

INTERNATIONAL
STANDARD

ISO/
IEC/IEEE
8802-1CB

First edition
2019-02

AMENDMENT 2
2023-02

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

**Part 1CB:
Frame replication and elimination for
reliability**

**AMENDMENT 2: Extend stream
identification functions**

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

Partie 1CB: Duplication de trame et son élimination pour la fiabilité

AMENDEMENT 2: Fonctions d'identification de flux étendu



Reference number
ISO/IEC/IEEE 8802-1CB:2019/Amd.2:2023(E)

Documents
Document Sharing Hub
© IEEE 2022



COPYRIGHT PROTECTED DOCUMENT

© IEEE 2022

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 IEEE at the address below.

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

Published in Switzerland

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/IEC documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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 <https://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. In the IEC, see www.iec.ch/understanding-standards.

ISO/IEC/IEEE 8802-1CB:2019/Amd2 was prepared by the LAN/MAN of the IEEE Computer Society (as IEEE 802-1CBdb™-2021) 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*.

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

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 and www.iec.ch/national-committees.

IEEE Std 802.1CBdb™-2021
(Amendment to IEEE Std 802.1CB™-2017
as amended by IEEE Std 802.1CBv™-2021)

**IEEE Standard for
Local and metropolitan area networks—**

Frame Replication and Elimination for Reliability

**Amendment 2: Extended Stream Identification
Functions**

Developed by the
LAN/MAN Standards Committee
of the
IEEE Computer Society

Approved 8 December 2021
IEEE SA Standards Board

Abstract: This amendment specifies procedures, managed objects, and protocols for bridges and end systems that provide identification and replication of packets for redundant transmission, identification of duplicate packets, and elimination of duplicate packets. It is not concerned with the creation of the multiple paths over which the duplicates are transmitted.

Keywords: amendment, Bridged Local Area Networks, Bridges, Bridging, Extended Stream identification, Frame Elimination, Frame Replication, IEEE 802[®], IEEE 802.1CB[™], IEEE 802.1CBdb[™], IEEE 802.1Q[™], local area networks (LANs), MAC Bridges, Redundancy, Stream identification, Time-Sensitive Networking, TSN, Virtual Bridged Local Area Networks (virtual LANs)

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

Copyright © 2022 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 23 March 2022. Printed in the United States of America.

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

PDF: ISBN 978-1-5044-8305-6 STD25175
Print: ISBN 978-1-5044-8306-3 STDPD25175

IEEE prohibits discrimination, harassment and bullying.

For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/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 Standards documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page (<https://standards.ieee.org/ipr/disclaimers.html>), appear in all standards and may be found under the heading “Important Notices and Disclaimers Concerning IEEE Standards Documents.”

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

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE SA) Standards Board. IEEE develops its standards through an accredited consensus development process, which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards are documents developed by volunteers with scientific, academic, and industry-based expertise in technical working groups. Volunteers are not necessarily members of IEEE or IEEE SA, 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 makes no warranties or representations concerning its standards, and expressly disclaims all warranties, express or implied, concerning this standard, including but not limited to the warranties of merchantability, fitness for a particular purpose and non-infringement. In addition, IEEE does not warrant or represent that the use of the material contained in its standards is free from patent infringement. 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: THE NEED TO PROCURE 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 is 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, nor 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 the presenter's views should be considered the personal views of that individual rather than the formal position of IEEE, IEEE SA, the Standards Committee, or the Working Group.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE or IEEE SA. However, **IEEE does not provide interpretations, 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 evaluating comments or in revisions to an IEEE standard is welcome to join the relevant IEEE working group. You can indicate interest in a working group using the Interests tab in the Manage Profile & Interests area of the [IEEE SA myProject system](#).¹ An IEEE Account is needed to access the application.

Comments on standards should be submitted using the [Contact Us](#) form.²

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 constitute 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.

Data privacy

Users of IEEE Standards documents should evaluate the standards for considerations of data privacy and data ownership in the context of assessing and using the standards in compliance with applicable laws and regulations.

1. Available at: <https://development.standards.ieee.org/myproject-web/public/view.html#landing>.

2. Available at: <https://standards.ieee.org/content/ieee-standards/en/about/contact/index.html>.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under US 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 licensing fees, 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; <https://www.copyright.com/>. 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. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every 10 years. When a document is more than 10 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 [IEEE Xplore](#) or [contact IEEE](#).³ For more information about the IEEE SA or IEEE's standards development process, visit the IEEE SA Website.

Errata

Errata, if any, for all IEEE standards can be accessed on the [IEEE SA Website](#).⁴ Search for standard number and year of approval to access the web page of the published standard. Errata links are located under the Additional Resources Details section. Errata are also available in [IEEE Xplore](#). Users are encouraged to periodically check for errata.

Patents

IEEE Standards are developed in compliance with the [IEEE SA Patent Policy](#).⁵

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

3. Available at: <https://ieeexplore.ieee.org/browse/standards/collection/ieee>.

4. Available at: <https://standards.ieee.org/standard/index.html>.

5. Available at: <https://standards.ieee.org/about/sasb/patcom/materials.html>.

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.

IMPORTANT NOTICE

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. IEEE Standards development activities consider research and information presented to the standards development group in developing any safety recommendations. Other information about safety practices, changes in technology or technology implementation, or impact by peripheral systems also may be pertinent to safety considerations during implementation of the standard. 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.

Participants

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

Glenn Parsons, *Chair*
Jessy Rouyer, *Vice-Chair*
János Farkas, *Chair, Time-Sensitive Networking Task Group*
Christophe Mangin, *Editor*

Astrit Ademaj	Woojung Huh	Maximilian Riegel
Ralf Assmann	Satoko Itaya	Silvana Rodrigues
Rudy Belliardi	Yoshihiro Ito	Atsushi Sato
Christian Boiger	Michael Karl	Frank Schewe
Paul Bottorff	Stephan Kehrer	Michael Seaman
Radhakrishna Canchi	Randy Kelsey	Maik Seewald
David Chen	Marcel Kiessling	Ramesh Sivakolundu
Feng Chen	Gavin Lai	Johannes Specht
Paul Congdon	James Lawlis	Marius Stanica
Rodney Cummings	Joao Lopes	Gunter Steindl
Josef Dorr	Lily Lv	Liyang Sun
Hesham Elbakoury	Scott Mansfield	Karim Traore
Anna Engelmann	Kenichi Maruhashi	Max Turner
Thomas Enzinger	Olaf Mater	Balazs Varga
Donald Fedyk	David McCall	Ganesh Venkatesan
Norman Finn	Larry McMillan	Tongtong Wang
Geoffrey Garner	John Messenger	Xinyuan Wang
Amrit Gopal	Hiroki Nakano	Karl Weber
Craig Gunther	Bob Noseworthy	Ludwig Winkel
Marina Gutierrez	Hiroshi Ohue	Jordon Woods
Stephen Haddock	Donald R. Pannell	Takahiro Yamaura
Mark Hantel	Michael Potts	Yue Yin
Jerome Henry	Dieter Proell	Nader Zein
Marc Holness	Wei Qiu	William Zhao
Daniel Hopf	Karen Randall	Helge Zinner

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

Thomas Alexander	Piotr Karocki	Alon Regev
Harry Bims	Stephan Kehrer	Maximilian Riegel
Christian Boiger	Randy Kelsey	Jessy Rouyer
Vern Brethour	Stuart Kerry	Frank Schewe
William Byrd	Evgeny Khorov	Michael Seaman
Paul Cardinal	Yongbum Kim	Eugene Stoudenmire
Pin Chang	Hyeong Ho Lee	Walter Struppler
Diego Chiozzi	Ting Li	Mitsutoshi Sugawara
Janos Farkas	Christophe Mangin	Bo Sun
Avraham Freedman	Scott Mansfield	Max Turner
Craig Gunther	Jonathon McLendon	John Vergis
Stephen Haddock	Satoshi Obara	Stephen Webb
Marco Hernandez	Glenn Parsons	Karl Weber
Werner Hoelzl	Bansi Patel	Scott Willy
Oliver Holland	Arumugam Paventhan	Yu Yuan
Pranav Jha	Clinton Powell	Oren Yuen
Lokesh Kabra	Dieter Proell	

When the IEEE SA Standards Board approved this standard on 8 December 2021, it had the following membership:

Gary Hoffman, *Chair*
Jon Walter Rosdahl, *Vice Chair*
John D. Kulick, *Past Chair*
Konstantinos Karachalios, *Secretary*

Edward A. Addy
Doug Edwards
Ramy Ahmed Fathy
J. Travis Griffith
Thomas Koshy
Joseph L. Koepfinger*
David J. Law

Howard Li
Daozhuang Lin
Kevin Lu
Daleep C. Mohla
Chenhui Niu
Damir Novosel
Annette Reilly
Dorothy Stanley

Mehmet Ulema
Lei Wang
F. Keith Waters
Karl Weber
Sha Wei
Howard Wolfman
Daidi Zhong

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 802.1CBdb-2021, IEEE Standard for Local and metropolitan area networks—Frame Replication and Elimination for Reliability—Amendment 2: Extended Stream Identification Functions.

This Standard defines Extended Stream identification functions.

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 can be obtained from

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

Contents

3.	Definitions	14
5.	Conformance	15
5.4	Stream identification component recommended behavior	15
5.5	Stream identification component optional behaviors	15
5.7	Talker end system recommended behaviors	15
5.8	Talker end system optional behaviors	15
5.10	Listener end system recommended behavior	15
5.11	Listener end system optional behaviors	16
5.13	Relay system recommended behaviors	16
5.15	FRER C-component required and optional behaviors	16
6.	Stream identification	17
6.1	Stream service subparameters	18
6.2	Stream identification function	18
6.3	Stream identification in systems	18
6.4	Null Stream identification	18
6.5	Source MAC and VLAN Stream identification	18
6.6	Active Destination MAC and VLAN Stream identification	19
6.7	IP Stream identification	19
6.8	Mask-and-match Stream identification	19
7.	Frame Replication and Elimination for Reliability	21
7.4	Sequencing function	21
7.4.1	Sequence generation function	21
7.4.1.3	SequenceGenerationReset	21
7.4.3	Base recovery function	21
7.4.3.3	SequenceRecoveryReset	21
7.4.3.4	VectorRecoveryAlgorithm	21
7.4.3.5	MatchRecoveryAlgorithm	24
7.8	Redundancy tag	25
7.9	HSR sequence tag	25
7.10	PRP sequence trailer	25
8.	Frame Replication and Elimination for Reliability in Bridges	26
8.1	Limiting options	26
8.2	FRER C-component input transformations	26
8.3	Frame Replication and Elimination for Reliability and VLAN tags	27
9.	Stream Identification Management	29
9.1	Stream identity table	29
9.1.1	tsnStreamIdEntry	29
9.1.1.6	tsnStreamIdIdentificationType	29
9.1.4	Managed objects for Active Destination MAC and VLAN Stream identifications	29
9.1.5	Managed objects for IP Stream identification	29
9.1.5.1	tsnCpeIpIdDestMac	29
9.1.6	Managed objects for Mask-and-match Stream identification	30
9.1.6.1	tsnCpeMmIdDestMacMask	30
9.1.6.2	tsnCpeMmIdDestMacMatch	30
9.1.6.3	tsnCpeMmIdSrcMacMask	30

9.1.6.4	tsnCpeMmIdSrcMacMatch	30
9.1.6.5	tsnCpeMmIdMsduMaskLength	30
9.1.6.6	tsnCpeMmIdMsduMask	30
9.1.6.7	tsnCpeMmIdMsduMatch	31
9.2	Operational per-port per-Stream Stream identification counters	31
9.3	Operational per-port Stream identification counters	31
9.4	Per-port managed object	31
9.4.1	tsnPpMmIdMsduMaskMaxLength	31
10.	Frame Replication and Elimination for Reliability management	32
10.2	Additional tsnStreamIdEntry managed objects	32
10.4	Sequence recovery table	32
10.4.1	frerSeqRcvyEntry	32
10.4.1.4	frerSeqRcvyReset	32
10.4.1.10	frerSeqRcvyIndividualRecovery	32
10.8	Operational per-port and per-Stream FRER counters	32
10.8.8	frerCpsSeqRcvyTaglessPackets	32
10.9	Operational per-port FRER counters	33
11.	Management Information Base (MIB)	34
11.2	Structure of the MIB	34
11.2.1	Structure of the IEEE8021-STREAM-IDENTIFICATION-MIB	36
11.5	MIB modules,	38
11.5.1	Definitions for the IEEE8021-STREAM-IDENTIFICATION-MIB	38
12.	YANG Data Model	70
12.2	IEEE Std 802.1CB YANG model	70
12.2.1	Stream identification model	70
12.3	Structure of the YANG model	71
12.3.1a	Structure of the ieee802-dot1cb-mask-and-match YANG module	71
12.4	Relationship to other YANG modules	72
12.4.6a	IEEE 802.1CB Extended Stream identification module	72
12.6	Definition of 802.1CB YANG modules,	72
12.6.1	YANG data scheme tree definitions	72
12.6.1.1a	YANG data scheme definition for ieee802-dot1cb-mask-and-match YANG module	72
12.6.2	YANG data module definitions	73
12.6.2.1	Definition for the ieee802-dot1cb-stream-identification-types YANG module	73
12.6.2.2a	Definition for the ieee802-dot1cb-mask-and-match module	75
Annex A (normative)	Protocol Implementation Conformance Statement (PICS) proforma	80
A.2	PICS proforma for Frame Replication and Elimination for Reliability	80
A.2.2	Stream identification component	80
A.2.3	Talker end system	81
A.2.4	Listener end system	82
A.2.5	Relay system	83
A.2.9	YANG	83
Annex C (informative)	Frame Replication and Elimination for Reliability in systems	84
C.2	Example 2: Various stack positions	84
C.5	Example 5: Protocol interworking	85
C.9	FRER and reserved bandwidth	85
C.10	Use of the Individual recovery function	85

Annex C1 (informative) Mask-and-match Stream identification function 86

 C1.1 Example 1: Generic Stream identification for industrial communication networks 86

 C1.2 Example 2: MPLS DetNet flow identification 86

Annex D (informative) Bibliography 88

IEEE Standard for Local and metropolitan area networks— Frame Replication and Elimination for Reliability Amendment 2: Extended Stream Identification Functions

(This amendment is based on IEEE Std 802.1CB™-2017 as amended by IEEE Std 802.1CBv™-2021.)

NOTE—The editing instructions contained in this amendment define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.

The editing instructions are shown in ***bold italic***. Four editing instructions are used: change, delete, insert, and replace. ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~striketrough~~ (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Deletions and insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editing instructions, change markings, and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard.⁶

⁶ Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

3. Definitions

Change the definition of “Internal Sublayer Service (ISS)” in Clause 3 as follows:

Internal Sublayer Service (ISS): An augmented version of the MAC Service, defined in ~~6.6 of IEEE Std 802.1Q-2014~~ [IEEE Std 802.1AC](#).

Insert the following new definition Clause 3 in alphabetical order:

Mask: A set of consecutive bits used to select bits of a particular significance in a bit field of the same length as the mask.

5. Conformance

5.4 Stream identification component recommended behavior

Change the lettered list in 5.4 as follows:

- a) [A Source MAC and VLAN Stream identification function \(6.5\);](#)
- b) ~~⊕~~ An Active Destination MAC and VLAN Stream identification function (6.6).

5.5 Stream identification component optional behaviors

Change the lettered list in 5.5 as follows:

- a) The items in 5.3 and 5.4 on more than one port;
- b) The items in 5.3 and 5.4 for some number of Compound Streams greater than 1;
- c) An IP Stream identification function (6.7); ~~and/or~~
- d) [A Mask-and-match Stream identification function \(6.8\); and/or](#)
- e) ~~⊕~~ Additional types of Stream identification functions.

5.7 Talker end system recommended behaviors

Change the lettered list in 5.7 as follows:

- a) [A Source MAC and VLAN Stream identification function \(6.5\);](#)
- b) ~~⊕~~ An Active Destination MAC and VLAN Stream identification function (6.6); and
- c) ~~⊕~~ A Stream splitting function (7.7).

5.8 Talker end system optional behaviors

Change the lettered list in 5.8 (as changed by IEEE Std 802.1CBcv-2021) as follows:

- a) The items in 5.6 and 5.7 on more than one port;
- b) The items in 5.6 and 5.7 for some number of Compound Streams greater than 1;
- c) An IP Stream identification function (6.7);
- d) [A Mask-and-match Stream identification function \(6.8\);](#)
- e) ~~⊕~~ Additional types of Stream identification functions;
- f) ~~⊕~~ The HSR sequence tag (7.9);
- g) ~~⊕~~ The PRP sequence trailer (7.10);
- h) ~~⊕~~ Additional types of Sequence encode/decode functions;
- i) ~~⊕~~ Support SMIPv2 MIB modules for the management of talker end system functions (Clause 11) as required by item e in 5.6; and/or
- j) ~~⊕~~ Support YANG modules for the management of talker end system functions (Clause 12) as required by item e in 5.6.

5.10 Listener end system recommended behavior

Change the lettered list in 5.10 as follows:

- a) [A Source MAC and VLAN Stream identification function \(6.5\);](#)
- b) ~~⊕~~ An Active Destination MAC and VLAN Stream identification function (6.6).

5.11 Listener end system optional behaviors

Change the lettered list in 5.11 (as changed by IEEE Std 802.1CBcv-2021) as follows:

- a) The items in 5.9 and 5.10 on more than one port;
- b) The items in 5.9 and 5.10 for some number of Compound Streams greater than 1;
- c) An IP Stream identification function (6.7);
- d) [A Mask-and-match Stream identification function \(6.8\);](#)
- e) ~~⊕~~ Additional types of Stream identification functions;
- f) ~~⊕~~ The HSR sequence tag (7.9);
- g) ~~⊕~~ The PRP sequence trailer (7.10);
- h) ~~⊕~~ Additional types of Sequence encode/decode functions;
- i) ~~⊕~~ At least two instances of Individual recovery functions (7.5), each using the VectorRecoveryAlgorithm (7.4.3.4);
- j) ~~⊕~~ Support SMIPv2 MIB modules for the management of listener end system functions (Clause 11) as required by item f in 5.9; and/or
- k) ~~⊕~~ Support YANG modules for the management of listener end system functions (Clause 12) as required by item f in 5.9.

5.13 Relay system recommended behaviors

Change 5.13 as follows:

A relay system should be able to instantiate the following in-facing functions on at least two ports, for both transmit and receive, for at least one Stream:

- a) [A Source MAC and VLAN Stream identification function \(6.5\);](#)
- b) ~~⊕~~ Active Destination MAC and VLAN Stream identification functions (6.6) for encoding and decoding packets; ~~and~~
- c) [Either of the following:](#)
 - 1) ~~⊕~~ IP Stream identification functions (6.7);
 - 2) [Mask-and-match Stream identification function \(6.8\)](#) for identifying packets.

NOTE—IP Stream identification [and Mask-and-match Stream identification](#) enables a relay system to proxy for a FRER-unaware end system.

5.15 FRER C-component required and optional behaviors

Change list item a) in 5.15 as follows:

- a) Shall meet all of the required and any or none of the optional behaviors for an IEEE 802.1Q C-VLAN component (5.5 of IEEE Std 802.1Q-~~2014~~[2018](#)).

6. Stream identification

Change the first paragraph of the introduction of Clause 6 as follows:

Clause 7 of IEEE Std 802.1AC-2016 describes the IEEE 802.1 layering model, that Frame Replication and Elimination for Reliability (FRER) follows. Stream identification utilizes a single Service Access Point (SAP) to a connectionless packet service offered by the layer below it [e.g., the Intermediate Sublayer Service (ISS) of Clause 11 of IEEE Std 802.1AC-2016, or the Enhanced Internal Sublayer Service (EISS) of 6.8 of IEEE Std 802.1Q-2018], and offers an array of SAPs to the layers above it, corresponding to different Streams. The Stream identification model is illustrated in Figure 6-1.

Change the note after the second paragraph of the introduction of Clause 6 as follows:

NOTE—In principle, any number of different methods for identifying and encoding Streams can be defined. Several ~~required~~ methods are specified in the following subclauses (6.4, 6.5, 6.6, 6.7, and 6.8).

Change item c) in the lettered list in the introduction of Clause 6 as follows:

- c) ~~Four~~Five specific Stream identification functions are described: Null Stream identification (6.4), Source MAC and VLAN Stream identification (6.5), Active Destination MAC and VLAN Stream identification (6.6), ~~and~~ IP Stream identification (6.7), and Mask-and-match Stream identification (6.8).

Change Table 6-1 as follows:

Table 6-1—Stream identification functions

Stream identification function	Active/passive	Examines	Overwrites	Reference
Null Stream identification	Passive	destination address, vlan_identifier	None	6.4, 9.1.2
Source MAC and VLAN Stream identification	Passive	source_address, vlan_identifier	None	6.5, 9.1.3
Active Destination MAC and VLAN Stream identification	Active	destination address, vlan_identifier	destination address, vlan_identifier, priority	6.6, 9.1.4
IP Stream identification	Passive	destination_address, vlan_identifier, IP source address, IP destination address, DSCP, IP next protocol, source port, destination port	None	6.7, 9.1.5
Mask-and-match Stream identification function	Passive	destination_address, source_address, mac_service_data_unit	None	6.8, 9.1.6

6.1 Stream service subparameters

Change the first paragraph of 6.1 as follows:

The ISS defined in IEEE Std 802.1AC [and the EISS defined in IEEE Std 802.1Q](#) includes a connection_identifier parameter that is of local significance (to a system) only. The parameter is not carried across the underlying service. Stream identification makes use of this parameter to carry parametrized information. Stream identification has need for more than one subparameter, but an implementor can create mathematical algorithms to combine those subparameters (and/or other subparameters for other layers) into a single connection_identifier parameter, especially since the connection_identifier's values are undefined outside the system implementing them. In this document, parameters that are assumed to be encoded in the connection_identifier are deemed *subparameters*.

6.2 Stream identification function

Change the note at the end of 6.2 into two notes as follows:

NOTE 1—The Stream identification method does not necessarily involve an actual transformation of the packet. See 6.4 and 6.6 for examples of both cases.

[NOTE 2—The order of precedence of Stream identification functions and the invocation of their instances, when more than one matches the same frame, is out of scope of this standard.](#)

6.3 Stream identification in systems

Change the third sentence of the first paragraph of 6.3 as follows:

Diagram a in Figure 6-5 illustrates a relay system (e.g., 8.6 of IEEE Std 802.1Q-~~2014~~[2018](#)) with two ports, that has its FRER capabilities embedded in its forwarding function, and not shown explicitly in the diagram.

6.4 Null Stream identification

Change the second sentence of the first paragraph of 6.4 as follows:

It can be defined using the Enhanced Internal Sublayer Service (EISS) described in 6.9 of IEEE Std 802.1Q-~~2014~~[2018](#), in which case it is enhanced with the extra stream_handle subparameter of the connection_identifier, specified in 6.1 of the present standard.

6.5 Source MAC and VLAN Stream identification

Change the second sentence of the first paragraph of 6.5 as follows:

It can be defined using the EISS described in 6.9 of IEEE Std 802.1Q-~~2014~~[2018](#), in which case it is enhanced with the extra stream_handle subparameter of the connection_identifier, specified in 6.1 of the present standard.

6.6 Active Destination MAC and VLAN Stream identification

Change the second sentence of the first paragraph of 6.6 as follows:

It can be defined using the EISS described in 6.9 of IEEE Std 802.1Q-2014/2018, in which case it is enhanced with the extra stream_handle subparameter of the connection_identifier, specified in 6.1 of the present standard.

Change the second paragraph of 6.6 as follows:

In the Active Destination MAC and VLAN Stream identification, the destination_address, vlan_identifier, and priority parameters of the frame passed down the stack from the upper layers or up the stack from the lower layers are replaced with alternate values. The replacement values for frames transmitted down the stack to the Active Destination MAC and VLAN Stream identification, and used to recognize frames passed up the stack to the Active Destination MAC and VLAN Stream identification function, ~~are those listed in 9.1.2 as well as~~ are described in 9.1.4. The replacement values for frames transmitted down the stack to the Active Destination MAC and VLAN Stream identification function are determined by the stream_handle subparameter passed down in the EISS request's connection_identifier. ~~—The replacement values for frames passed up the stack (not including the priority parameter)~~

6.7 IP Stream identification

Change the second sentence of the first paragraph of 6.7 as follows:

It can be defined using the union of the IP address primitives listed in 9.1.5 and parameters defined by the EISS described in 6.9 of IEEE Std 802.1Q-2014/2018, in which case it is enhanced with the stream_handle subparameter of the connection_identifier, specified in 6.1 of the present standard.

Insert new subclause 6.8 after 6.7 as follows:

6.8 Mask-and-match Stream identification

The Mask-and-match Stream identification is a passive Stream identification that operates at the frame level. It can be defined using the Internal Sublayer Service (ISS) described in IEEE Std 802.1AC, in which case it is enhanced with the extra stream_handle subparameter of the connection_identifier, specified in 6.1 of the present standard.

It discards the stream_handle subparameter passed down the stack. It generates a stream_handle subparameter on frames passed up the stack based on information extracted from a subset of the frame's ISS parameters. It does not change any of a packet's parameters, other than the connection_identifier.

Input information for the Mask-and-match Stream identification function is obtained by masking one or more of the following ISS parameters:

- Source_address,
- Destination_address, and
- The first N octets of mac_service_data_unit, N being a system-dependent variable.

Stream identification is then done by comparing these masked ISS parameters with specific match values.

The Mask-and-match Stream identification function supports Stream identification schemes ranging from very simple, using a single mask applied to one of its input ISS parameters, to complex schemes involving

masks applied to all input ISS parameters, and in particular a specific `mac_service_data_unit` mask to identify communication flows supported by various higher-layer protocols.

In order to instantiate the Mask-and-match Stream identification function, the `tsnStreamIdIdentificationType` managed object (9.1.1.6) is encoded using the OUI (00-80-C2) and the type values as shown in Table 9-1.

The managed objects for Mask-and-match Stream identification are described in 9.1.6.

Mask-and-match Stream identification can be coupled, for example, with Active Destination MAC and VLAN Stream identification (6.6) to assign a particular {MAC address, VLAN, priority} triplet to packets belonging to a particular unicast application Stream identified by the combination of the values of particular fields in the MAC service data unit, as shown in Figure 8-1, Port A, where Mask-and-match Stream identification would be in the box labeled “Passive Upper Stream identification functions (6.2).”

7. Frame Replication and Elimination for Reliability

7.4 Sequencing function

7.4.1 Sequence generation function

7.4.1.3 SequenceGenerationReset

Insert the following note at the end of 7.4.1.3:

NOTE—SequenceGenerationReset can cause packet drop.

7.4.3 Base recovery function

Change the third paragraph and NOTE 1 in 7.4.3 as follows:

The sequence recovery function has two sequence recovery algorithms (7.4.3.4, 7.4.3.5) so that it can be used either for Intermittent Streams (item c in 7.1.1) or for Bulk Streams (item d in 7.1.1). As long as the maximum difference in the number of packets in flight among all of the paths taken by the Member Streams served by a given sequence recovery function does not exceed the size of the SequenceHistory variable (7.4.3.2.2, 10.4.1.6), the packets are delivered without duplication, but can be delivered out-of-order. If the difference exceeds this value, then ~~duplicate packets can be delivered~~ packets can be discarded.

NOTE 1—The requirements for conformance to this standard, particularly item c in 5.9 and item e in 5.12, specify that the sequence recovery function need only support a minimum difference in path length for the correct elimination of duplicates in Bulk Streams. If the actual path difference in a given network exceeds the capability of a sequence recovery function, ~~then duplicate packets will be delivered~~ then packets will be discarded. It is up to the user to see that the capabilities of the systems purchased match the needs of the particular network in which they are employed.

7.4.3.3 SequenceRecoveryReset

Insert the following note at the end of 7.4.3.3:

NOTE—Reset of Sequence recovery function may cause temporary duplicate delivery.

7.4.3.4 VectorRecoveryAlgorithm

Change the second, third, and fourth paragraphs of 7.4.3.4 as follows:

~~One can observe that if the managed object frerSeqRcvyHistoryLength contains the value 1, then this algorithm is suitable for Intermittent Streams (item c in 7.1.1). In that case, the SequenceHistory variable (7.4.3.2.2) merely records whether the RecovSeqNum (7.4.3.2.3) does or does not record the sequence number subparameter of a received packet. [It does not immediately after SequenceRecoveryReset (7.4.3.3) is called.] If frerSeqRcvyHistoryLength contains a value greater than one, VectorRecoveryAlgorithm serves as the more complex algorithm suitable for Bulk Streams (item d in 7.1.1).~~

Immediately after SequenceRecoveryReset (7.4.3.3) is called, the VectorRecoveryAlgorithm accepts the first packet received as valid. After the first packet has been accepted, all subsequent packets that are in the ~~window last packet number accepted ± frerSeqRcvyHistoryLength are accepted, and recovery window~~ (i.e., last packet number accepted – frerSeqRcvyHistoryLength + 1 to last packet number accepted + frerSeqRcvyHistoryLength) are accepted, and those packets with sequence_number values outside that range are discarded. Each packet accepted and passed up the stack resets the timer variable RemainingTicks (7.4.3.2.4). If that variable ticks down to 0, meaning that no packet has been accepted in frerSeqRcvyResetMSec milliseconds (10.4.1.7), then SequenceRecoveryReset again resets the algorithm, and the next packet received is accepted.

This timeout mechanism means that:

- “Rogue” packets, meaning packets outside the ~~frerSeqRcvyHistoryLength~~ window, recovery window, are discarded as invalid.
- If a Base recovery function somehow gets out of step with its corresponding Sequence generation function, then after frerSeqRcvyResetMSec milliseconds, the Base recovery function will be reset and data will again be passed.
- If a Sequence generation function is reset, perhaps by rebooting a system, then Base recovery functions that have not been reset are likely to discard packets until the timeout has occurred.
- If a Talker ~~or a relay system~~ fails in such a way as to repeatedly transmit packets with the same sequence_number subparameter (perhaps repeating exactly the same packet), ~~those packets will continue to be discarded, at least until the sequence_number wraps around~~ then in the case of Individual recovery (7.5), all repeated packets are discarded. If only Sequence recovery (7.4.2) is used, then all except one repeated packets are discarded per RemainingTicks interval. If a relay system fails the same way, then in the case of Individual recovery (7.5), all packets are discarded. If only Sequence recovery (7.4.2) is used and if there is a correct Member Stream, then the failed Member Stream pollutes the correct Member Stream.

Change the pseudo-code at the end of 7.4.3.4 as follows:

```
void VectorRecoveryAlgorithm () {
    // Check that sequence number is present in the packet
    unsigned int sequence_number;
    if (sequence_number == frerSeqRcvyInvalidSequenceValue) {
        frerCpsSeqRcvyTaglessPackets = frerCpsSeqRcvyTaglessPackets + 1;
        if (frerSeqRcvyTakeNoSequence) {
            frerCpsSeqRcvyPassedPackets = frerCpsSeqRcvyPassedPackets + 1;
            frerCpSeqRcvyPassedPackets = frerCpSeqRcvyPassedPackets + 1;
            RemainingTicks =
                ((frerSeqRcvyResetMSec*TicksPerSecond)+999)/1000;
            PRESENT_DATA;
        } else {
            frerCpsSeqRcvyDiscardedPackets =
                frerCpsSeqRcvyDiscardedPackets + 1;
            frerCpSeqRcvyDiscardPackets = frerCpSeqRcvyDiscardPackets + 1;
        }
        return;
    }
    // Compute signed difference modulo RecovSeqSpace.
    int delta = (sequence_number-RecovSeqNum) & (RecovSeqSpace - 1);
    if (0 != (delta & (RecovSeqSpace/2)))
        delta = delta - RecovSeqSpace;
    // Here, -(RecovSeqSpace/2) <= delta <= ((RecovSeqSpace/2)-1)
    // After reset, accept any packet
    if (TakeAny) {
        TakeAny = false;
        SequenceHistory[0] = 1; // Shift, adding a "seen" bit
        RecovSeqNum = sequence_number;
        frerCpsSeqRcvyPassedPackets = frerCpsSeqRcvyPassedPackets + 1;
        frerCpSeqRcvyPassedPackets = frerCpSeqRcvyPassedPackets + 1;
        RemainingTicks =
            ((frerSeqRcvyResetMSec * TicksPerSecond) + 999) / 1000;
        PRESENT_DATA;
    } else if (delta >= frerSeqRcvyHistoryLength ||
```

```

        delta <= -frerSeqRcvyHistoryLength      )
    {
        // Packet is out-of-range. Count and discard it.
        frerCpsSeqRcvyRoguePackets = frerCpsSeqRcvyRoguePackets + 1;
        frerCpSeqRcvyDiscardPackets = frerCpSeqRcvyDiscardPackets + 1;
        // Reset timer if working on an individual Stream
        if (frerSeqRcvyIndividualRecovery)
            RemainingTicks =
                ((frerSeqRcvyResetMSec * TicksPerSecond) + 999) / 1000;
    } else if (delta <= 0) {
        // Packet is old and in SequenceHistory; have we seen it before?
        if (0 == SequenceHistory[-delta]) {
            // Packet has not been seen. Take it.
            SequenceHistory[-delta] = 1;
            frerCpsSeqRcvyOutOfOrderPackets =
                frerCpsSeqRcvyOutOfOrderPackets + 1;
            frerCpsSeqRcvyPassedPackets = frerCpsSeqRcvyPassedPackets + 1;
            frerCpSeqRcvyPassedPackets = frerCpSeqRcvyPassedPackets + 1;
            RemainingTicks =
                ((frerSeqRcvyResetMSec * TicksPerSecond) + 999) / 1000;
            PRESENT_DATA;
        } else {
            // Packet has been seen. Do not forward. Count the discard.
            frerCpsSeqRcvyDiscardedPackets =
                frerCpsSeqRcvyDiscardedPackets + 1;
            frerCpSeqRcvyDiscardPackets = frerCpSeqRcvyDiscardPackets + 1;
            // Reset timer if working on an individual Stream
            if (frerSeqRcvyIndividualRecovery)
                RemainingTicks =
                    ((frerSeqRcvyResetMSec * TicksPerSecond) + 999) / 1000;
        }
    } else {
        // Packet is not too far ahead of the one we want.
        // Packet is out-of-order unless it directly follows RecovSeqNum
        if (delta != 1)
            frerCpsSeqRcvyOutOfOrderPackets =
                frerCpsSeqRcvyOutOfOrderPackets + 1;
        // Shift the history until bit 0 refers to sequence_number.
        while (0 != (delta = delta - 1))
            ShiftSequenceHistory(0); // Shift, adding a "not seen" bit
        ShiftSequenceHistory(1); // Shift, adding a "seen" bit
        RecovSeqNum = sequence_number;
        frerCpsSeqRcvyPassedPackets = frerCpsSeqRcvyPassedPackets + 1;
        frerCpSeqRcvyPassedPackets = frerCpSeqRcvyPassedPackets + 1;
        RemainingTicks =
            ((frerSeqRcvyResetMSec * TicksPerSecond) + 999) / 1000;
        PRESENT_DATA;
    }
}

```

7.4.3.5 MatchRecoveryAlgorithm

Change the second and third paragraphs of 7.4.3.5 as follows:

Immediately after SequenceRecoveryReset (7.4.3.3) is called, the MatchRecoveryAlgorithm accepts the first packet received as valid. After the first packet has been accepted, all subsequent packets either match the last packet number accepted, and are therefore discarded, or do not, in which case they are accepted. Each packet accepted and passed up the stack resets the timer variable RemainingTicks (7.4.3.2.4). Dropped packets also reset the timer variable RemainingTicks (7.4.3.2.4) in the case of Individual recovery. If that variable ticks down to 0, meaning that no packet has been accepted in frerSeqRcvyResetMSec milliseconds (10.4.1.7), then SequenceRecoveryReset again resets the algorithm, and the next packet received is accepted.

~~The timer mechanism prevents the MatchRecoveryAlgorithm from getting stuck forever, blocking packet 1, in case a Talker fails or is reset soon after initialization.~~

Change the pseudo-code at the end of 7.4.3.5 as follows:

```

void MatchRecoveryAlgorithm () {
    // Check that sequence number is present in the packet
    unsigned int sequence_number;
    if (sequence_number != frerSeqRcvyInvalidSequenceValue) {
        frerCpsSeqRcvyTaglessPackets = frerCpsSeqRcvyTaglessPackets + 1;
        frerCpsSeqRcvyPassedPackets = frerCpsSeqRcvyPassedPackets + 1;
        frerCpSeqRcvyPassedPackets = frerCpSeqRcvyPassedPackets + 1;
        PRESENT_DATA;
        return;
    }
    // After reset, accept any packet
    if (TakeAny) {
        TakeAny = false;
        RecovSeqNum = sequence_number;
        frerCpsSeqRcvyPassedPackets = frerCpsSeqRcvyPassedPackets + 1;
        frerCpSeqRcvyPassedPackets = frerCpSeqRcvyPassedPackets + 1;
        RemainingTicks =
            ((frerSeqRcvyResetMSec * TicksPerSecond) + 999) / 1000;
        PRESENT_DATA;
        return;
    }
    // Compute signed difference modulo RecovSeqSpace.
    int delta = (sequence_number - RecovSeqNum) & (RecovSeqSpace - 1);
    if (delta == 0) {
        // Packet has been seen. Do not forward. Count the discard.
        frerCpsSeqRcvyDiscardedPackets =
            frerCpsSeqRcvyDiscardedPackets + 1;
        frerCpSeqRcvyDiscardPackets = frerCpSeqRcvyDiscardPackets + 1;
        // Reset timer if working on an individual Stream
        if (frerSeqRcvyIndividualRecovery)
            RemainingTicks =
                ((frerSeqRcvyResetMSec * TicksPerSecond) + 999) / 1000;
    } else {
        // Packet has not been seen; accept it.
        // Packet is out-of-order unless it directly follows RecovSeqNum
        if (delta != 1)

```

```

    frerCpsSeqRcvyOutOfOrderPackets =
        frerCpsSeqRcvyOutOfOrderPackets + 1;
    RecovSeqNum = sequence_number;
    frerCpsSeqRcvyPassedPackets = frerCpsSeqRcvyPassedPackets + 1;
    frerCpSeqRcvyPassedPackets = frerCpSeqRcvyPassedPackets + 1;
    RemainingTicks =
        ((frerSeqRcvyResetMSec * TicksPerSecond) + 999) / 1000;
    PRESENT_DATA;
}
}

```

7.8 Redundancy tag

Change the second sentence of the first paragraph of 7.8 as follows:

It operates at the frame level and can be defined using the ISS defined by IEEE Std 802.1AC, or the EISS described in 6.9 of IEEE Std 802.1Q-~~2014~~[2018](#), enhanced with the extra stream_handle and sequence_number subparameters specified in 6.1.

7.9 HSR sequence tag

Change the second sentence of the first paragraph of 7.9 as follows:

It operates at the frame level and can be defined using the ISS defined by IEEE Std 802.1AC, or the EISS described in 6.9 of IEEE Std 802.1Q-~~2014~~[2018](#), enhanced with the extra stream_handle and sequence_number subparameters specified in 6.1.

7.10 PRP sequence trailer

Change the second sentence of the first paragraph of 7.10 as follows:

It operates at the frame level and can be defined using the ISS defined by IEEE Std 802.1AC, or the EISS described in 6.9 of IEEE Std 802.1Q-~~2014~~[2018](#), enhanced with the extra stream_handle and sequence_number subparameters specified in 6.1.