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IEEE Standard for
Local and metropolitan area networks—

Frame Replication and Elimination for Reliability

Sponsor

LAN/MAN Standards Committee
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IEEE Computer Society

Approved 28 September 2017

IEEE-SA Standards Board

Abstract: This standard 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: Bridged Local Area Networks, Bridges, Bridging, Frame Elimination, Frame Replication, IEEE 802®, IEEE 802.1CB™, IEEE 802.1Q™, local area networks (LANs), MAC Bridges, Redundancy, Time-Sensitive Networking, TSN, Virtual Bridged Local Area Networks (virtual LANs)

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This introduction is not part of IEEE Std 802.1CB-2017, IEEE Standard for Local and metropolitan area networks—Frame Replication and Elimination for Reliability.

This standard defines Frame Replication and Elimination for Reliability.

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IEEE Standard for
Local and metropolitan area networks—

Frame Replication and Elimination for Reliability

1. Overview

1.1 Scope

This standard 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.

1.2 Rationale

The reason for Frame Replication and Elimination for Reliability (FRER) is to increase the probability that a given packet will be delivered. It is expected that, in many applications, other means to increase the probability of delivery are likely to be used as well. When FRER is used over paths that are fixed to a specific topology, and that are protected against congestion loss (e.g., by using techniques described by IEEE Std 802.1BA™ [B1]), FRER can substantially reduce the probability of packet loss due to equipment failures.[1]

1.3 State diagram conventions

This document uses the programming language C (ISO/IEC 9899:2011) to document the operation of conformant systems.[2] C functions are distinguished with `this special fixed-width font` (e.g., 7.4.3.3). Each C function is executed when a given event occurs, as described for that code segment or in the accompanying text. Events are assumed to take place sequentially, not simultaneously, and code routines execute instantaneously.

1.4 Specification model

The model of operation documented by this standard is simply a basis for describing the functionality of compliant equipment. Implementations can adopt any internal model of operation compatible with the externally visible behavior that this standard specifies. Conformance of equipment to this standard is purely in respect of observable protocol.

[1]The numbers in brackets correspond to those of the bibliography in Annex D.
[2]Information on references can be found in Clause 2.

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1.5 Specification precedence

If any conflict among parts of this standard become apparent, C functions (see 1.3) take precedence over other parts of the standard, followed by information in normative tables, followed by that in normative text, followed by that in normative figures. Non-normative tables, figures, and text are in annexes and are clearly marked as such.

1.6 Introduction

This standard is one of a number of IEEE 802.1™ and other standards suitable for Time-Sensitive Networking (TSN) that together have the overall goal of providing extremely low packet loss rates and finite, low, and stable end-to-end latencies. TSN supports unicast and multicast Streams of packets that implement a wide range of demanding real-time applications including audio/video studios, industrial processes, and the control of machines and vehicles. The TSN goals are not achieved at the expense of hampering the ability of the network to carry traffic for non-time-critical applications.

At the highest level, this standard posits the existence of one Talker end system and one or more Listener end systems per Stream. A Stream is characterized by a maximum packet size and number of packets transmitted per time interval. Because the Stream's maximum throughput is known, the resources, including link bandwidth, buffer space, and control parameters, required at every hop along the Stream's path to guarantee that Stream zero congestion loss and finite latency, can be provided (by other standards, e.g., Clause 35 of IEEE Std 802.1Q™-2014). This provisioned path carrying the Stream is called a *Reservation*.

On the assumption that the time required for a dynamic network control protocol to recover from an equipment failure is unacceptable in certain applications, this standard defines Frame Replication and Elimination for Reliability (FRER), which divides a Stream into one or more linked Member Streams, thus making the original Stream a Compound Stream. It replicates the packets of the Stream, splitting the copies into the multiple Member Streams, and then rejoins those Member Streams at one or more other points, eliminates the replicates, and delivers the reconstituted Stream from those points.

In order to accommodate existing applications and to promote interoperability with similar standards, this standard defines a number of schemes for identifying packets belonging to Streams and distinguishing them from other packets.

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2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies. Non-normative references (i.e., that provide additional information not required for the application of this document) are given in Annex D.

IEC 62439-3:2016, Industrial communication networks—High availability automation networks—Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR).[3]

IEEE Std 802®, IEEE Standard for Local and metropolitan area networks: Overview and Architecture.[4, 5]

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1Q™, IEEE Standard for Local and metropolitan area networks—Bridges and Bridged Networks.

IETF RFC 768, User Datagram Protocol, Postel, J., August 1980.[6]

IETF RFC 791, Internet Protocol, Postel, J., Ed., September 1981.

IETF RFC 793, Transmission Control Protocol, Postel, J., Ed., September 1981.

IETF RFC 2460, Internet Protocol, Version 6 (IPv6) Specification, Deering, S. and R. Hinden, December 1998.

IETF RFC 2474, Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers, Nichols, K., et al., December 1998.

IETF RFC 4960, Stream Control Transmission Protocol, Stewart, R., Ed., September 2007.

ISO/IEC 9899:2011, Information technology—Programming languages—C.[7]

[3]IEC publications are available from the International Electrotechnical Commission (http://www.iec.ch) and the American National Standards Institute (http://www.ansi.org/).

[4]The IEEE standards or products referred to in Clause 2 are trademarks owned by The Institute of Electrical and Electronics Engineers, Incorporated.

[5]IEEE publications are available from The Institute of Electrical and Electronics Engineers (http://standards.ieee.org).

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

[7]ISO/IEC publications are available from the International Organization for Standardization (http://www.iso.org/) and the American National Standards Institute (http://www.ansi.org/).

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3. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause. [8]

This standard makes use of the following terms defined in IEEE Std 802®:

- End station
- Organizationally Unique Identifier (OUI)
- Company ID (CID)

bridge: A layer 2 interconnection device that conforms to IEEE Std 802.1Q.

Company ID (CID): CIDs allow a general means of assuring unique identifiers for a number of purposes. See Clause 8 of IEEE Std 802-2014.

Compound Stream: A Compound Stream is a Stream composed of one or more Member Streams linked together via Frame Replication and Elimination for Reliability (FRER).

down: The direction through the protocol stack from a sublayer using a service provided by another sublayer to the sublayer whose services it uses; the direction of output packets.

end station: A device attached to a local area network (LAN) or metropolitan area network (MAN), which acts as a source of and/or destination for data traffic carried on the LAN or MAN. (From IEEE Std 802)

end system: A system attached to a network that is an initial source or a final destination of packets transmitted across that network.

NOTE—The term *end system* is often used in this document in places where the reader of IEEE 802 standards would expect the term *end station* in order to avoid confusion caused by standards relating to routers. For example, a router, as defined by IETF, is an *IEEE 802 end station*, but not an end system. Where this standard specifically refers to the use of IEEE 802 services, the term *end station* is used. Where it refers to more generalized instances of connectionless services, the term *end system* is used.[9]

in-facing: In a system that includes a Stream Transfer Function, the “in-facing” protocol functions are those functions that are below the Stream Transfer Function on the port that is not above the physical layer. On a system that does not include a Stream Transfer Function, there are no in-facing protocol functions.

NOTE—See Figure 6-6.

input: Input packets are those moving up the protocol stack, regardless of the position of receiving function relative to the physical media, for example, by the M_UNITDATA.indication primitive of the Internal Sublayer Service (ISS).

Internal local area network (LAN): An instance of a connectionless packet service with two Service Access Points (SAPs), both internal to a single system, that relays packets from one SAP to the other. It is not observable externally to that system.

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

[8] *IEEE Standards Dictionary Online* is available at: http://dictionary.ieee.org.
[9] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

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Media Access Control (MAC): The data link sublayer that is responsible for transferring data to and from the Physical Layer.

Member Stream: A Stream that is linked with other Member Streams via Frame Replication and Elimination for Reliability (FRER) to form a Compound Stream.

Non-Stream Transfer Function (NSTF): A two-port function that relays service indications on one port to service requests on the other port.

Organizationally Unique Identifier (OUI): OUIs allow a general means of assuring unique identifiers for a number of purposes. See Clause 9 and Clause 10 of IEEE Std 802-2014.

out-facing: In a system that includes a Stream Transfer Function, the “out-facing” protocol functions are those functions that are below the Stream Transfer Function on the port that is above the physical layer. On a system that does not include a Stream Transfer Function, all TSN functions are out-facing.

NOTE—See Figure 6-6.

output: Output packets are those moving down the protocol stack, regardless of the position of receiving function relative to the physical media, for example, by the M_UNITDATA.request primitive of the Internal Sublayer Service (ISS).

packet: A unit of data carried over a network, comprising, at least, one or more pairs of destination and source addresses and a payload. A packet carried on an Ethernet local area network (LAN) is a frame.

NOTE—The term *packet* is often used in this document in places where the reader of IEEE 802 standards would expect the term *frame*. Where the standard specifically refers to the use of IEEE 802 services, the term *frame* is used. Where the standard refers to more generalized instances of connectionless services, the term *packet* is used.

Quality of Service (QoS): Overall performance of a packet Stream as it relates to packet loss probability, latency, and latency variation.

relay system: A router or a bridge.

NOTE—The term *relay system* is often used in this document in places where the reader of IEEE 802 standards would expect the term *bridge*. A relay system can, in theory, be a router, a bridge, or some other kind of forwarding device. Where this standard specifically refers to one or the other, the terms *router* or *bridge* are used. Where it refers to more generalized instances of connectionless services, the term *relay system* is used.

Reservation: The collection of state information and resources allocated, in a chain of end systems and relay systems, for one or more Streams.

router: A packet forwarding device operating on Internet Protocol (IP) packets.

Stream: A unidirectional flow of time-sensitive data from one source to one or more destinations, and at the highest level, one Talker end system to one or more Listener end systems.

Stream Transfer Function: A two-port function that relays service indications on one port to service requests on the other port, where the service includes all TSN service subparameters.

subparameter: A service parameter encoded into the value of the connection_identifier parameter of the Internal Sublayer Service (ISS).

system: An end system or a relay system.

up: The direction through the protocol stack from a sublayer offering a service to the sublayer making use of that service; the direction of input packets.

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