	Relationship of the IEEE8021-SRP-MIB to other MIB modules	645
17.3.15	Relationship of the IEEE8021-MVRPX-MIB to other MIB modules	645
17.3.16	Relationship of the IEEE8021-MIRP-MIB to other MIB modules	645
17.3.17	Relationship of the PFC MIB to other MIB modules	645
17.3.18	Relationship of the IEEE8021-TEIPS-MIB to other MIB modules	646
17.3.19	Relationship of the of the IEEE8021-SPB-MIB to other MIB modules	646
17.3.20	Relationship of the IEEE8021-EVB-MIB to other MIB modules	646
17.3.21	Relationship of the of the IEEE8021-ECMP-MIB to other MIB modules	646
17.3.22	Relationship of the PCR MIB to other MIB modules	646
17.3.23	Relationship of the IEEE8021-ST-MIB to other MIBs	646
17.3.24	Relationship of the IEEE8021-Preemption-MIB to other MIBs	647
17.3.25	Relationship of IEEE8021-PSFP-MIB to other MIBs	647
17.4	Security considerations	647
17.4.1	Security considerations of the IEEE8021-TC-MIB	647
17.4.2	Security considerations of the IEEE8021-BRIDGE-MIB	647
17.4.3	Security considerations of the IEEE8021-SPANNING-TREE MIB	648
17.4.4	Security considerations of the IEEE8021-Q-BRIDGE-MIB	649
17.4.5	Security considerations of the IEEE8021-PB-MIB	650
17.4.6	Security considerations of the IEEE8021-MSTP-MIB	650
17.4.7	Security considerations of the IEEE8021-CFM-MIB	651
17.4.8	Security considerations of the IEEE8021-PBB-MIB	653
17.4.9	Security considerations of the IEEE8021-DDCFM-MIB	653
17.4.10	Security considerations of the IEEE8021-PBBTE-MIB	654
17.4.11	Security considerations of the TPMR MIB	655
17.4.12	Security considerations of the IEEE8021-FQTSS-MIB	655
17.4.13	Security considerations of the Congestion Notification MIB	656
17.4.14	Security considerations of the IEEE8021-SRP-MIB	657
17.4.15	Security considerations of the IEEE8021-MVRPX-MIB	658
17.4.16	Security considerations of the IEEE8021-MIRP-MIB	658
17.4.17	Security considerations for the PFC MIB	659

17.4.18	Security considerations of the IEEE8021-TEIPS-MIB	659
17.4.19	Security considerations of the IEEE8021-SPB-MIB	659
17.4.20	Security considerations of the IEEE8021-EVB-MIB	660
17.4.21	Security considerations of the IEEE8021-ECMP-MIB	661
17.4.22	Security considerations of the PCR MIB	662
17.4.23	Security considerations of the IEEE8021-ST-MIB	662
17.4.24	Security considerations of the IEEE8021-Preemption-MIB	663
17.4.25	Security considerations of the IEEE8021-PSFP-MIB	663
17.5	Dynamic component and Port creation.....	665
17.5.1	Overview of the dynamically created Bridge entities	665
17.5.2	Component creation	666
17.5.3	Port creation	667
17.6	MIB operations for service interface configuration.....	677
17.6.1	Provisioning PBN service interfaces	677
17.6.2	Provisioning Backbone Bridged Network service interfaces	680
17.7	MIB modules,	686
17.7.1	Definitions for the IEEE8021-TC-MIB module	686
17.7.2	Definitions for the IEEE8021-BRIDGE-MIB module	697
17.7.3	Definitions for the IEEE8021-SPANNING-TREE-MIB module	737
17.7.4	Definitions for the IEEE8021-Q-BRIDGE-MIB module	755
17.7.5	Definitions for the IEEE8021-PB-MIB module	801
17.7.6	Definitions for the IEEE8021-MSTP-MIB module	819
17.7.7	Definitions for the CFM MIB modules	848
17.7.8	Definitions for the IEEE8021-PBB-MIB module	931
17.7.9	Definitions for the IEEE8021-DDCFM-MIB module	954
17.7.10	Definitions for the IEEE8021-PBBTE-MIB module	972
17.7.11	Definitions for the IEEE8021-TPMR-MIB module	989
17.7.12	Definitions for the IEEE8021-FQTSS-MIB module	1003
17.7.13	Definitions for the IEEE8021-CN-MIB module	1014
17.7.14	Definitions for the IEEE8021-SRP-MIB module	1050
17.7.15	Definitions for the IEEE8021-MVRPX-MIB module	1066
17.7.16	Definitions for the IEEE8021-MIRP-MIB module	1071
17.7.17	Definitions for the IEEE8021-PFC-MIB module	1077
17.7.18	Definitions for the IEEE8021-TEIPS-V2-MIB module	1081
17.7.19	Definitions for the IEEE8021-SPB-MIB module	1096
17.7.20	Definitions for the IEEE8021-EVB-MIB module	1140
17.7.21	Definitions for the IEEE8021-ECMP-MIB module	1169
17.7.22	Definitions for the IEEE8021-ST-MIB module	1177
17.7.23	Definitions for the IEEE8021-Preemption-MIB module	1190
17.7.24	Definitions for the IEEE8021-PSFP-MIB module	1196
18.	Principles of Connectivity Fault Management operation	1220
18.1	Maintenance Domains and DoSAPs.....	1221
18.2	Service instances and MAs	1223
18.3	Maintenance Domain Levels	1224
19.	CFM entity operation.....	1228
19.1	Maintenance Points (MPs).....	1228
19.2	MA Endpoints (MEPs)	1229
19.2.1	MEP identification	1229
19.2.2	MEP functions	1230
19.2.3	MEP architecture	1230
19.2.4	MP Type Demultiplexer	1232

19.2.5	MP Multiplexer	1232
19.2.6	MP Level Demultiplexer	1232
19.2.7	MP OpCode Demultiplexer	1232
19.2.8	MEP Continuity Check Receiver	1233
19.2.9	MEP Continuity Check Initiator	1233
19.2.10	MP Loopback Responder	1234
19.2.11	MEP Loopback Initiator	1234
19.2.12	MEP Linktrace Initiator	1234
19.2.13	MEP LTI SAP	1234
19.2.14	MEP Linktrace SAP	1234
19.2.15	MEP CCM Database	1234
19.2.16	MEP Fault Notification Generator	1234
19.2.17	MEP Decapsulator Responder (DR)	1235
19.2.18	MEP RFM Receiver	1235
19.3	MIP Half Function	1235
19.3.1	MHF identification	1235
19.3.2	MHF functions	1235
19.3.3	MHF architecture	1236
19.3.4	MHF Level Demultiplexer	1236
19.3.5	MHF Type Demultiplexer	1236
19.3.6	MHF OpCode Demultiplexer	1236
19.3.7	MHF Multiplexer	1236
19.3.8	MHF Loopback Responder	1236
19.3.9	MHF Continuity Check Receiver	1237
19.3.10	MIP CCM Database	1237
19.3.11	MHF Linktrace SAP	1238
19.3.12	MHF DR	1238
19.3.13	MHF RFM Receiver	1238
19.4	MP addressing.....	1238
19.5	Linktrace Output Multiplexer (LOM).....	1239
19.6	Linktrace Responder	1239
20.	CFM protocols	1241
20.1	Continuity Check protocol	1242
20.1.1	MAC status reporting in the CCM	1244
20.1.2	Defects and Fault Alarms	1244
20.1.3	CCM reception	1245
20.2	Loopback protocol	1245
20.2.1	LBM transmission	1246
20.2.2	LBM reception and LBR transmission	1246
20.2.3	LBR reception	1247
20.3	Linktrace protocol	1247
20.3.1	LTM origination	1248
20.3.2	LTM reception, forwarding, and replying	1249
20.3.3	LTR reception	1250
20.4	CFM state machines	1251
20.5	CFM state machine timers	1251
20.5.1	LTFwhile	1253
20.5.2	CCIwhile	1253
20.5.3	errorCCMwhile	1253
20.5.4	xconCCMwhile	1253
20.5.5	LBIfwhile	1253
20.5.6	FNGwhile	1253

20.5.7	mmCCMwhile	1253
20.5.8	mmLocwhile	1253
20.5.9	mmFNGwhile	1253
20.5.10	rMEPwhile	1253
20.6	CFM procedures	1254
20.6.1	CCMtime()	1254
20.7	Maintenance Domain variable	1254
20.7.1	mdLevel	1254
20.8	MA variables	1254
20.8.1	CCMinterval	1254
20.9	MEP variables	1254
20.9.1	MEPactive	1255
20.9.2	enableRmepDefect	1255
20.9.3	MAdefectIndication	1256
20.9.4	allRMEPsDead	1256
20.9.5	lowestAlarmPri	1256
20.9.6	presentRDI	1256
20.9.7	MEPprimaryVID	1256
20.9.8	presentTraffic	1256
20.9.9	presentmmLoc	1256
20.9.10	ISpresentTraffic	1257
20.9.11	ISpresentmmLoc	1257
20.9.12	EpMEP	1257
20.10	MEP Continuity Check Initiator variables	1257
20.10.1	CCIenabled	1257
20.10.2	CCIsentCCMs	1257
20.10.3	MACstatusChanged	1257
20.10.4	Npaths	1257
20.10.5	flowHash[]	1258
20.10.6	pathN	1258
20.10.7	CCMent	1258
20.11	MEP Continuity Check Initiator procedures	1258
20.11.1	xmitCCM()	1258
20.12	MEP Continuity Check Initiator state machine	1259
20.13	MHF Continuity Check Receiver variables	1260
20.13.1	MHFrecvdCCM	1260
20.13.2	MHFCCMPDU	1260
20.14	MHF Continuity Check Receiver procedures	1260
20.14.1	MHFprocessCCM()	1260
20.15	MHF Continuity Check Receiver state machine	1260
20.16	MEP Continuity Check Receiver variables	1261
20.16.1	CCMreceivedEqual	1261
20.16.2	CCMequalPDU	1261
20.16.3	CCMreceivedLow	1261
20.16.4	CCMlowPDU	1261
20.16.5	recvMacAddress	1261
20.16.6	recvRDI	1261
20.16.7	recvInterval	1262
20.16.8	recvPortState	1262
20.16.9	recvInterfaceStatus	1262
20.16.10	recvSenderId	1262
20.16.11	recvFrame	1262
20.16.12	CCMsequenceErrors	1262
20.16.13	recvTrafficBit	1262

20.17	MEP Continuity Check Receiver procedures	1262
20.17.1	MEPprocessEqualCCM()	1263
20.17.2	MEPprocessLowCCM()	1263
20.18	MEP Continuity Check Receiver state machine	1264
20.19	Remote MEP variables	1264
20.19.1	rMEPCCMdefect	1264
20.19.2	rMEPlastRDI and rMEPlastRDI[i]	1264
20.19.3	rMEPlastPortState	1265
20.19.4	rMEPlastInterfaceStatus	1265
20.19.5	rMEPlastSenderId	1265
20.19.6	rCCMreceived	1265
20.19.7	rMEPmacAddress	1265
20.19.8	rMEPportStatusDefect	1265
20.19.9	rMEPinterfaceStatusDefect	1265
20.19.10	lastPathN	1265
20.20	Remote MEP state machine	1266
20.21	Remote MEP Error variables	1267
20.21.1	errorCCMreceived	1267
20.21.2	errorCCMlastFailure	1267
20.21.3	errorCCMdefect	1267
20.22	Remote MEP Error state machine	1267
20.23	MEP Cross Connect variables	1268
20.23.1	xconCCMreceived	1268
20.23.2	xconCCMlastFailure	1268
20.23.3	xconCCMdefect	1268
20.24	MEP Cross Connect state machine	1268
20.25	MEP Mismatch variables	1269
20.25.1	mmCCMreceived	1269
20.25.2	mmCCMdefect	1269
20.25.3	mmCCMTime	1269
20.25.4	disableLocdefect	1269
20.25.5	mmLocdefect	1269
20.26	MEP Mismatch state machines	1270
20.27	MP Loopback Responder variables	1271
20.27.1	LBMreceived	1271
20.27.2	LBMPDU	1271
20.28	MP Loopback Responder procedures	1271
20.28.1	ProcessLBM()	1271
20.28.2	xmitLBR()	1272
20.29	MP Loopback Responder state machine	1272
20.30	MEP Loopback Initiator variables	1273
20.30.1	LBMsToSend	1273
20.30.2	nextLBMtransID	1273
20.30.3	expectedLBRtransID	1273
20.30.4	LBIactive	1273
20.30.5	xmitReady	1273
20.30.6	LBRreceived	1273
20.30.7	LBRPDU	1273
20.31	MEP Loopback Initiator transmit procedures	1274
20.31.1	xmitLBM()	1274
20.32	MEP Loopback Initiator transmit state machine	1275
20.33	MEP Loopback Initiator receive procedures	1275
20.33.1	ProcessLBR()	1275
20.34	MEP Loopback Initiator receive state machine	1276

20.35	MEP Fault Notification Generator variables	1276
20.35.1	fngPriority	1276
20.35.2	fngDefect	1277
20.35.3	fngAlarmTime	1277
20.35.4	fngResetTime	1277
20.35.5	someRMEPCCMdefect	1277
20.35.6	someMACstatusDefect	1277
20.35.7	someRDId defect	1277
20.35.8	highestDefectPri	1277
20.35.9	highestDefect	1277
20.36	MEP Fault Notification Generator procedures	1278
20.36.1	xmitFaultAlarm()	1278
20.37	MEP Fault Notification Generator state machine	1278
20.38	MEP Mismatch Fault Notification Generator variables	1279
20.38.1	mfngAllowed	1279
20.38.2	mmdefectIndication	1279
20.38.3	mfngAlarmTime	1279
20.38.4	mfngResetTime	1279
20.39	MEP Mismatch Fault Notification Generator procedures	1279
20.39.1	xmitFaultAlarm()	1279
20.40	MEP Mismatch Fault Notification Generator state machine	1280
20.41	MEP Linktrace Initiator variables	1280
20.41.1	nextLTMtransID	1280
20.41.2	ltmReplyList	1281
20.42	MEP Linktrace Initiator procedures	1283
20.42.1	xmitLTM()	1283
20.43	MEP Linktrace Initiator receive variables	1284
20.43.1	LTRreceived	1284
20.43.2	LTRPDU	1284
20.44	MEP Linktrace Initiator receive procedures	1284
20.44.1	ProcessLTR()	1284
20.45	MEP Linktrace Initiator receive state machine	1285
20.46	Linktrace Responder variables	1285
20.46.1	nPendingLTRs	1285
20.46.2	LTMreceived	1285
20.46.3	LTMPDU	1285
20.47	LTM Receiver procedures	1286
20.47.1	ProcessLTM()	1286
20.47.2	clearPendingLTRs()	1290
20.47.3	ForwardLTM()	1290
20.47.4	enqueueLTR()	1291
20.48	LTM Receiver state machine	1292
20.49	LTR Transmitter procedure	1293
20.49.1	xmitOldestLTR()	1293
20.50	LTR Transmitter state machine	1293
20.51	CFM PDU validation and versioning	1294
20.51.1	Goals of CFM PDU versioning	1294
20.51.2	PDU transmission	1294
20.51.3	PDU validation	1294
20.51.4	Validation pass	1295
20.51.5	Execution pass	1296
20.51.6	Future extensions	1296
20.52	PDU identification	1297
20.53	Use of transaction IDs and sequence numbers	1297

21.	Encoding of CFM PDUs	1299
21.1	Structure, representation, and encoding	1299
21.2	CFM encapsulation	1299
21.3	CFM request and indication parameters	1300
21.3.1	destination_address parameter	1300
21.3.2	source_address parameter	1300
21.4	Common CFM Header	1300
21.4.1	MD Level	1300
21.4.2	Version	1300
21.4.3	OpCode	1301
21.4.4	Flags	1301
21.4.5	First TLV Offset	1302
21.5	TLV format	1302
21.5.1	General format for CFM TLVs	1302
21.5.2	Organization-Specific TLV	1303
21.5.3	Sender ID TLV	1304
21.5.4	Port Status TLV	1305
21.5.5	Interface Status TLV	1306
21.5.6	Data TLV	1307
21.5.7	End TLV	1307
21.6	CCM format	1307
21.6.1	Flags	1308
21.6.2	First TLV Offset	1309
21.6.3	Sequence Number	1309
21.6.4	Maintenance association Endpoint Identifier	1309
21.6.5	Maintenance Association Identifier	1309
21.6.6	Defined by ITU-T Y.1731 (02/2008)	1312
21.6.7	Optional CCM TLVs	1312
21.7	LBM and LBR formats	1312
21.7.1	Flags	1312
21.7.2	First TLV Offset	1313
21.7.3	Loopback Transaction Identifier	1313
21.7.4	Additional LBM/LBR TLVs	1313
21.7.5	PBB-TE MIP TLV	1314
21.8	LTM format	1315
21.8.1	Flags	1315
21.8.2	First TLV Offset	1315
21.8.3	LTM Transaction Identifier	1315
21.8.4	LTM TTL	1316
21.8.5	Original MAC Address	1316
21.8.6	Target MAC Address	1316
21.8.7	Additional LTM TLVs	1316
21.8.8	LTM Egress Identifier TLV	1316
21.9	LTR format	1317
21.9.1	Flags	1317
21.9.2	First TLV Offset	1318
21.9.3	LTR Transaction Identifier	1318
21.9.4	Reply TTL	1318
21.9.5	Relay Action	1318
21.9.6	Additional LTR TLVs	1318
21.9.7	LTR Egress Identifier TLV	1319
21.9.8	Reply Ingress TLV	1319
21.9.9	Reply Egress TLV	1321

22.	CFM in systems	1323
22.1	CFM shims in Bridges	1323
22.1.1	Preliminary positioning of MPs	1323
22.1.2	CFM and the Forwarding Process	1324
22.1.3	Up/Down separation of MPs	1326
22.1.4	Service instances over multiple Bridges	1328
22.1.5	Multiple VID service instances	1330
22.1.6	Untagged CFM PDUs	1330
22.1.7	MPs and non-VLAN-aware Bridges	1330
22.1.8	MPs and other standards	1331
22.1.9	CFM and IEEE 802.3 OAM	1333
22.2	Maintenance Entity creation	1333
22.2.1	Creating Maintenance Domains and MAs	1334
22.2.2	Creating MEPs	1334
22.2.3	Creating MIPs	1336
22.2.4	CFM configuration errors	1337
22.3	MPs, Ports, and MD Level assignment.....	1338
22.4	Stations and CFM	1338
22.5	Scalability of CFM.....	1339
22.6	CFM in Provider Bridges.....	1340
22.6.1	MPs and C-VLAN components	1340
22.6.2	Maintenance C-VLAN on a Port-based service interface	1341
22.6.3	Maintenance C-VLAN on a C-tagged service interface	1342
22.6.4	MPs and Port-mapping S-VLAN components	1342
22.7	Management Port MEPs and CFM in the enterprise environment.....	1344
22.8	Implementing CFM on Bridges that implement earlier revisions of IEEE Std 802.1Q	1346
23.	MAC status propagation	1347
23.1	Model of operation.....	1348
23.1.1	MAC Status Shim (MSS)	1349
23.1.2	Relationship of CFM to the MSS	1350
23.2	MAC Status Protocol (MSP) overview	1350
23.3	MSP state machines	1355
23.4	State machine timers	1356
23.4.1	linkNotifyWhen	1356
23.4.2	linkNotifyWhile	1356
23.4.3	macNotifyWhile	1356
23.4.4	macRecoverWhile	1356
23.5	MSP performance parameters.....	1356
23.5.1	LinkNotify	1357
23.5.2	LinkNotifyWait	1357
23.5.3	LinkNotifyRetry	1357
23.5.4	MACNotify	1357
23.5.5	MACNotifyTime	1357
23.5.6	MACRecoverTime	1357
23.6	State machine variables	1357
23.6.1	BEGIN	1357
23.6.2	addConfirmed	1357
23.6.3	disableMAC	1357
23.6.4	disabledMAC	1357
23.6.5	disableMSS	1358
23.6.6	lossConfirmed	1358
23.6.7	macOperational	1358

23.6.8	mssOperational	1358
23.6.9	prop	1358
23.6.10	rxAck	1358
23.6.11	rxAdd	1358
23.6.12	rxAddConfirm	1358
23.6.13	rxLoss	1358
23.6.14	rxLossConfirm	1358
23.6.15	txAck	1358
23.6.16	txAdd	1358
23.6.17	txAddConfirm	1359
23.6.18	txLoss	1359
23.6.19	txLossConfirm	1359
23.7	State machine procedures	1359
23.8	Status Transition state machine (STM)	1359
23.9	Status Notification state machine (SNM)	1360
23.10	Receive Process	1360
23.11	Transmit Process	1360
23.12	Management of MSP	1360
23.13	MSPDU transmission, addressing, and protocol identification	1361
23.13.1	Destination MAC Address	1361
23.13.2	Source MAC Address	1361
23.13.3	Priority	1362
23.13.4	EtherType use and encoding	1362
23.14	Representation and encoding of octets	1362
23.15	MSPDU structure	1362
23.15.1	Protocol Version	1362
23.15.2	Packet Type	1363
23.16	Validation of received MSPDUs	1363
23.17	Other MSP participants	1363
24.	Bridge performance	1364
24.1	Guaranteed Port Filtering Rate	1364
24.2	Guaranteed Bridge Relaying Rate	1364
24.3	RSTP performance requirements	1364
25.	Support of the MAC Service by PBBNs	1366
25.1	Service transparency	1368
25.2	Customer service interface	1368
25.3	Port-based service interface	1369
25.4	S-tagged service interface	1370
25.5	I-tagged service interface	1372
25.6	Service instance segregation	1374
25.7	Service instance selection and identification	1374
25.8	Service priority and drop eligibility selection	1375
25.9	Service access protection	1375
25.9.1	Class II redundant LANs access protection	1377
25.9.2	Class III simple redundant LANs and nodes access protection	1378
25.10	Support of the MAC Service by a PBB-TE Region	1379
25.10.1	Provisioning TESIs	1380
25.10.2	ESP forwarding behavior	1381
25.11	Transparent service interface	1382

26.	Principles of Provider Backbone Bridged Network (PBBN) operation	1384
26.1	PBBN overview	1384
26.2	PBBN example	1385
26.3	B-VLAN connectivity	1387
26.4	Backbone addressing	1388
26.4.1	Learning individual backbone addresses at a PIP	1389
26.4.2	Translating backbone destination addresses at a CBP	1389
26.4.3	Backbone addressing considerations for CFM MPs	1390
26.5	Detection of connectivity loops through attached networks	1390
26.6	Scaling of PBBs	1390
26.6.1	Hierarchical PBBNs	1391
26.6.2	Peer PBBNs	1391
26.7	Network management	1391
26.8	CFM in PBBs	1392
26.8.1	CFM over Port-based and S-tagged service interfaces	1397
26.8.2	CFM over I-tagged Service Interfaces	1398
26.8.3	CFM over hierarchical E-NNI	1398
26.8.4	CFM over peer E-NNI	1398
26.9	CFM in a PBB-TE Region	1399
26.9.1	Addressing PBB-TE MEPs	1399
26.9.2	TESI identification	1400
26.9.3	PBB-TE MEP placement in a Bridge Port	1400
26.9.4	PBB-TE MIP placement in a Bridge Port	1400
26.9.5	TESI Maintenance Domains	1400
26.9.6	PBB-TE enhancements of the CFM protocols	1401
26.9.7	Addressing Infrastructure Segment MEPs	1403
26.9.8	Infrastructure Segment identification	1403
26.9.9	Infrastructure Segment MEP placement in a Bridge Port	1404
26.9.10	Infrastructure Segment Maintenance Domains	1404
26.9.11	IPS extensions to Continuity Check operation	1404
26.10	Protection switching for point-to-point TESIs	1406
26.10.1	Introduction	1406
26.10.2	1:1 point-to-point TESI protection switching	1407
26.10.3	Protection Switching state machines	1410
26.11	IPS in PBB-TE Region	1415
26.11.1	Infrastructure Segment monitoring	1416
26.11.2	1:1 IPS	1417
26.11.3	IPS Control entity	1420
26.11.4	1:1 IPS state machines	1421
26.11.5	M:1 IPS	1421
26.12	Mismatch defect	1427
26.13	Signaling VLAN registrations among I-components	1428
27.	Shortest Path Bridging (SPB)	1429
27.1	Protocol design requirements	1431
27.2	Protocol support	1432
27.3	Protocol design goals	1433
27.4	ISIS-SPB VLAN configuration	1433
27.4.1	SPT Region and ISIS-SPB adjacency determination	1434
27.5	ISIS-SPB information	1436
27.6	Calculating CIST connectivity	1437
27.7	Connectivity between regions in the same domain	1438
27.8	Calculating SPT connectivity	1438

27.8.1	ISIS-SPB overload	1439
27.9	Loop prevention.....	1439
27.10	SPVID and SPSourceID allocation.....	1439
27.11	Allocation of VIDs to FIDs	1441
27.12	SPBV SPVID translation.....	1442
27.13	VLAN topology management.....	1442
27.14	Individual addresses and SPBM	1443
27.14.1	Loop mitigation	1444
27.14.2	Loop prevention	1444
27.15	SPBM group addressing	1445
27.16	Backbone service instance topology management	1447
27.17	Equal cost shortest paths, ECTs, and load spreading	1447
27.18	Connectivity Fault Management for SPBM	1448
27.18.1	SPBM MA types	1448
27.18.2	SPBM MEP placement in a Bridge Port	1448
27.18.3	SPBM MIP placement in a Bridge Port	1449
27.18.4	SPBM modifications of the CFM protocols	1449
27.19	Using SPBV and SPBM modes	1451
27.19.1	Shortest Path Bridging—VID	1451
27.19.2	Shortest Path Bridging—MAC	1452
27.20	Security considerations	1454
28.	ISIS-SPB Link State Protocol.....	1455
28.1	ISIS-SPB control plane MAC.....	1455
28.2	Formation and maintenance of ISIS-SPB adjacencies	1456
28.3	Loop prevention.....	1457
28.4	The Agreement Digest.....	1457
28.4.1	Agreement Digest Format Identifier	1458
28.4.2	Agreement Digest Format Capabilities	1458
28.4.3	Agreement Digest Convention Identifier	1458
28.4.4	Agreement Digest Convention Capabilities	1459
28.4.5	Agreement Digest Edge Count	1459
28.4.6	The Computed Topology Digest	1459
28.5	Symmetric shortest path tie breaking.....	1460
28.6	Symmetric ECT framework.....	1461
28.7	Symmetric ECT	1462
28.8	Symmetric ECT Algorithm details	1463
28.9	ECT Migration.....	1464
28.9.1	Use of a new ECT Algorithm in SPBV	1465
28.9.2	Use of a new ECT Algorithm in SPBM	1465
28.10	MAC address registration	1466
28.11	Circuit IDs and Port Identifiers.....	1467
28.12	ISIS-SPB TLVs.....	1467
28.12.1	MT-Capability TLV	1468
28.12.2	SPB MCID sub-TLV	1468
28.12.3	SPB Digest sub-TLV	1469
28.12.4	SPB Base VLAN-Identifiers sub-TLV	1469
28.12.5	SPB Instance sub-TLV	1471
28.12.6	SPB Instance Opaque ECT Algorithm sub-TLV	1473
28.12.7	SPB Link Metric sub-TLV	1474
28.12.8	SPB Adjacency Opaque ECT Algorithm sub-TLV	1475
28.12.9	SPBV MAC address sub-TLV	1476
28.12.10	SPBM Service Identifier and Unicast Address (ISID-ADDR) sub-TLV	1477

29.	DDCFM operations and protocols	1480
29.1	Principles of DDCFM operation	1480
29.1.1	Data-driven and data-dependent faults (DDFs)	1480
29.1.2	Basic principle to diagnose and isolate DDFs	1480
29.2	DDCFM Entity operation	1483
29.2.1	DDCFM implementation	1483
29.2.2	FPT RR	1484
29.2.3	RR-related parameters	1485
29.2.4	Reflection Target and RFM Receiver	1486
29.2.5	RPT-related parameters	1486
29.2.6	Decapsulator Responder (DR)	1487
29.2.7	SFM Originator	1488
29.3	DDCFM protocols	1488
29.3.1	RR variables	1488
29.3.2	RR Filter procedures	1490
29.3.3	RR Encapsulation procedures	1491
29.3.4	RR Transmit procedure	1492
29.3.5	RR-related state machines	1493
29.3.6	RFM Receiver variables	1495
29.3.7	RFM Receiver procedure	1495
29.3.8	DR variables	1496
29.3.9	DR procedures	1497
29.3.10	Decapsulator Responder state machine	1498
29.4	Encoding of DDCFM PDUs	1498
29.4.1	RFM and SFM Header	1498
29.4.2	RFM format	1499
29.4.3	SFM format	1500
30.	Principles of congestion notification	1502
30.1	Congestion notification design requirements	1502
30.2	Quantized Congestion Notification protocol (QCN)	1504
30.2.1	The CP algorithm	1505
30.2.2	Basic RP algorithm	1506
30.2.3	RP algorithm with timer	1507
30.3	Congestion Controlled Flow (CCF)	1508
30.4	Congestion Notification Priority Value (CNPV)	1509
30.5	Congestion Notification tag (CN-TAG)	1509
30.6	Congestion Notification Domain (CND)	1509
30.7	Multicast data	1510
30.8	Congestion notification and additional tags	1510
31.	Congestion notification entity operation	1512
31.1	Congestion-aware Bridge Forwarding Process	1512
31.1.1	Congestion Point (CP)	1513
31.1.2	CP ingress multiplexer	1513
31.2	Congestion-aware end station functions	1513
31.2.1	Output flow segregation	1514
31.2.2	Per-CNPV station function	1515
31.2.3	Flow Select Database	1517
31.2.4	Flow multiplexer	1517
31.2.5	CNM demultiplexer	1517
31.2.6	Input flow segregation	1517

31.2.7	End station input queue	1518
31.2.8	Reception selection	1518
32.	Congestion notification protocol	1519
32.1	CND operations	1519
32.1.1	CND defense	1519
32.1.2	Automatic CND recognition	1521
32.1.3	Variables controlling CND defense	1521
32.2	CN component variables	1522
32.2.1	cngMasterEnable	1523
32.2.2	cngCnmTransmitPriority	1523
32.2.3	cngDiscardedFrames	1523
32.2.4	cngErroredPortList	1523
32.3	Congestion notification per-CNPV variables	1523
32.3.1	cncpDefModeChoice	1523
32.3.2	cncpAlternatePriority	1524
32.3.3	cncpAutoAltPri	1524
32.3.4	cncpAdminDefenseMode	1524
32.3.5	cncpCreation	1524
32.3.6	cncpLldpInstanceChoice	1524
32.3.7	cncpLldpInstanceSelector	1524
32.4	CND defense per-Port per-CNPV variables	1525
32.4.1	cnpdDefModeChoice	1525
32.4.2	cnpdAdminDefenseMode	1525
32.4.3	cnpdAutoDefenseMode	1526
32.4.4	cnpdLldpInstanceChoice	1526
32.4.5	cnpdLldpInstanceSelector	1526
32.4.6	cnpdAlternatePriority	1526
32.4.7	cnpdXmitCnpvCapable	1526
32.4.8	cnpdXmitReady	1526
32.4.9	cncpDoesEdge	1527
32.4.10	cnpdAcceptsCnTag	1527
32.4.11	cnpdRcvdCnpv	1527
32.4.12	cnpdRcvdReady	1527
32.4.13	cnpdIsAdminDefMode	1527
32.4.14	cnpdDefenseMode	1528
32.5	CND defense procedures	1528
32.5.1	DisableCnpvRemapping()	1528
32.5.2	TurnOnCnDefenses()	1528
32.5.3	TurnOffCnDefenses()	1528
32.6	CND defense state machine	1528
32.7	Congestion notification protocol	1529
32.8	CP variables	1530
32.8.1	cpMacAddress	1531
32.8.2	cpId	1531
32.8.3	cpQSp	1531
32.8.4	cpQLen	1531
32.8.5	cpQLenOld	1531
32.8.6	cpW	1531
32.8.7	cpQOffset	1531
32.8.8	cpQDelta	1531
32.8.9	cpFb	1531
32.8.10	cpEnqueued	1532

32.8.11	cpSampleBase	1532
32.8.12	cpDiscardedFrames	1532
32.8.13	cpTransmittedFrames	1532
32.8.14	cpTransmittedCnms	1532
32.8.15	cpMinHeaderOctets	1532
32.9	CP procedures	1532
32.9.1	Random	1532
32.9.2	NewCpSampleBase()	1532
32.9.3	EM_UNITDATA.request (parameters)	1533
32.9.4	GenerateCnmPdu()	1533
32.10	RP per-Port per-CNPV variables	1534
32.10.1	rpppMaxRps	1534
32.10.2	rpppCreatedRps	1534
32.10.3	rpppRpCentiseconds	1535
32.11	RP group variables	1535
32.11.1	rpgEnable	1535
32.11.2	rpgTimeReset	1535
32.11.3	rpgByteReset	1535
32.11.4	rpgThreshold	1536
32.11.5	rpgMaxRate	1536
32.11.6	rpgAiRate	1536
32.11.7	rpgHaiRate	1536
32.11.8	rpgGd	1536
32.11.9	rpgMinDecFac	1536
32.11.10	rpgMinRate	1536
32.12	RP timer	1536
32.12.1	RpWhile	1537
32.13	RP variables	1537
32.13.1	rpEnabled	1537
32.13.2	rpByteCount	1537
32.13.3	rpByteStage	1537
32.13.4	rpTimeStage	1537
32.13.5	rpTargetRate	1537
32.13.6	rpCurrentRate	1538
32.13.7	rpFreeze	1538
32.13.8	rpLimiterRate	1538
32.13.9	rpFb	1538
32.14	RP procedures	1538
32.14.1	ResetCnm	1538
32.14.2	TestRpTerminate	1539
32.14.3	TransmitDataFrame	1539
32.14.4	ReceiveCnm	1539
32.14.5	ProcessCnm	1540
32.14.6	AdjustRates	1540
32.15	RP rate control state machine	1540
32.16	Congestion notification and encapsulation interworking function	1542
33.	Encoding of congestion notification PDUs	1544
33.1	Structure, representation, and encoding	1544
33.2	CN-TAG format	1544
33.2.1	Flow Identifier	1545
33.3	Congestion Notification Message (CNM)	1545
33.4	Congestion Notification Message PDU format	1545

33.4.1	Version	1545
33.4.2	ReservedV	1546
33.4.3	Quantized Feedback	1546
33.4.4	Congestion Point Identifier	1546
33.4.5	cnmQOffset	1546
33.4.6	cnmQDelta	1547
33.4.7	Encapsulated priority	1547
33.4.8	Encapsulated destination MAC address	1547
33.4.9	Encapsulated MSDU length	1547
33.4.10	Encapsulated MSDU	1547
33.4.11	CNM Validation	1547
34.	Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS).....	1548
34.1	Overview.....	1548
34.2	Detection of SRP domains.....	1548
34.3	The bandwidth availability parameters.....	1549
34.3.1	Relationships among bandwidth availability parameters	1549
34.3.2	Bandwidth availability parameter management	1550
34.4	Deriving actual bandwidth requirements from the size of the MSDU	1550
34.5	Mapping priorities to traffic classes for time-sensitive streams	1551
34.6	End station behavior	1553
34.6.1	Talker behavior	1553
34.6.2	Listener behavior	1554
35.	Stream Reservation Protocol (SRP).....	1555
35.1	Multiple Stream Registration Protocol (MSRP).....	1556
35.1.1	MSRP and Shared Media	1557
35.1.2	Behavior of end stations	1557
35.1.3	Behavior of Bridges	1559
35.1.4	SRP domains and status parameters	1559
35.2	Definition of the MSRP application.....	1559
35.2.1	Definition of internal state variables	1560
35.2.2	Definition of MRP elements	1562
35.2.3	Provision and support of Stream registration service	1572
35.2.4	MSRP Attribute Propagation	1576
35.2.5	Operational reporting and statistics	1581
35.2.6	Encoding	1581
35.2.7	Attribute value support requirements	1582
36.	Priority-based Flow Control (PFC)	1583
36.1	PFC operation	1583
36.1.1	Overview	1583
36.1.2	PFC primitives	1584
36.1.3	Detailed specification of PFC operation	1585
36.2	PFC-aware system queue functions	1586
36.2.1	PFC Initiator	1587
36.2.2	PFC Receiver	1587
37.	Enhanced Transmission Selection (ETS)	1589
37.1	Overview.....	1589
37.1.1	Relationship to other transmission selection algorithms	1589
37.2	ETS configuration parameters	1589

37.3	ETS algorithm	1589
37.4	Legacy configuration	1590
38.	Data Center Bridging eXchange protocol (DCBX)	1591
38.1	Overview	1591
38.2	Goals	1591
38.3	Types of DCBX attributes	1591
38.3.1	Informational attributes	1591
38.4	DCBX and LLDP	1592
38.4.1	Asymmetric attribute passing	1592
38.4.2	Symmetric attribute passing	1593
39.	Multiple I-SID Registration Protocol (MIRP)	1595
39.1	MIRP overview	1595
39.1.1	Behavior of I-components	1597
39.1.2	Behavior of B-components	1597
39.2	Definition of the MIRP application	1597
39.2.1	Definition of MRP elements	1597
39.2.2	Alternate MIRP model for B-components	1600
39.2.3	Use of “new” declaration capability	1602
39.2.4	Attribute value support requirements	1602
39.2.5	MRP Message filtering	1602
40.	Edge Virtual Bridging (EVB)	1603
40.1	EVB architecture without S-channels	1604
40.2	EVB architecture with S-channels	1605
40.3	Asymmetric EVB architecture without S-channels	1607
40.4	EVB status parameters	1609
40.4.1	EVBMode = Not supported	1609
40.4.2	EVBMode = EVB Bridge	1609
40.4.3	EVBMode = EVB station	1609
41.	VSI Discovery and Configuration Protocol (VDP)	1610
41.1	VSI manager ID TLV definition	1610
41.1.1	TLV type	1610
41.1.2	TLV information string length	1610
41.1.3	VSI Manager ID	1611
41.2	VDP association TLV definitions	1611
41.2.1	TLV type	1611
41.2.2	TLV information string length	1612
41.2.3	Status	1612
41.2.4	VSI Type ID (VTID)	1613
41.2.5	VSI Type Version	1613
41.2.6	VSIID format	1613
41.2.7	VSIID	1613
41.2.8	Filter Info format	1614
41.2.9	Filter Info field	1614
41.2.10	VDP TLV type and Status semantics	1617
41.3	Organizationally defined TLV definitions	1618
41.3.1	TLV type	1618
41.3.2	TLV information string length	1618
41.3.3	Organizationally unique identifier (OUI) or Company ID (CID)	1618