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IEEE Std 802.1BA™-2021
(Revision of IEEE Std 802.1BA-2011)

IEEE Standard for Local and Metropolitan Area Networks—

Audio Video Bridging (AVB) Systems

Developed by the

LAN/MAN Standards Committee
of the
IEEE Computer Society

Approved 8 December 2021

IEEE SA Standards Board

Abstract: Profiles that select features, options, configurations, defaults, protocols, and procedures of bridges, stations, and LANs that are necessary to build networks that are capable of transporting time-sensitive audio and/or video data streams are defined in this standard.

Keywords: audio video bridging, AVB, Bridged Local Area Networks, IEEE 802.1BA, LANs, local area networks, MAC Bridges, MANs, metropolitan area networks, time-sensitive data streams, time-sensitive networking, TSN, Virtual Bridged Local Area Networks, virtual LANs

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Introduction

This introduction is not part of IEEE Std 802.1BA-2021, IEEE Standard for Local and Metropolitan Area Networks—Audio Video Bridging (AVB) Systems.

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

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IEEE Standard for Local and Metropolitan Area Networks—

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1. Overview

1.1 Scope

This standard defines profiles that select features, options, configurations, defaults, protocols, and procedures of bridges, stations, and Local Area Networks (LANs) that are necessary to build networks that are capable of transporting time-sensitive audio and/or video data streams.

1.2 Purpose

The purpose of this standard is to specify defaults and profiles that manufacturers of LAN equipment can use to develop AVB-compatible LAN components, and to enable a person not skilled in networking to build a network, using those components, that does not require configuration to provide working audio and/or video services.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).[6, 7]

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

[6] The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

[7] The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

1.4 Introduction

The successful support of time-sensitive audio and/or video data streams in a Bridged LAN requires the selection of specific features and options that are specified in a number of different standards, some of which are standards developed in IEEE 802®, and others (in particular, those that relate to functionality in OSI layer 3 and above in ISO/IEC 7498-1:1994 [B7]) that are developed by other bodies. In this standard, it is the selection of features and options that support OSI layer 1 and 2 LAN functionality that is of interest, in order to specify the requirements for LAN support in Bridges and the end stations that attach to them.

The standards from which features and options are selected by this standard are as follows:

a) The VLAN Bridge specification in IEEE Std 802.1Q.
b) The time-synchronization standard, IEEE Std 802.1AS.
c) The MAC and PHY standards specified for the various LAN MAC/PHY technologies, such as IEEE Std 802.3, IEEE Std 802.11, ITU-T G.9960 & ITU-T G.9961 (Powerline), and MoCA.

These features and options are selected by means of the profiles described in Clause 7. These profiles support specific functions within an AVB network, such as the Bridges and LAN technologies used to carry the AV streams, and the end stations that attach to the LAN and that provide the source(s) and the destination(s) of the stream data.

In some cases, there are functions that are needed in order to construct a usable AVB network, but that are not described in any other standard. In those cases, the technical specification is included in Clause 6 of this standard, along with a statement of the conformance requirements associated with the function, so that the function can be referenced by a profile in the same way as functions defined in any other standard.

Clause 5 introduces the architecture for AVB systems and AVB networks, and some of the terminology used in describing them.

1.5 Objectives

The architecture described in Clause 5, the AVB functions specified in Clause 6, and the profiles specified in Clause 7, are intended to meet the following objectives:

a) Describe the components that can be combined to form an AVB network (i.e., a network whose components cooperate and interoperate to allow the transmission of AV streams) and how those components can be combined.
b) Describe some of the consequences and limitations for AVB streaming that result from the incorporation of non-AV capable devices in an AVB network.
c) Define additional functions that are required for AVB operation that are not otherwise documented in contributing standards.
d) Provide guidance in terms of meeting the end-to-end latency requirements for successful AVB operation.
e) Define conformance requirements for AVB systems, in terms of the standards to which conformance is required for the various system components and the optional features of those standards that are required to be implemented. These conformance requirements address the guaranteed delivery, end-to-end latency, and time-synchronization requirements for successful AVB operation.

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 the 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.

IEEE Std 802®, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.[8, 9]

IEEE Std 802.1AS™, IEEE Standard for Local and Metropolitan Area Networks—Timing and Synchronization for Time-Sensitive Applications.

IEEE Std 802.1Q™, IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks.

IEEE Std 802.1Qcc™, IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks—Amendment 31: Stream Reservation Protocol (SRP) Enhancements and Performance Improvements.

IEEE Std 802.3™, IEEE Standard for Ethernet.

IEEE Std 802.11™, IEEE Standard for Information Technology—Telecommunications and Information Exchange between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

ITU-T Recommendation G.9960 (11/2018), Unified high-speed wireline-based home networking transceivers—System architecture and physical layer specification.[10]

ITU-T Recommendation G.9961 (11/2018), Unified high-speed wireline-based home networking transceivers—Data link layer specification.

MoCA MAC/PHY SPECIFICATION v2.0, (MoCA-M/P-SPEC-V2.0-170601) Multimedia over Coax Alliance (www.mocalliance.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.[11]

AV Bridge: Relay device (e.g., an IEEE 802.1Q Bridge or an IEEE 802.11 access point) that conforms to the requirements stated in the AVB profile for a Bridge as specified in this standard.

AVB domain: The intersection of a gPTP domain 0, which implements BMCA, and an SRP domain.

NOTE—The term "SRP domain" is defined in IEEE Std 802.1Q. The terms "gPTP domain" and "BMCA" are defined in IEEE Std 802.1AS. IEEE Std 802.1AS supports multiple gPTP domains. AVB operation requires support for a single domain 0.[12]

AVB network: A contiguous set of Bridges and end stations that meet the conformance requirements of IEEE Std 802.1BA.

AVB profile: A set of feature and option selections that specifies aspects of Bridge and end station operation, and states the conformance requirements for support of AVB functionality for a specific class of user applications.

AVB stream: A data stream associated with a stream reservation established using the Stream Reservation Protocol (SRP).

AVB system: A system (a piece of equipment that implements Bridge and/or end station functionality) that meets the conformance requirements for an AVB profile.

end station, station: These terms are defined in IEEE Std 802.

grandmaster-capable PTP instance: This term is defined in IEEE Std 802.1AS.

Listener: An end station that is the destination, receiver, or consumer of a stream.

MRP participant: The MRP state machine that participates in MRP protocol, as defined in Clause 10 of IEEE Std 802.1Q-2018 and Clause 10 of IEEE Std 802.1Qcc-2018. There are five variants as follows:

a) Full Participant
b) Full Participant, point-to-point subset
c) New-Only Participant
d) Applicant-Only Participant
e) Simple-Applicant Participant

Talker: An end station that is the source, transmitter, or producer of a stream.

[11] *The IEEE Standards Dictionary Online* is available at https://dictionary.ieee.org/. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.
[12] Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

4. Acronyms and abbreviations

AV	audio/video
AVB	audio video bridging
BMCA	Best Master Clock Algorithm
C-VLAN	Customer VLAN (IEEE Std 802.1Q)
CSN	coordinated shared network
EISS	Extended Internal Sublayer Service (IEEE Std 802.1Q)
IPG	interpacket gap
FID	Filtering Identifier (IEEE Std 802.1Q)
FQTSS	Forwarding and Queuing Enhancements for Time-Sensitive Streams (IEEE Std 802.1Q)
G.hn	ITU-T G.9960 and ITU-T G.9961
gPTP	generalized precision time protocol
LAN	Local Area Network (IEEE Std 802.1Q)
MTIE	Maximum Time Interval Error
PCS	Profile Conformance Statement
PICS	Protocol Implementation Conformance Statement
PVID	Port VLAN identifier (IEEE Std 802.1Q)
SFD	start-of-frame delimiter
SR	stream reservation (IEEE Std 802.1Q)
SR_PVID	Stream Reservation Port VLAN Identifier (IEEE Std 802.1Q)
SRP	Stream Reservation Protocol (IEEE Std 802.1Q)
MAC	Media Access Control
MMRP	Multiple MAC Registration Protocol (IEEE Std 802.1Q)
MSRP	Multiple Stream Registration Protocol (IEEE Std 802.1Q)
MVRP	Multiple VLAN Registration Protocol (IEEE Std 802.1Q)
TSpec	traffic specification (IEEE Std 802.1Q)
VID	VLAN identifier (IEEE Std 802.1Q)
VLAN	Virtual LAN (IEEE Std 802.1Q)

5. Architecture of AVB networks

This standard is concerned with the requirements for layer 2 support in bridged networks that support AV traffic. In that context, an AVB network is considered to consist of the following:

a) End stations that act as Talkers
b) End stations that act as Listeners
c) End stations that act as Talkers and Listeners
d) MAC Bridges that support the bridging requirements of the AVB network
e) Individual LANs that interconnect the Bridges, Talkers, and Listeners

NOTE 1—A non-exhaustive list of LAN technologies can be found in Table 6-1. For the purposes of this standard, LANs are taken to include IEEE 802 LANs and any other LAN technologies that are able to provide the internal sublayer service (ISS) defined in Clause 11 of IEEE Std 802.1AC-2016 [B6].

Figure 5-1 gives an example of how these components can be combined in an AVB network.

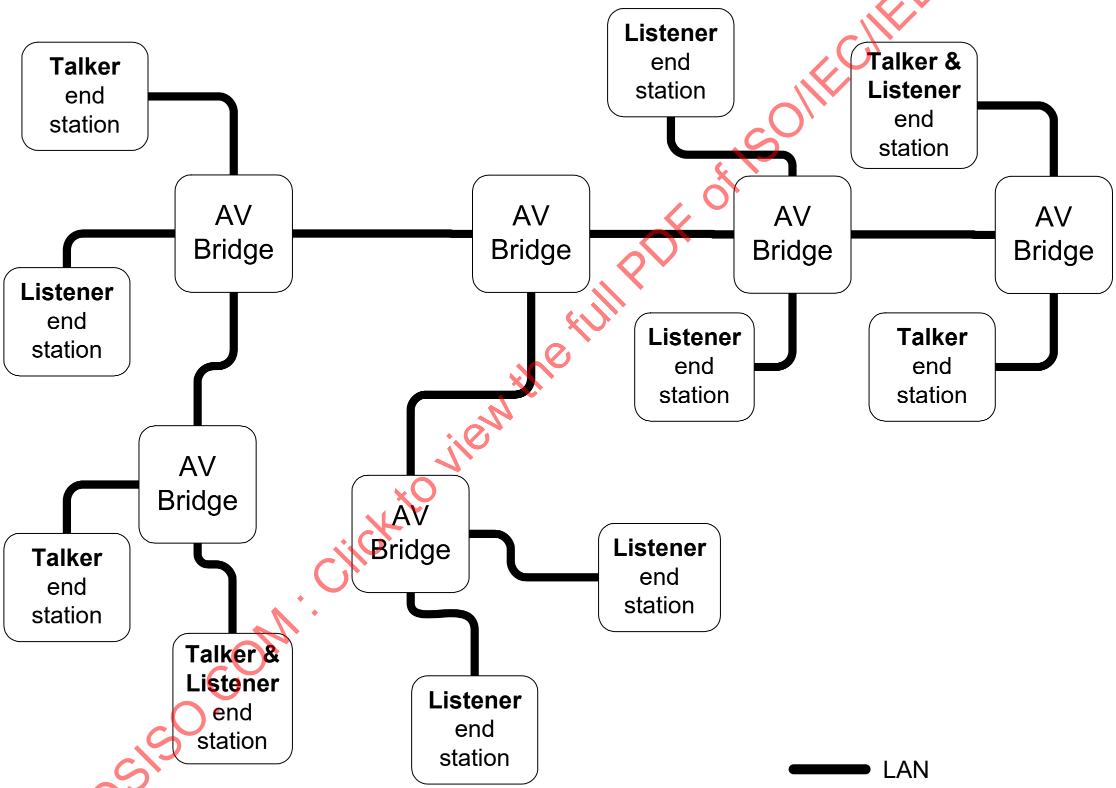

Figure 5-1—An AVB network

Practical installations of AVB equipment frequently include non-AVB components (Bridges and end stations) that are connected to the AVB network, but do not themselves participate in the transmission, relay, or receipt of AV traffic.

Figure 5-2 illustrates the effect of the establishment of AVB domains (see 6.4) on the ability of AVB systems to communicate streams. AVB stream communication can be established with MSRP versions 0x00 and 0x01, as implementations of the latter are backward compatible with the former. End stations 1 and 2 are within AVB domain 1, and can therefore communicate stream traffic between them, via the AV Bridge that connects them. Similarly, end stations 3, 4, and 5 are all within AVB domain 2, and can therefore communicate stream traffic among them. However, because end stations 1 and 3 are connected via a region of the network that is not AVB-capable, they are in distinct AVB domains, and therefore cannot establish AVB stream communication between them, but all non-AVB communications continue between these end stations. End station 6 is the only device within AVB domain 3, and therefore cannot establish AVB stream communication with any other AVB end station. AVB end station 7 and AVB end station 8 are connected only to each other and form AVB domain 4, which is isolated; stations 7 and 8 can only communicate with each other.

NOTE 2—A consequence of the registration process and SRP operation is that any given end station is a member of only one domain.

The non-AV Bridges shown in Figure 5-2 could be conformant IEEE 802.1Q Bridges that do not meet the minimum requirements of the AVB profile in use in the network, or they could be non-conformant bridges that forward frames addressed to the reserved addresses in Table 8-1, Table 8-2, and Table 8-3 of IEEE Std 802.1Q-2018. In the former case, the detection of the domain boundary is the result of the operation of MSRP; in the latter case, the boundary detection is achieved by the determination of "asCapable" of domain 0 by the generalized precision time protocol (gPTP) defined in IEEE Std 802.1AS (see 10.2.5.1 of IEEE Std 802.1AS-2020).

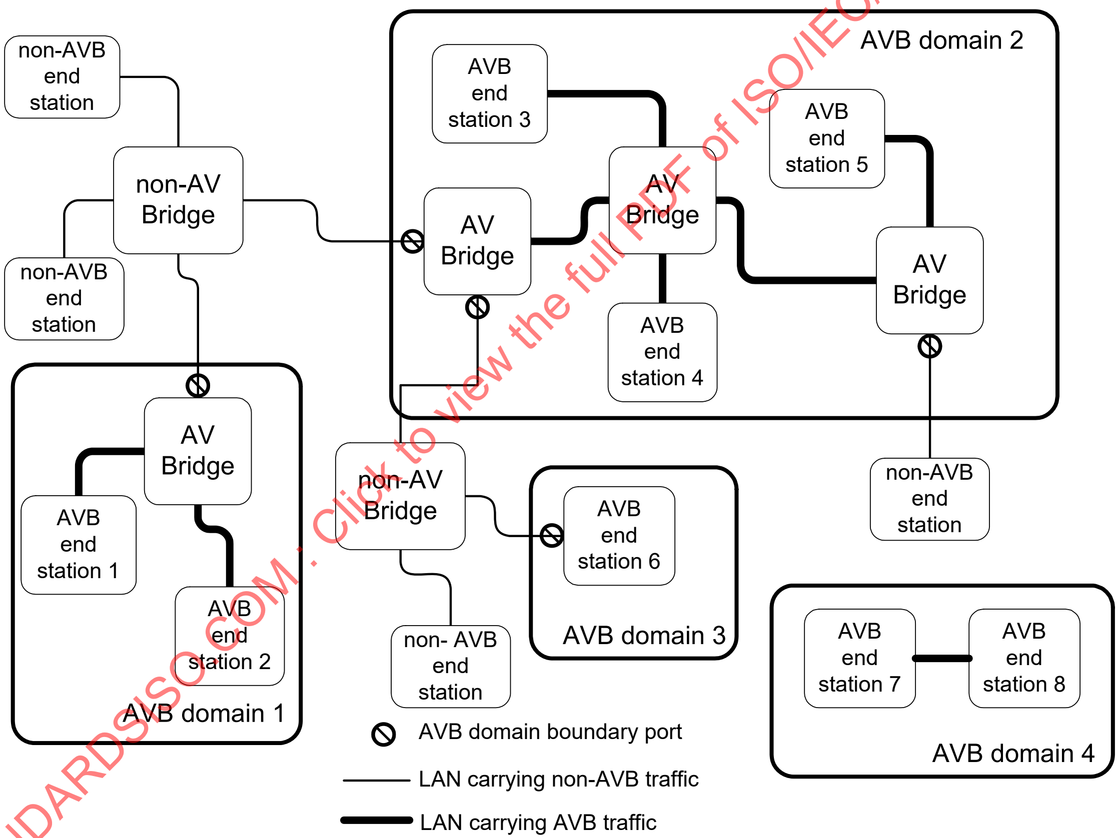

Figure 5-2—AVB domain boundaries created by non-AVB systems

AVB domain boundaries are also created in a network if the priority to SR class associations are not consistent across the network. For example, if some Bridges use the default values shown in Table 6-5 of IEEE Std 802.1Q-2018, where priority 3 is associated with SR Class A traffic and priority 2 is associated with SR class B traffic, and others associate, say, priority 4 with SR class A traffic and priority 2 with SR class B traffic, then, because AVB domains are created per SR class, all of the devices are in the same AVB domain for SR class B traffic, but adjacent devices that use different priorities for SR Class A traffic are in different AVB domains for SR class A traffic. This is illustrated in Figure 5-3, where the Bridges and end stations in AVB domains 2 and 3 use priority 3 with SR class A, whereas AVB domain 4 uses priority 4 and AVB domain 1 uses priority 5. AVB stream communication using SR class A cannot take place between end stations in different AVB domains, regardless of the fact that all of the devices in the network are AVB-capable (but non-AVB stream communication can take place). Even though AVB domain 2 and 3 both use priority 3 for SR class A traffic, AVB streams cannot flow between the two domains because the AV Bridge in AVB domain 1 does not use priority 3 for SR class A traffic and is therefore an AVB domain boundary between AVB domains 2 and 3.

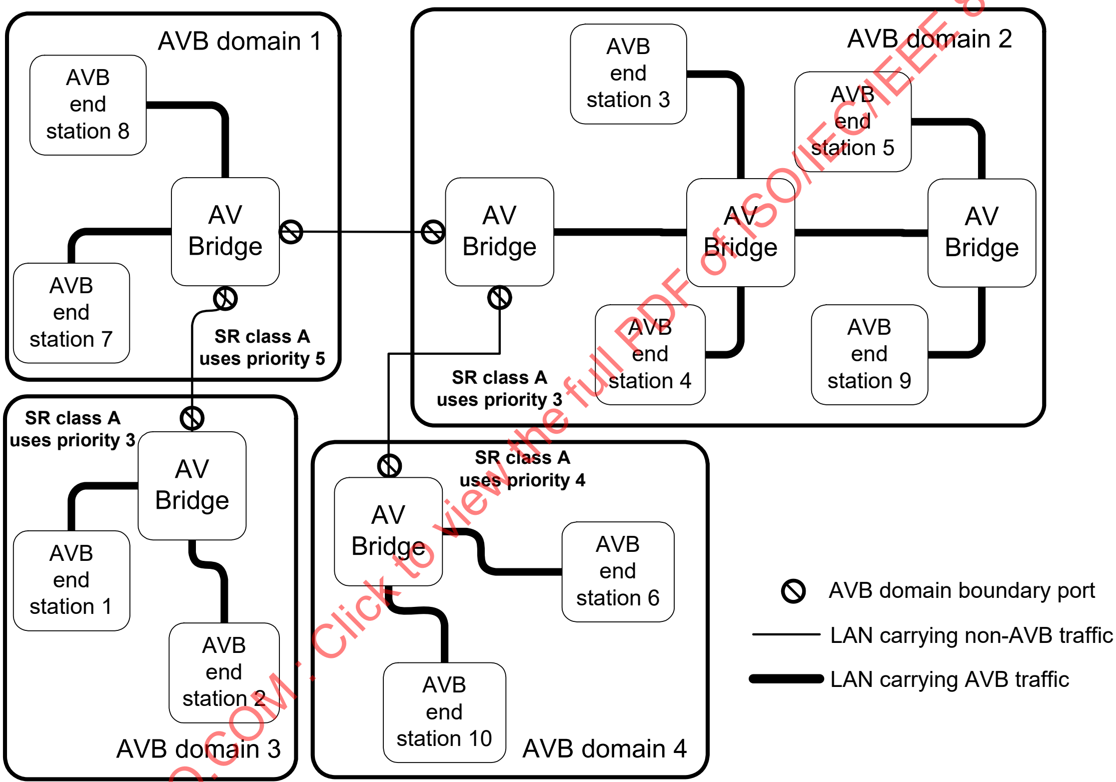

Figure 5-3—AVB domain boundaries created by different SR class A priorities

AVB domain boundaries can be different for different SR classes because they are created as a consequence of the priority values associated with each SR class in each AVB system. This is illustrated in Figure 5-4, where the AVB domain boundaries for SR class B are different from those shown in Figure 5-3 for SR class A, despite the underlying network connectivity being identical in both figures. Hence, end stations 2 and 7 (for example) can communicate using AVB stream traffic on SR class B, whereas they are not able to do so using SR class A.

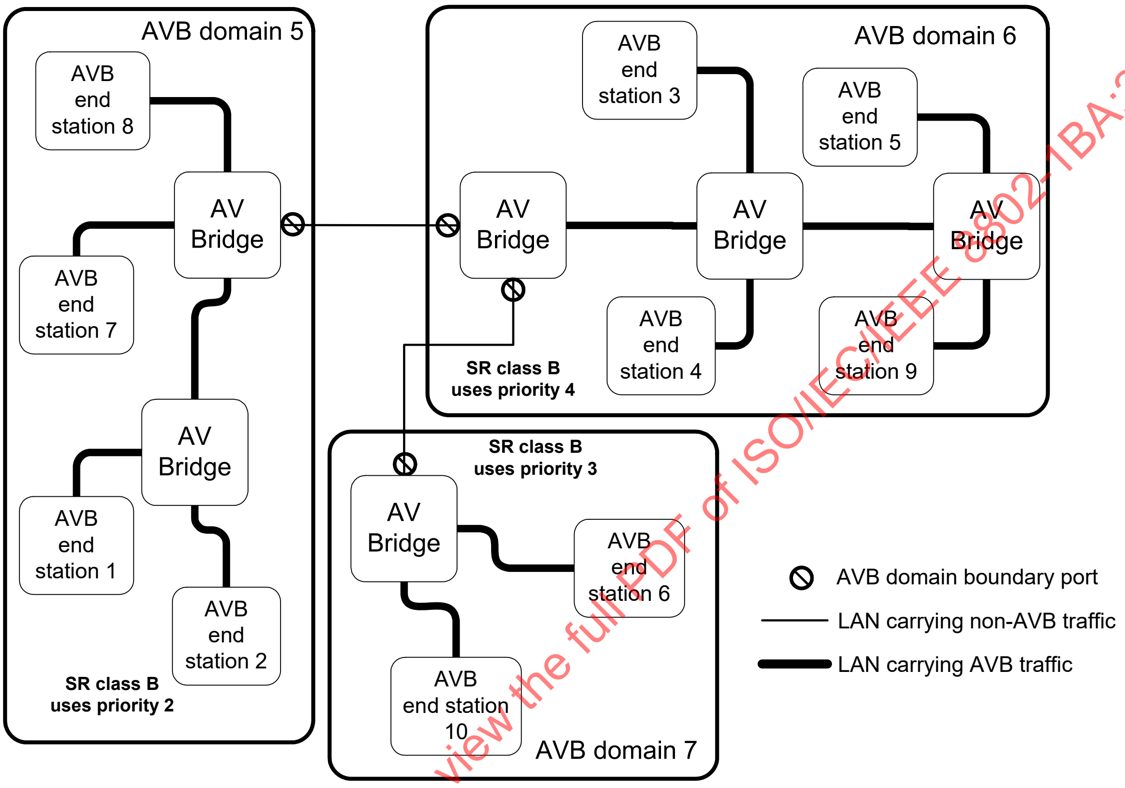

Figure 5-4—AVB domain boundaries created by different SR class B priorities

NOTE 3—End stations may benefit from specifications of the protocol format to transport audio video streams, for example see IEEE Std 1722™-2016 [B5].

6. AVB functions

This clause specifies additional functions that are important to the operation of an AVB system, but that are not specified in the base standards that are used in constructing AVB systems.

6.1 Energy Efficient Ethernet

Energy Efficient Ethernet (EEE, specified in Clause 78 of IEEE Std 802.3-2018) specifies a Low Power Idle (LPI) mode of operation for Ethernet LANs that allows the LAN to transition to a low power state when there is no activity. Control of the LPI state is performed by the LPI client, which determines, on the transmission side, when LPI is asserted and when it is de-asserted. When LPI is de-asserted, there is a delay (wake time) before the link is ready to operate; the longer the wake time, the longer the additional latency due to the operation of EEE.

In order for EEE to be deployed in a manner that is compatible with AVB operation, the following specifications apply to all Bridges and end stations that participate in a single AVB network.

AVB systems that support EEE and that have an active reservation on a given Port (i.e., the Port supports the credit-based shaper algorithm, as defined in IEEE Std 802.1Q, as the transmission selection algorithm for one or more traffic classes, and the idleSlope parameter associated with at least one traffic class is non-zero) shall support one or both of the following modes of operation:

a) Never assert LPI on the Port.
b) Support EEE as follows:
   1) Assert LPI on the Port when the transmission selection function for the Port determines that there are no frames available for transmission.
   2) De-assert LPI on the Port when the transmission selection algorithm for the Port determines that there is at least one frame ready to transmit.
   3) Execute the transmission selection algorithm on the Port again when the PHY for the Port has come out of the LPI state and is ready to transmit.
   4) Use a wake time that does not exceed the greater of 30 microseconds or the transmission time for a maximum-sized Ethernet frame on the PHY technology supported by the Port.

NOTE—Requirement b) 3) ensures that, when the transmitter becomes available for transmission, it is the highest priority frame that is selected for transmission, and not a lower priority frame that became available earlier and triggered the transition out of the LPI state.

6.2 Flow control

The operation of flow control protocols, for example IEEE 802.3 MAC control PAUSE, or IEEE 802.1Q Priority-based flow control operating on the priorities that are used to support SR classes, can invalidate any latency guarantees that result from AVB operation. A conformant AVB system that supports flow control methods shall:

a) Disable the operation of MAC control PAUSE on any Ports that support AV streams.
b) Force the SRPdomainBoundaryPort parameter (see 6.4) to TRUE for any given Port and SR class if Priority-based flow control is enabled on that Port for the priority associated with that SR class.

NOTE—Should any SRP exchanges attempt to cross an SRP domain boundary, the SRP entity transmits the failure code "Egress Port is not AVB capable" to signal that a stream cannot be established on that path.

Given the Bridge architectural model for points of attachment for higher layer entities, as illustrated in Figure 8-19 of IEEE Std 802.1Q-2018, any higher layer entities within a Bridge are not subject to this restriction on the use of flow control protocols. However, where the implementation makes use of the same MAC interface to support relayed frames and also higher layer protocol operation, and where the implementation supports other MAC control protocols that are not subject to relay by the Bridge, all transmitted frames that are not relayed by the Bridge shall be subject to the same transmission selection algorithms as relayed frames, in order to ensure that stream traffic latency is not adversely affected.

6.3 Frame sizes

The performance characteristics of an AVB network are sensitive to the data frame sizes that are used in the network, both for the stream data and for any non-AV data frames that are carried on the network. A conformant AVB system shall therefore adhere to the maximum frame size rules that apply to IEEE 802.3 frames, regardless of the medium type that is in use, on Ports that support AV traffic. This means that, on Ports that support AV traffic, the maximum data payload carried in a frame is 1500 octets, and the maximum frame size including headers, tags, etc., is 2000 octets. For the purposes of latency calculations (see 6.6), SRP can take into account the maximum frame size that is present on a given Port. For example, for Ethernet, if nothing but the basic IEEE 802.3 headers are being used with an IEEE 802.1Q C-VLAN tag, then the maximum frame size on this interface is 1522 octets.

Different media have different maximum frame sizes. If a device is configured to support MAC PDU sizes larger than 2000 octets on one or more Ports, then those Ports shall be considered not to be AVB capable from the point of view of the operation of SRP.

6.4 Detection of AVB domains

IEEE Std 802.1Q defines an SRP domain as a connected set of devices and LANs that support SRP with the same priority per SR class, and IEEE Std 802.1AS defines a generalized precision time protocol (gPTP) domain as a connected set of PTP Instances. SRP domains are determined by the operation of the MSRP protocol defined in Clause 35 of IEEE Std 802.1Q-2018 and gPTP domains are determined by the operation of gPTP. As the availability of both gPTP with a single domain 0 that implements BMCA, and SRP is considered to be a requirement for the support of AVB functionality in the profiles described in this standard, an *AVB domain*, that is, a connected set of devices and LANs within which AVB operation is supported, is the intersection of an SRP domain and a gPTP domain 0, that implements BMCA.

The operation of MSRP allows a Port to make a declaration on its attached LAN of the SR classes that it supports, and for each supported SR class, the priority code point value that it associates with that SR class. By comparing its own supported SR classes and priority values with those received from a neighboring device attached to the Port, a determination can be made as to whether the Port is at the boundary of the SRP domain for a given SR class or not. That information is then used to set the value of the SRPdomainBoundaryPort parameter (35.1.4 of IEEE Std 802.1Q-2018) for that SR class. If the Port is an SRP domain boundary port for a given SR class, then for that SR class, the operation of the MAP function in SRP is such that any *Talker Advertise* declarations for that SR class that would otherwise be propagated through that Port are converted to *Talker Failed* declarations with a failure code (IEEE Std 802.1Q-2018 Table 35-6) of 8, meaning “Egress port is not AVB-capable”. The consequence of this behavior is that stream reservations can only be established in circumstances where the Talker and the Listener(s) for the stream are located within the same SRP domain.

gPTP detects the existence of LANs or devices that cannot support time synchronization; for example, LANs that cause excessively large transmission delay variation caused by the presence of non-standard devices (and detected by the measurement of a transmission delay that exceeds the value of meanLinkDelayThresh for the PTP Port, as defined in IEEE Std 802.1AS), or LANs that do not support the time-stamping mechanisms required by gPTP. A port that has been determined not to be capable of supporting IEEE 802.1AS is labeled as such by gPTP setting the *asCapable* variable of domain 0 FALSE for that port.

Some LAN technologies, and in particular, shared medium technologies that are not able to coordinate their use of the shared medium for stream traffic, are unable to support AVB. Table 6-1 lists the technologies that were either known to be capable of supporting AVB, or known not to be capable of supporting AVB, at the time of publication of this standard; however, it is not an exhaustive list.

Table 6-1—AVB support in LAN technologies

LAN technology	AVB support
IEEE 802.3, full duplex and ≥ 100 Mb/s	Yes
IEEE 802.3, half duplex or < 100 Mb/s	No
IEEE 802.3, EPON	Yes
IEEE 802.11 HT (High-throughput) or faster, with support for all of: a) the IEEE 802.11 timing measurement function b) the IEEE 802.11 ADDTS QoS mechanism c) the IEEE 802.11 robust AV streaming	Yes
MoCA v2.0 and v2.5 with AVB extensions	Yes
ITU-T G.9960, ITU-T G.9961 with AVB extensions	Yes
NOTE—The measurement point for data rates is assumed to be at the MAC service boundary.	

This standard extends the SRP domain detection behavior specified in MSRP, in order to take account of the capability of the attached LAN and the information provided by gPTP, as follows:

a) If the Port does not support gPTP, or if the Port supports the operation of gPTP and gPTP has determined that the value of *asCapable* of domain 0 is FALSE, or if the LAN attached to the Port is not capable of supporting AVB, then:

   1) The value of the SRPdomainBoundaryPort parameters for all SR classes supported by the Port shall be TRUE.

   2) The operation of the MAP function in SRP shall be such that any *Talker Advertise* declarations for that SR class that would otherwise be propagated through that Port are converted to *Talker Failed* declarations, with a failure code of 8 ("Egress port is not AVB-capable").

b) If the Port supports gPTP and the value of *asCapable* of domain 0 for the Port is TRUE, the value of the SRPdomainBoundaryPort parameters for all SR classes supported by the Port are determined as described in Clause 35 of IEEE Std 802.1Q-2018.

To support conformance with the profiles defined in this standard, Bridges and end stations shall support IEEE 802.1AS.

6.5 Credit based shaper combined with timed gate operation

As per 8.6.8.2 of IEEE Std. 802.1Q-2018, the calculation of idle slope is modified if GateEnabled is TRUE so that sufficient bandwidth is available within OperCycleTime/GateOpenTime. If GateOpenTime extends over multiple (non consecutive) GateControlList entries, each timeIntervalValue is large enough to transport a stream frame. Dynamic configuration of bandwidth using SRP may need to change the GateControlList.

6.6 Meeting latency targets for SR classes A and B

One of the objectives behind the profiles specified in this standard is to allow the construction of AVB networks that meet a common performance metric in terms of the worst-case end-to-end latency that a stream experiences in transmission between a Talker and a Listener. For SR classes A and B, target values for the maximum worst-case latency from Talker to Listener have been set as shown in Table 6-2.

Table 6-2—Latency targets for SR classes A and B

SR class	Max end-to-end latency
A	2 ms
B	50 ms

NOTE 1—The choice of latency targets shown in Table 6-2 reflects the requirements of some typical deployment scenarios, and should not be taken as hard-and-fast limits on the end-to-end latency in an AV network. They do, however, form a useful basis for achieving "plug-and-play" interoperability.

NOTE 2—The 2 ms figure for SR Class A can be met for 7 hops of 100 Mb/s Ethernet if the maximum frame size on the LAN is 1522 octets.

NOTE 3—The above calculation does not take timed gate operation into account. See 6.5.

For some media, for example IEEE 802.3 full-duplex media, the latency contribution of the media access technology itself is small, so the dominant factor in the latency contribution of a Bridge is delays experienced within the Bridge relay, as a result of maximum size interfering frames, fan-in, network topology, and queuing delays (see L.3 in IEEE Std 802.1Q-2018). The queuing delays include the frame propagation time through the Bridge, which can have fixed and variable components, along with the effects of the credit-based shaper defined in IEEE Std 802.1Q-2018 (see 8.6.8.2, Clause 34, and Annex L). For other media, such as IEEE 802.11 wireless media, the latency contribution caused by the media access technology itself is the dominant factor; for example, it is unlikely that a latency contribution of less than 20 ms can be achieved in a hop based on IEEE Std 802.11. One of the consequences is that where the latency contribution of a particular LAN technology is large, its use might have to be restricted in order for the overall system performance to meet the latency targets; for example, it is clear from this discussion that, because IEEE 802.11 wireless technologies contribute at least 20 ms to the end-to-end latency, they cannot be employed in a Bridged LAN that is intended to support SR class A with a maximum end-to-end latency of 2 ms, and at most two IEEE 802.11 wireless hops can be employed in a Bridged LAN that is intended to support SR class B with a maximum end-to-end latency of 50 ms. Two wireless hops are supported for the case where a stream is transmitted from a Talker to a Listener via an IEEE 802.11 access point. In general, for a given SR class, the latency target for the SR class is met if the sum of the latency contributions made by each hop does not exceed the latency target for the class. For example, if the path between Talker and Listener consisted of 6 hops that contributed 5 ms each and 10 hops that contributed 2 ms each, then the latency target for SR Class B would be met, because the sum of the latency contributions is 50 ms, and therefore does not exceed 50 ms.

A consequence of the choice of observation intervals for SR classes A and B (125 µs and 250 µs respectively—see 34.6.1.1 of IEEE Std 802.1Qcc-2018) is that it is impractical to support AVB streaming over data rates of less than 100 Mb/s, both because of the limit that would be placed on the frame sizes that could be used, and the impact on the end-to-end latency that would result from maximum-sized frames interfering with AV streams.

It follows that, for "plug-and-play" operation of a network supporting SR class A with a maximum end-to-end latency of 2 ms, it is necessary to use IEEE 802.3 media at data rates of 100 Mb/s or greater (or other LAN technologies that can equal the performance achievable by IEEE 802.3 media running at 100 Mb/s or greater). For "plug-and-play" support of SR class B with a maximum end-to-end latency of 50 ms, there can be at most two IEEE 802.11n (or faster) hops, each of which can contribute no more than 20 ms to the latency, and the remaining hops, contributing at most a further 10 ms to the maximum latency, based on other technologies such as IEEE 802.3.

As discussed in L.3 of IEEE Std 802.1Q-2018, there are a number of factors that increase the latency contribution of a Bridge. AVB Talkers and Bridges shall report each hop's worst-case latency via SRP. Equation (6-1) and Equation (6-2) give an example of how worst-case latency can be calculated for Class A streams.

$$\text{Max Latency} = t_{\text{Device}} + t_{\text{MaxPacketSize+IPG}} + (t_{\text{AllStreams}} - t_{\text{StreamPacket+IPG}}) \times \frac{Rate}{MaxAllocBand} + t_{\text{StreamPacket}} \qquad (6\text{-}1)$$

$$t_{\text{AllStreams}} = \frac{MaxAllocBand \times t_{\text{Interval}}}{Rate} \qquad (6\text{-}2)$$

where

t_{Device}	is the internal delay of the device (in increments of 512 bit times)
$t_{\text{MaxPacketSize+IPG}}$	is the transmission time for a maximum size interfering frame (1522 octets to 2000 octets) plus its preamble and start-of-frame delimiter (SFD) (8 octets), and the following interpacket gap (IPG) (12 octets)
$t_{\text{StreamPacket}}$	is the transmission time for the maximum frame size of the stream that is being reserved, plus its preamble and SFD (8 octets)
$t_{\text{StreamPacket+IPG}}$	is the transmission time for the maximum frame size of the stream that is being reserved, plus its preamble and SFD (8 octets) and the following IPG (12 octets)
Rate	is the portTransmitRate R0 as per L.3.1.1 of IEEE Std 802.1Q-2018
MaxAllocBand	is the maximum allocatable bandwidth, the maximum amount of bandwidth the AVB system is able to allocate for Class A streams on the port (maximum of idleSlope as per L.2 of IEEE Std 802.1Q-2018)
t_{Interval}	is the Class A observation interval or 125 µs
$t_{\text{AllStreams}}$	is the sum of the transmission times of all Class A stream frames the AVB System is able to allocate in an observation interval (125 µs) on a port

NOTE 4—t_{Device} is an integral multiple of 512 bit times so that it scales with the speed of the media.

NOTE 5—Talkers that are not aware of their maximum allocatable bandwidth and Bridges should use maximum values for their maximum allocatable bandwidth (75% of the port transmission rate) and for their $t_{\text{AllStreams}}$ (93.75 µs in the case of Class A).

NOTE 6—The logic behind the above formulation for Max Latency can be found in "AVB Latency Math" [B8]. Further discussion of latency issues can be found in "Class A Latency Issues" [B1]. Only SR class A example calculations are shown; SR class B examples can be similarly derived.

NOTE 7—The calculation in Equation (6-1) and Equation (6-2) does not take timed gate operation into account. See 6.5.

For example, a Talker (which is able to allocate 75% of the bandwidth) or Bridge with 100 Mb/s IEEE 802.3 Ports using standard IEEE 802.3 framing (i.e., the maximum frame size is 1522 octets per 6.3), reserving a stream with a maximum frame size of 64 octets, where the device's internal delay is no more than 512 bit times, would report the following Max Latency:

$$\text{Max Latency} = 5.12\ \mu s + 123.36\ \mu s + ((75\ \text{Mb/s} \times 125\ \mu s) / 100\ \text{Mb/s} - 6.72\ \mu s) \times (100\ \text{Mb/s} / 75\ \text{Mb/s}) + 5.76\ \mu s$$

$$= 250.28\ \mu s$$

In comparison, a Talker that is able to allocate only 16% of the bandwidth with 100 Mb/s IEEE 802.3 Ports using standard IEEE 802.3 framing (using a maximum frame size of 1522 octets per 6.3) reserving a stream with a maximum frame size of 230 octets (i.e., the Talker can only transmit one stream, as 16% of the bandwidth equals one Class A stream with a frame size of 230 octets) where the device's internal delay is no more than 512 bit times would report the following Max Latency:

$$\text{Max Latency} = 5.12\ \mu s + 123.36\ \mu s + ((16\ \text{Mb/s} \times 125\ \mu s) / 100\ \text{Mb/s} - 20\ \mu s) \times (100\ \text{Mb/s} / 16\ \text{Mb/s}) + 19.04\ \mu s$$

$$= 147.52\ \mu s$$

A Talker (which is able to allocate 75% of the bandwidth) or a Bridge with 1000 Mb/s IEEE 802.3 Ports using standard IEEE 802.3 framing (using a maximum frame size of 1522 octets per 6.3) reserving a stream with a maximum frame size of 64 octets where the device's internal delay is no more than 512 bit times would report the following Max Latency:

$$\text{Max Latency} = 0.512\ \mu s + 12.336\ \mu s + ((750\ \text{Mb/s} \times 125\ \mu s) / 1000\ \text{Mb/s} - 0.672\ \mu s) \times (1000\ \text{Mb/s} / 750\ \text{Mb/s}) + 0.576\ \mu s$$

$$= 137.528\ \mu s$$

In comparison, a Talker that is able to allocate only 1.6% of the bandwidth with 1000 Mb/s IEEE 802.3 Ports using standard IEEE 802.3 framing (using a maximum frame size of 1522 octets per 6.3) reserving a stream with a maximum frame size of 230 octets (i.e., the Talker can only transmit one stream, as 1.6% of the bandwidth equals one Class A stream with a frame size of 230 octets) where the device's internal delay is no more than 512 bit times would report the following Max Latency:

$$\text{Max Latency} = 0.512\ \mu s + 12.336\ \mu s + ((16\ \text{Mb/s} \times 125\ \mu s) / 1000\ \text{Mb/s} - 2.0\ \mu s) \times (1000\ \text{Mb/s} / 16\ \text{Mb/s}) + 1.904\ \mu s$$

$$= 14.752\ \mu s$$

Other media types are not discussed here as IEEE 802.3 is the only media type that can, at the time of this standard's publication, support Class A's end-to-end latency targets.

NOTE 8—The internal delay of a device is device specific and needs to be reported in the device's documentation.

To summarize, the following rules of thumb apply to the technologies that can be used to support SR classes A and B, based on the latency targets in Table 6-2:

a) SR Class A is supportable in Bridges only by full duplex IEEE 802.3 media running at 100 Mb/s or higher rates, or by other LAN technologies that can equal the performance achievable by IEEE 802.3 media running at 100 Mb/s or higher rates, and where the sum of the worst-case latency contributions per hop results in an overall end-to-end worst-case latency of 2 ms or less.
b) SR Class A traffic cannot be supported over IEEE 802.11, MoCA, and G.hn media, because these technologies cannot offer a latency contribution lower than 2 ms.

c) SR Class B is supportable in Bridges by any combination of the following:
   1) Full duplex IEEE 802.3 media running at 100 Mb/s or higher rates
   2) Other LAN technologies that can equal the performance achievable by IEEE 802.3 media running at 100 Mb/s or higher rates
   3) IEEE 802.11n (or faster) media
   4) MoCA
   5) ITU-T G.9960 and ITU-T G.9961 (G.hn)
   6) Other LAN technologies that support data rates of 100 Mb/s or more, as long as the sum of the worst-case latency contributions per hop results in an overall end-to-end worst-case latency of 50 ms or less
d) Only media that support data rates of 100 Mb/s or more can be supported within an AVB domain.

6.7 Variable data rate LANs

In some LAN technologies, such as IEEE 802.11 wireless LANs, the available bandwidth can and does change dynamically as a result of changes in the transmission properties of the wireless medium, interference from other devices, and so on. Any change in the bandwidth available on a Bridge Port causes MSRP to recalculate which streams can be accommodated within the new Port bandwidth, on the basis of the bandwidth availability parameter values for the supported SR classes (see 34.3 in IEEE Std 802.1Qcc-2018). Consequently, a reduction in the available bandwidth could result in some streams being dropped in accordance with the procedures specified in SRP; these streams could then be re-established following a later increase in the available bandwidth.

If the frequency of bandwidth changes is high, the impact on the user experience caused by streams being dropped and then re-established could prove to be undesirable or unacceptable. In order to mitigate the effect of such fluctuations, for Ports that are supported by variable data rate LANs it is recommended that maxRes, the total reservable bandwidth of the Port in bits/s, should be dynamically managed in a manner that maximizes the number of reservations that can be accommodated while reducing the probability of reservations being dropped and re-established unnecessarily. An example of how that might be achieved follows:

a) The initial value of *maxRes* when the Port becomes operable is set to 50% of the current data rate of the attached LAN.
b) If at any time the value of *maxRes* is greater than 75% of the current data rate of the attached LAN, then *maxRes* is set to 50% of the current data rate, and MSRP re-calculates which streams can be accommodated within the reduced bandwidth.
c) If at any time the value of *maxRes* is less than 40% of the current data rate of the attached LAN, then *maxRes* is set to 50% of the current data rate, and MSRP re-calculates which streams can be accommodated within the increased bandwidth.
d) If at any time the attached LAN reaches its maximum data rate, reset *maxRes* to 50% of that maximum data rate.

6.8 Basic support for streams

There are many different applications to which AVB equipment will be put, and the requirements for those applications vary greatly. The most basic requirement in order for a device to be able to claim to support AVB is that it is capable of supporting a single stream (in the case of Talkers and Listeners) or a single stream per Port (in the case of Bridges). The profile tables in 7.4.6.2, 7.4.7.2, and 7.4.8.2 therefore identify support of a single stream as a minimum requirement. The detailed requirements for such support are identified in 6.8.1 through 6.8.3.

6.8.1 Basic support for streams in Bridges

The requirements for a Bridge implementation to claim basic support for streams, for those Ports of the Bridge that support AVB, are as follows:

a) All Ports shall be capable of supporting at least one stream reservation, associated with a traffic class that supports FQTSS.
b) All Ports shall be capable of supporting the registration, declaration, and propagation of the MSRP attributes associated with a single stream; that is, a single Talker declaration and the resulting Listener declaration(s) (see 35.1.2 and 35.1.3 of IEEE Std 802.1Q-2018).
c) All Ports shall be capable of supporting gPTP for a single domain 0, which implements BMCA.
d) All Bridges shall support SR class B.
e) Bridges that support two or more IEEE 802.3 Ports shall support SR class A on all IEEE 802.3 Ports.
f) Bridges shall not support Talker pruning.
g) All Ports shall support the following state machines in IEEE Std 802.1AS:
AnnounceIntervalSetting,
SyncIntervalSetting,
GptpCapableIntervalSetting,
LinkDelayIntervalSetting.

NOTE—The existing conformance requirements in IEEE Std 802.1Q-2018 mean that support of MVRP is mandatory—see 6.9 and 5.4 of IEEE Std 802.1Q-2018.

6.8.2 Basic support for streams in Talkers

The requirements for a Talker implementation to claim basic support for streams are as follows:

a) The implementation shall be capable of transmitting at least one stream.
b) The implementation shall be capable of declaring the MSRP attributes associated with a single stream; that is, a single Talker declaration, and registering the MSRP attributes associated with the Listener declaration(s) that result from that Talker declaration (see 35.1.2 and 35.1.3 of IEEE Std 802.1Q-2018).
c) The Port shall be capable of supporting gPTP for a single domain 0, which implements BMCA.
d) The PTP Instance that synchronizes the Talker shall be grandmaster capable.
e) All Ports shall support the following state machines in IEEE Std 802.1AS:
AnnounceIntervalSetting,
SyncIntervalSetting,
GptpCapableIntervalSetting,
LinkDelayIntervalSetting.

NOTE—It is possible to build a system that supports Talker capability on multiple Ports. From the point of view of this specification, such systems are logically multiple Talkers, each with a single Port, housed in the same system.

6.8.3 Basic support for streams in Listeners

The requirements for a Listener implementation to claim basic support for streams are as follows:

a) The implementation shall be capable of receiving at least one stream.
b) The implementation shall be capable of registering the MSRP attributes associated with a single stream; that is, a single Talker declaration, and declaring the MSRP attributes associated with the Listener declaration that results from that Talker declaration (see 35.1.2 and 35.1.3 of IEEE Std 802.1Q-2018).
c) The Port shall be capable of supporting gPTP for a single domain 0, which implements BMCA.

d) The Port shall be capable of supporting MVRP, and declare a VLAN membership request for the VID contained in the Talker Advertise [see 11.2.2 and 35.2.2.8.3 b) of IEEE Std 802.1Q-2018].
e) The port shall not support Talker pruning.
f) All Ports shall support the following state machines in IEEE Std 802.1AS:
AnnounceIntervalSetting,
SyncIntervalSetting,
GptpCapableIntervalSetting,
LinkDelayIntervalSetting.

NOTE—It is possible to build a system that supports Listener capability on multiple Ports. From the point of view of this specification, such systems are logically multiple Listeners, each with a single Port, housed in the same system.

6.9 Minimum Bridge requirements

There is a minimum set of optional features specified in IEEE Std 802.1Q that are required in order for a Bridge to properly support AVB operation. Further detailed requirements are specified in 7.4.6; however, the following paragraphs give an overview of the required features (references in square brackets in the remainder of this subclause are to IEEE Std 802.1Q-2018 unless stated otherwise).

The starting point is that an AV Bridge is a VLAN Bridge [5.9], which is defined to be a single C-VLAN component, which is in turn defined to be a VLAN-aware Bridge component that supports the EISS by the use of Customer VLAN Tags [5.5]. Therefore, a conformant AV Bridge supports all of the VLAN-aware Bridge component requirements stated in [5.4 a) through r)].

The most basic requirements for a VLAN-aware Bridge component imply support of Rapid Spanning Tree (the original Spanning Tree Protocol has been deprecated and removed from IEEE Std 802.1Q), support of at least one VID, and support of tagged frames and untagged frames. For AVB support, at least two VIDs are required; the default PVID (which is untagged, by default, to carry non-AV traffic), and the default SR_PVID (tagged, to carry stream traffic). An AV Bridge implementation shall meet the following requirements in addition to those for VLAN-aware Bridges [5.4]:

a) Support of at least the Acceptable Frame Types parameter value of *Admit All frames* on each Port [see 5.4 l)].
b) Support of the use of at least two VIDs, one of which is the default PVID [Table 9-2], configured to be untagged on all Ports, and the other is the default SR_PVID [Table 9-2, 35.2.1.4], configured to be tagged on all Ports.

NOTE 1—A PVID that has been configured to be untagged implies the existence of at least one Static VLAN Registration Entry in the filtering database that specifies the PVID to be forwarded untagged on all Ports. An SR_PVID that has been configured to be tagged on all Ports implies that either there is no Static VLAN Registration Entry for the SR_PVID, or that a Static VLAN Registration Entry exists for the SR_PVID and specifies that the SR_PVID is forwarded tagged on all Ports. If a Static VLAN Registration Entry exists for the SR_PVID, then some filtering efficiency can be lost, as any non-stream traffic that uses that VID can potentially be transmitted on all outbound Ports, not just those where Listeners have registered for that VLAN via MVRP. Hence, it is desirable for there to be no Static VLAN Registration Entry in the filtering database for the SR_PVID, and to rely on MVRP to register for VIDs dynamically as required by the currently active streams.

c) If only a single FID is supported [5.4 q)], then support the ability to allocate both the PVID and the SR_PVID to that single FID (i.e., the implementation supports shared VLAN Learning [8.8.8]).

Support of the following VLAN-aware Bridge component options [5.4.1] is required in an AV Bridge implementation:

d) Support of forwarding and queuing for time-sensitive streams [5.4.1].
e) Support of Multiple Stream Reservation Protocol (MSRP).

NOTE 2—MVRP is mandatory for a VLAN Bridge, so it is not mentioned here as it is already covered under [5.4 o)]. Similarly, support of MMRP is not a requirement for AVB.

6.10 IEEE 802.1AS time-synchronization event message transmission interval

IEEE Std 802.1AS makes provision for adjustment of the interval between transmissions of time-synchronization event messages (see 10.7.2.3 of IEEE Std 802.1AS-2020). In order to support low power/low cost devices that are limited in their ability to process frequent time-synchronization event messages, all ports that are capable of operating as Master ports, and that conform to the profiles defined in this standard, shall support a minimum range of 0.125 s through 1 s for time-synchronization event message transmission interval.

6.11 Effect of hop count on IEEE 802.1AS accuracy

The use of IEEE 802.1AS time-synchronization results in any pair of end stations, separated by no more than 7 hops, being synchronized to within 1 µs. Worst-case time-synchronization accuracy degrades linearly beyond 7 hops. A number of jitter and wander accumulation simulations were performed, with the results expressed in terms of Maximum Time Interval Error (MTIE). For the cases simulated (see Garner [B2], Garner [B3], and Garner [B4]) the increase in MTIE on each successive hop after the first hop is less than the MTIE increase over the first hop.

7. AVB profiles[13]

This clause defines a set of AVB profiles that specify the requirements that are to be met by implementations of Bridges, Talker end stations, and Listener end stations for which claims of conformance are made. The profiles are presented in a tabular format based on the format used for PICS proformas.

For each type of implementation (Bridge, Talker, and Listener), a set of common features are identified in the tables in 7.4. There is also a table in 7.4.5 that identifies common requirements for MAC support. The tables identify functionality defined in other standards, and focus on the optional features defined in those standards in order to make particular choices that are appropriate for the profile concerned. Hence, a feature that is optional in one of the referenced standards might become mandatory in one or more of the profiles defined in this standard. Similarly, where a parameter in a referenced standard can take a range of values, that range can be further defined or restricted in order to meet the requirements of a particular profile.

The tables do not contain an exhaustive list of all requirements that are stated in the referenced standards; for example, if a row in a table asks whether the implementation is conformant to Standard X, and the answer "Yes" is chosen, then it is assumed that it is possible, for that implementation, to fill out the PCS proforma defined in Standard X to show that the implementation is conformant; however, the tables in this standard only further refine those elements of conformance to Standard X where particular answers are required for the profiles defined here.

The profiles are not intended to be mutually exclusive; it is possible that a given implementation can support more than one of the profiles defined in this standard. If that is the case, then either the PCS for the implementation should be filled out in order to reflect the support of multiple profiles, or a separate PCS should be filled out to reflect each profile supported.

7.1 Introduction to PCS proformas

The supplier of an implementation that is claimed to conform to a particular profile defined in this standard shall complete the corresponding Profile Conformance Statement (PCS) proforma(s).

A completed PCS proforma is the PCS for the implementation in question. The PCS is a statement of which capabilities and options of the protocol have been implemented. The PCS can have a number of uses, including the following:

a) By the protocol implementer, as a checklist to reduce the risk of failure to conform to the standard through oversight.

b) By the supplier and acquirer—or potential acquirer—of the implementation, as a detailed indication of the capabilities of the implementation, stated relative to the common basis for understanding provided by the standard PCS proforma.

c) By the user—or potential user—of the implementation, as a basis for initially checking the possibility of interworking with another implementation (note that, while interworking can never be guaranteed, failure to interwork can often be predicted from incompatible PCSs).

d) By a protocol tester, as the basis for selecting appropriate tests against which to assess the claim for conformance of the implementation.

[13] *Copyright release for AVB profiles:* Users of this standard may freely reproduce the AVB profiles and PCS proformas in this clause so that they can be used for the intended purpose and may further publish the completed profiles and PCS.

7.2 Abbreviations and special symbols

7.2.1 Status symbols

M	mandatory
O	optional
O.n	optional, but support of at least one of the group of options labeled by the same numeral n is required
X	prohibited
pred:	conditional-item symbol, including predicate identification: see 7.3.4
¬	logical negation, applied to a conditional item's predicate

7.2.1.1 General abbreviations

N/A	not applicable
PCS	Profile Conformance Statement

7.3 Instructions for completing the PCS proforma

7.3.1 General structure of the PCS proforma

The first part of the PCS proforma, implementation identification and protocol summary, is to be completed as indicated with the information necessary to identify fully both the supplier and the implementation.

The main part of the PCS proforma is a fixed-format questionnaire, divided into several subclauses, each containing a number of individual items. Answers to the questionnaire items are to be provided in the rightmost column, either by simply marking an answer to indicate a restricted choice (usually Yes or No) or by entering a value or a set or range of values. (Note that there are some items where two or more choices from a set of possible answers can apply; all relevant choices are to be marked.)

Each item is identified by an item reference in the first column. The second column contains the question to be answered; the third column records the status of the item—whether support is mandatory, optional, or conditional: see also 7.3.4. The fourth column contains the reference or references to the material that specifies the item in the main body of the relevant standard, and the fifth column provides the space for the answers.

A supplier may also provide (or be required to provide) further information, categorized as either Additional Information or Exception Information. When present, each kind of further information is to be provided in a further subclause of items labeled *Ai* or *Xi,* respectively, for cross-referencing purposes, where *i* is any unambiguous identification for the item (e.g., simply a numeral). There are no other restrictions on its format and presentation.

A completed PCS proforma, including any Additional Information and Exception Information, is the Profile Conformance Statement for the implementation in question.

NOTE—Where an implementation is capable of being configured in more than one way, a single PCS may be able to describe all such configurations. However, the supplier has the choice of providing more than one PCS, each covering some subset of the implementation's configuration capabilities, in case that makes for easier and clearer presentation of the information.

7.3.2 Additional information

Items of Additional Information allow a supplier to provide further information intended to assist the interpretation of the PCS. It is not intended or expected that a large quantity will be supplied, and a PCS can be considered complete without any such information. Examples might be an outline of the ways in which a (single) implementation can be set up to operate in a variety of environments and configurations, or information about aspects of the implementation that are outside the scope of this standard but that have a bearing on the answers to some items.

References to items of Additional Information may be entered next to any answer in the questionnaire and may be included in items of Exception Information.

7.3.3 Exception information

It might occasionally happen that a supplier wishes to answer an item with mandatory status (after any conditions have been applied) in a way that conflicts with the indicated requirement. There is no pre-printed answer in the Support column for this item. Instead, the supplier shall write the missing answer into the Support column, together with an *Xi* reference to an item of Exception Information, and shall provide the appropriate rationale in the Exception item itself.

An implementation for which an Exception item is required in this way does not conform to this standard.

NOTE—A possible reason for the situation described previously is that a defect in this standard has been reported, a correction for which is expected to change the requirement that is not met by the implementation.

7.3.4 Conditional status

7.3.4.1 Conditional items

The PCS proforma contains a number of conditional items. These are items for which both the applicability of the item itself, and its status if it does apply—mandatory or optional—are dependent on whether certain other items are supported.

Where a group of items is subject to the same condition for applicability, a separate preliminary question about the condition appears at the head of the group, with an instruction to skip to a later point in the questionnaire if the "Not applicable" answer is selected. Otherwise, individual conditional items are indicated by a conditional symbol in the Status column.

A conditional symbol is of the form "**pred:**S" where **pred** is a predicate as described in 7.3.4.2, and S is a status symbol, M or O.

If the value of the predicate is TRUE (see 7.3.4.2), the conditional item is applicable, and its status is indicated by the status symbol following the predicate and the answer column is to be marked in the usual way. If the value of the predicate is FALSE, the "Not applicable" (N/A) answer is to be marked.

7.3.4.2 Predicates

A predicate is one of the following:

a) An item-reference for an item in the PCS proforma: The value of the predicate is TRUE if the item is marked as supported and is FALSE otherwise.
b) A predicate-name, for a predicate defined as a Boolean expression constructed by combining item-references using the Boolean operator OR: The value of the predicate is TRUE if one or more of the items is marked as supported.
c) A predicate-name, for a predicate defined as a Boolean expression constructed by combining item-references using the Boolean operator AND: The value of the predicate is TRUE if all of the items are marked as supported.