P802.1ASds/D0.1
November 14, 2023
(Amendment to IEEE Std 802.1AS™-202x)

Draft Standard for Local and metropolitan area networks—

Timing and Synchronization for Time-Sensitive Applications

Amendment: Support for the IEEE Std 802.3 Clause 4 Media Access Control (MAC) operating in half-duplex

Sponsor

LAN/MAN Standards Committee
of the
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Time-Sensitive Networking (TSN) Task Group of IEEE 802.1

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The text proper of this draft begins with the title page (1). The cover pages (a), (b), (c) etc. are for 802.1 WG information, and will be removed prior to Sponsor Ballot.

Editors' Foreword

This draft standard is an amendment. The scope of changes to the base standard is thus strictly limited, as detailed in the PAR.

Information on participation in this project, and in the IEEE 802.1 Working Group can be found here.

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As part of our IEEE 802 process, the text of the PAR and CSD (Criteria for Standards Development, formerly referred to as the 5 Criteria or 5C's) is reviewed on a regular basis in order to ensure their continued validity. A vote of "Approve" on this draft is also an affirmation by the balloter that the PAR is still valid.

Project Authorization Request, Scope, Purpose, and Criteria for Standards Development (CSD)

The complete amendment PAR, as approved by IEEE NesCom 23 February 2022, can be found at:

https://development.standards.ieee.org/myproject-web/public/view.html#pardetail/9522

The ‘Scope of the Proposed changes’ and the ‘Need for the Project’ specify the changes to be made by this amendment (see below).

Scope of the Proposed changes:

This amendment specifies protocols, procedures, and managed objects that support IEEE Std 802.3 Clause 4 Media Access Control (MAC) operating in half-duplex while retaining existing functionality and backward compatibility, and remaining a profile of IEEE Std 1588™-2019.
This amendment addresses errors and omissions in the description of existing functionality.

Need for the Project:

Support is needed in applications such as automotive in-vehicle networks and industrial automation networks for the IEEE Std 802.3 Clause 4 MAC operating in half-duplex, including those using links with the 10BASE-T1S PHY in either point-to-point or multidrop half-duplex mode recently introduced by IEEE Std 802.3cg-2019.

Criteria for Standards Development:

The complete Criteria for Standards Development (CSD) can be found at:

https://mentor.ieee.org/802-ec/dcn/21/ec-21-0308-00-ACSD-p802-1asds.pdf

Draft IEEE Standard for Local and metropolitan area networks—

Timing and Synchronization for Time-Sensitive Applications

Amendment: Support for the IEEE Std 802.3 Clause 4 Media Access Control (MAC) operating in half-duplex

[This amendment is based on IEEE Std 802.1AS™-2020 as modified by IEEE Std 802.1AS™-2020/Cor 1 - 2021.], P802.1ASdr, P802.1ASdm, and P802.1ASdn.

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 ~~strikethrough~~ (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.[1]

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

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Prepared by the
Time-Sensitive Networking (TSN)Task Group of IEEE 802.1

Sponsor
LAN/MAN Standards Committee
of the
IEEE Computer Society

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Abstract: This amendment to IEEE Std 802.1AS™-2020 specifies protocols, procedures, and managed objects that support IEEE Std 802.3 Clause 4 Media Access Control (MAC) operating in half-duplex while retaining existing functionality and backward compatibility, and remaining a profile of IEEE Std 1588™-2019.

This amendment addresses errors and omissions in the description of existing functionality.

Keywords: best timeTransmitter, frequency offset, Grandmaster Clock, Grandmaster PTP Instance, PTP End Instance, PTP Relay Instance, IEEE 802.1AS™, phase offset, synchronization, syntonization, time-aware system

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János Farkas, *TSN Task Group Chair*
Silvana Rodrigues, *Editor IEEE Std 802.1AS*
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Introduction

This introduction is not part of IEEE Std 802.1ASds™-20xx, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications—Amendment: Inclusive Terminology

The first edition of IEEE Std 802.1AS was published in 2011. A first corrigendum, IEEE Std 802.1AS™-2011/Cor1-2013, provided technical and editorial corrections. A second corrigendum, IEEE Std 802.1AS™-2011/Cor2-2015 provided additional technical and editorial corrections.

The second edition, IEEE Std 802.1AS-2020, added support for multiple gPTP domains, Common Mean Link Delay Service, external port configuration, and Fine Timing Measurement for 802.11 transport. Backward compatibility with IEEE Std 802.1AS-2011 was maintained. A corrigendum, IEEE Std 802.1AS™-2020/Cor1-2021, provides technical and editorial corrections.

This amendment to IEEE Std 802.1AS-2020 specifies protocols, procedures, and managed objects that support IEEE Std 802.3 Clause 4 Media Access Control (MAC) operating in half-duplex while retaining existing functionality and backward compatibility, and remaining a profile of IEEE Std 1588™-2019.

This amendment addresses errors and omissions in the description of existing functionality

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IEEE Standard for Local and Metropolitan Area Networks — Timing and Synchronization for Time-Sensitive Applications

Amendment: Support for the IEEE Std 802.3 Clause 4 Media Access Control (MAC) operating in half-duplex

1. Overview

1.1 Scope

This standard specifies protocols, procedures, and managed objects used to ensure that the synchronization requirements are met for time-sensitive applications, such as audio, video, and time-sensitive control, across networks, for example, IEEE 802 and similar media. This includes the maintenance of synchronized time during normal operation and following addition, removal, or failure of network components and network reconfiguration. It specifies the use of IEEE 1588™ specifications where applicable in the context of IEEE Std 802.1Q™-2018. Synchronization to an externally provided timing signal [e.g., a recognized timing standard such as Coordinated Universal Time (UTC) or International Atomic Time (TAI)] is not part of this standard but is not precluded.

1.2 Purpose

This standard enables systems to meet the respective jitter, wander, and time-synchronization requirements for time-sensitive applications, including those that involve multiple streams delivered to multiple end stations. To facilitate the widespread use of packet networks for these applications, synchronization information is one of the components needed at each network element where time-sensitive application data are mapped or demapped or a time-sensitive function is performed. This standard leverages the work of the IEEE 1588 Working Group by developing the additional specifications needed to address these requirements

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*).[1,2]

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*).

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

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

4. Acronyms and abbreviations

Insert the following acronym in clause 4 as follows:

HDE	Half-duplex Ethernet

7. Time-synchronization model for a packet network

7.2 Architecture of a time-aware network

Add the following new subclause after 7.2.5:

7.2.6 Half-duplex Ethernet (HDE) using Hot Standby

<<editor's note: This subclause can be removed if it delays the standard. But this appears to come for free with the listed restrictions. Comments are requested>>

Figure 7-7 a Hot Standby (see 18) network using HDE. It is a based on Figure 7-5 where the lower four end stations are connected to the upper two Bridges using a single shared media HDE link. As long as all Bridge connections to the HDE link are Time Transmitters, the same protocol used for Figure 19-1 can be used for each Hot Standby domain. For example, if two domains are used, two HDE gPTP Instances are needed.

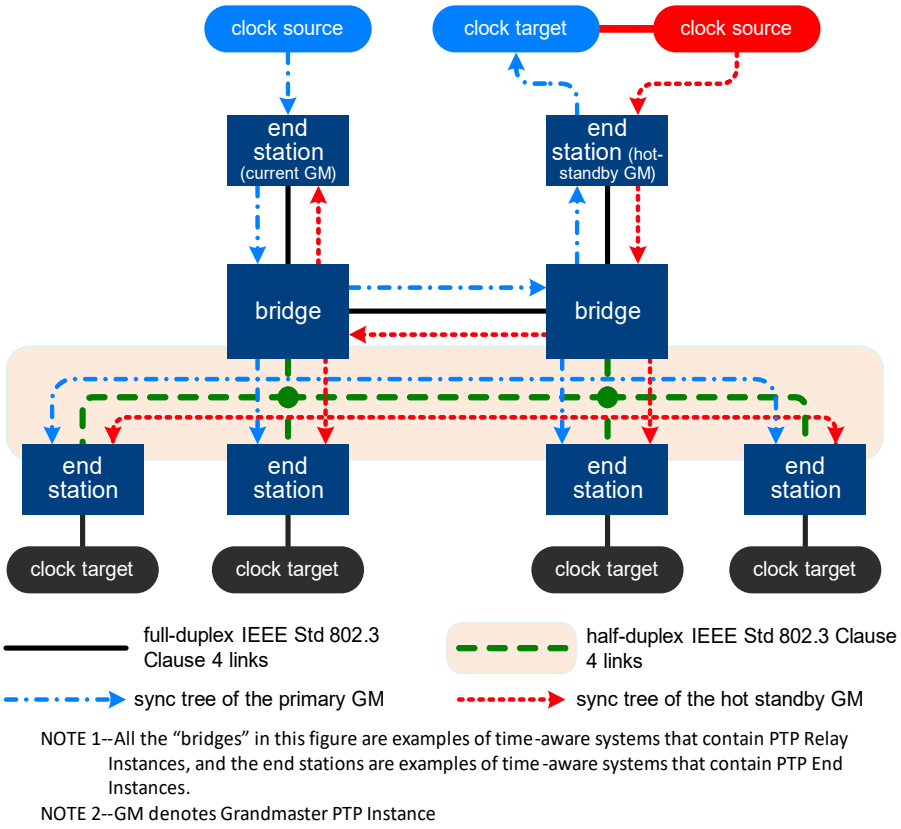


Figure 7-7—Time-aware network example for GM redundancy with one primary GM and one hot-standby GM, separated by two gPTP domains, where the lower links use HDE

This means that:

1) The HDE link cannot serve as a redundant physical link as the point-to-point links in Figure 7-7 can. This is due to the restriction that Bridge ports can only be Time Transmitters.

1) End stations need to transmit Pdelay_Req message for each clock domain it is interested in. Common Mean Link Delay Service (CMLDS - see 11.2.17) is not supported on HDE links.

NOTE 3—Figure 7-7 shows all HDE end stations listening to both clock domains to be consistent with what was shown in Figure 7-5. There is no requirement that all end stations have to listen to all clock domains.

11. Media-dependent layer specification for full-duplex point-to-point links

11.2 State machines for MD entity specific to full-duplex point-to-point links

11.2.19 MDPdelayReq state machine

11.2.19.2 State machine variables

Change 11.2.19.2.2 as follows:

11.2.19.2.1 rcvdPdelayResp: A Boolean variable that notifies the current state machine when a Pdelay_Resp message is received and its requestingPortIdentity.clockIdentity is equal of the current PTP instance. This variable is reset by the current state machine.

Change 11.2.19.2.4 as follows:

11.2.19.2.2 rcvdPdelayRespFollowUp: A Boolean variable that notifies the current state machine when a Pdelay_Resp_Follow_Up message is received and its requestingPortIdentity.clockIdentity is equal of the current PTP instance. This variable is reset by the current state machine.

Insert a new variable after 11.2.19.2.13 as follows:

11.2.19.2.14 pdelayReqSendDisabled: A boolean that is administratively set to TRUE if Pdelay_Req messages are not transmitted by this port. The default value for this variable shall be FALSE.

11.2.19.4 State diagram

Replace Figure 11-9 with the following:.

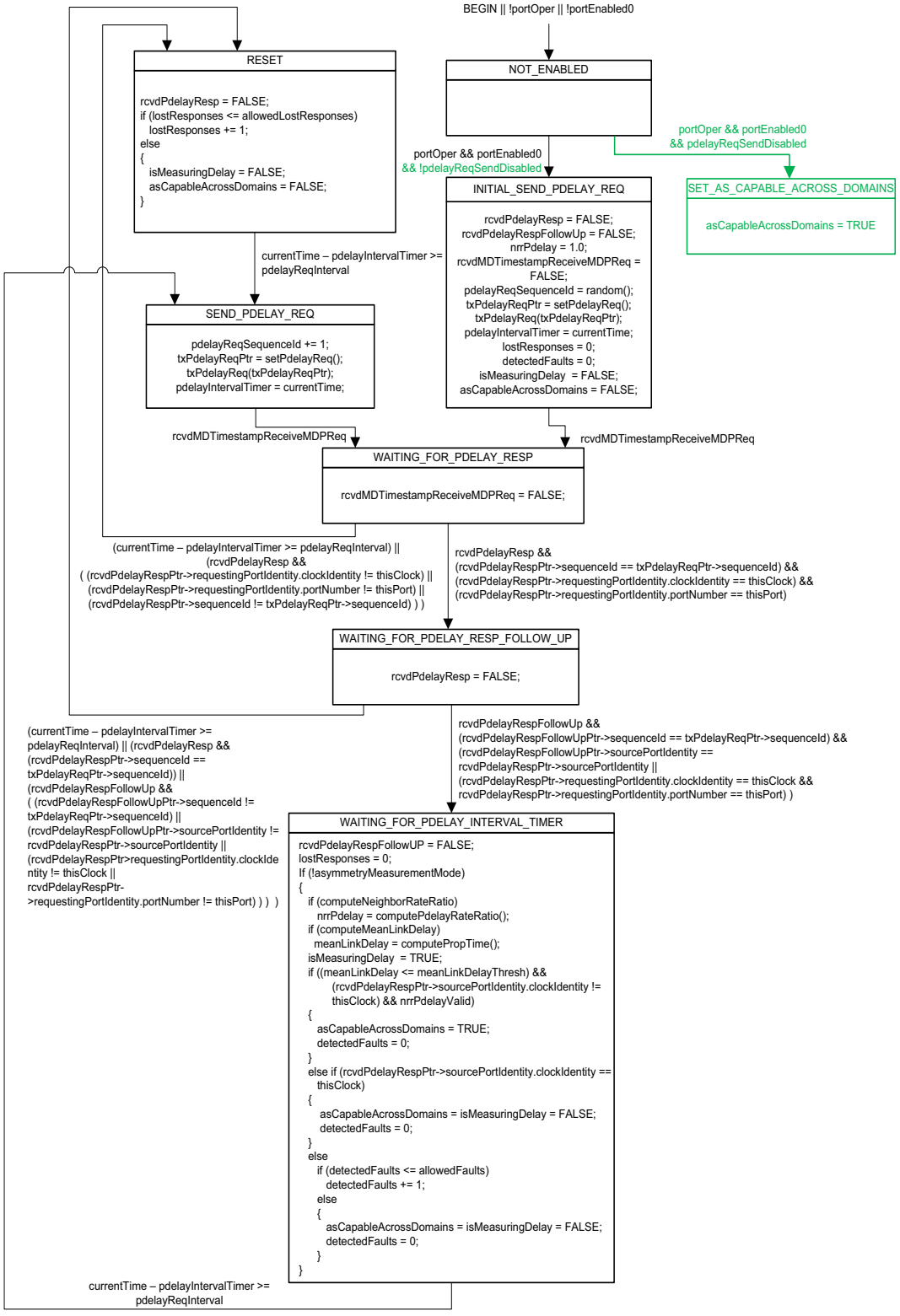


Figure 11-9—MDPdelayReq state machine

11.2.20 MDPdelayResp state machine

11.2.20.2 State machine variables

Insert a new variable after 11.2.20.2.5 as follows:

11.2.20.2.6 pdelayRespSendDisabled: A boolean that is administratively set to TRUE if Pdelay_Resp messages are not transmitted by this port. The default value for this variable shall be FALSE.

11.2.20.4 State diagram

Replace Figure 11-10 with the following:

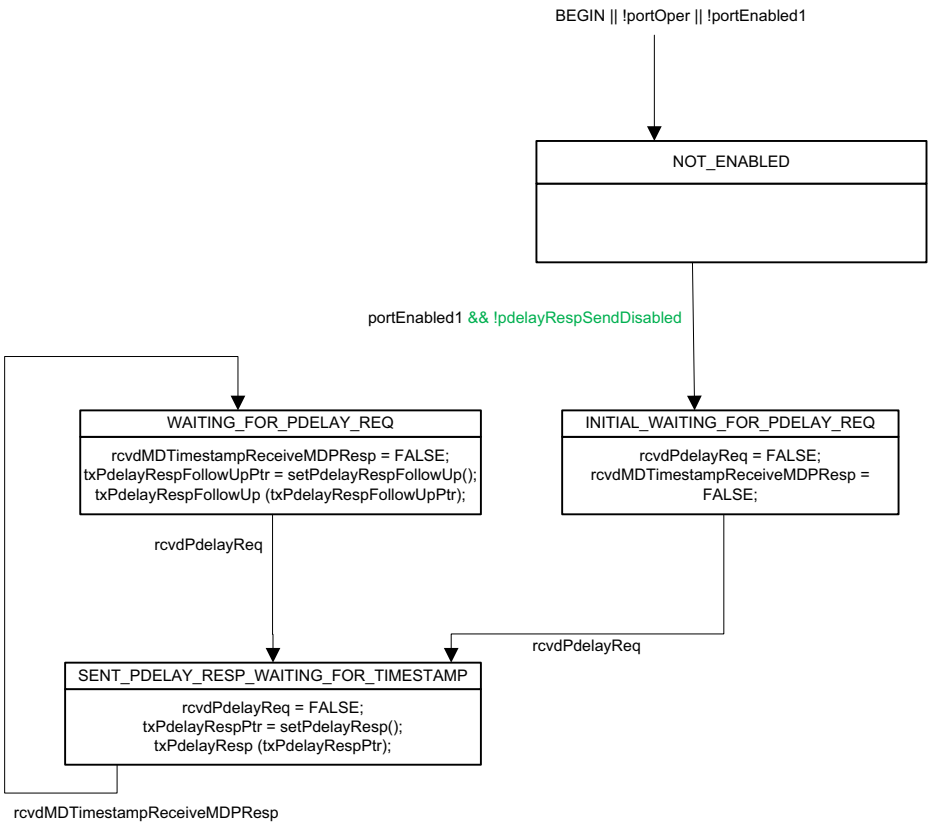


Figure 11-10—MDPdelayResp state machine

14. Timing and synchronization management

<<**Editor's note: Need to include new managed objects related to ASds.**>>

19. Media-dependent layer specification for IEEE 802.3 Clause 4 Media Access Control (MAC) operating in half-duplex

19.1 Overiew

19.1.1 General

Accurate synchronized time is distributed throughout a gPTP domain through time measurements between adjacent PTP Relay Instances or PTP End Instances in a packet network. Time is communicated from the root of the clock spanning tree (i.e., the Grandmaster PTP Instance) toward the leaves of the tree (i.e., from leaf-facing timeTransmitter ports to root-facing timeReceiver ports) through measurements made across the links connecting the PTP Instances. While the semantics of time transfer are consistent across the time-aware packet network, the method for communicating synchronized time from a timeTransmitter port to its immediate downstream link partner(s) varies depending on the type of link interconnecting the two PTP Instances. This clause specifies the protocol that provides accurate synchronized time across links that use IEEE 802.3 (Ethernet) Clause 4 MACs operating in half-duplex (HDE) as part of a packet network.

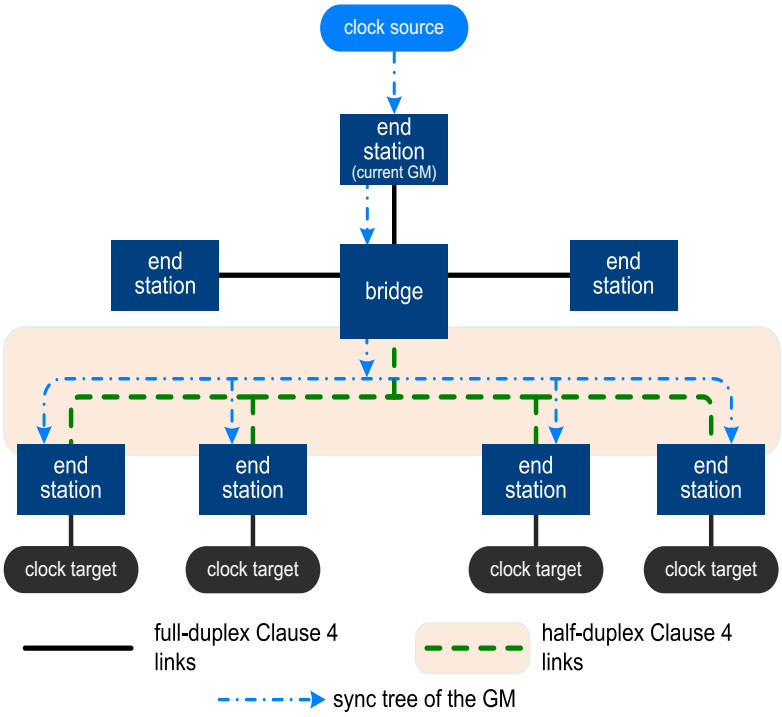
19.1.1.1 Half-duplex Ethernet (HDE) characteristics

The Ethernet IEEE 802.3 Clause 4 MAC can operate in either full-duplex or half-duplex mode. When this MAC is operating in full-duplex, its media-dependent specification for gPTP is covered in Clause 11 of this document. This Clause is used when the 802.3 Clause 4 MAC is operating in half-duplex as this mode necessitates additional managed object settings and frame processing due to the effects of the shared media this mode supports.

NOTE—Shared media allows multiple devices to be connected to the same physical wire without the need of bridges or PTP Relay Instances between them, as shown in Figure 19-1.

A half-duplex Ethernet (HDE) network is a Carrier Sense, Multiple Access, Collision Detect (CSMA/CD) network when used with most IEEE 802.3 physical layer devices (PHYs) specified to connect to the 802.3's Clause 4 MAC. The CSMA/CD mechanism allows only one device at a time to successfully transmit a frame on the shared media using a non-deterministic random back-off mechanism whenever a collision is detected (see 4.2 of IEEE 802.3-2022). But it becomes a deterministic, collision-free, network when used with an 802.3 PHY that supports PHY Level Collision Avoidance (PLCA - see 148 of IEEE 802.3-2022 and 19.3).

The same Clause 4 MAC operating in half-duplex mode (HDE) can be used with either PHY type (i.e., PLCA or not). While gPTP could know what kind of PHY is attached to a given MAC via managed objects, the frames the MAC receives and passes up to the gPTP layer are not different as every MAC on the wire receives every frame successfully transmitted on the wire. Therefore, both PHY types can use the same gPTP protocol as long as the timestamps follow 8.4.3. This is due to gPTP being a higher layer protocol that only deals with successfully received frames.



Note 1: The "bridge" in this figure is an examples of a time-aware systems that contains a PTP Relay Instance, and the end stations with clock targets are examples of time-aware systems that contain PTP End Instances.
Note 2: GM denotes Grandmaster PTP Instance

Figure 19-1—Time-aware network example where the lower links use HDE

19.1.1.2 Half-duplex Ethernet (HDE) using PLCA (10BASE-T1S) PHYs

IEEE 802.3 PHYs that support PHY Level Collision Avoidance (PLCA) form deterministic links by avoiding the MAC's random back-off cause by collisions (see 148 of IEEE 802.3-2022). Simply stated, collisions are avoided by assigning local_nodeIDs that represent a device's transmit opportunity number where one of the devices on the link sends out a BEACON which starts the transmit opportunity cycle. Following each BEACON, the lowest local_nodeID gets to transmit first (assuming it has a frame ready to transmit) followed by the next higher local_nodeID, etc., until all the link's local_nodeIDs have been given a transmit opportunity. Then the process is repeats with another BEACON.

NOTE 1—In IEEE 802.3-2022, the only PHY that supports PLCA is 10BASE-T1S which is specified in 147 of IEEE 802.3-2022.

NOTE 2—Configuration of PLCA local_nodeID numbers, etc., are out of scope of this standard.

19.1.2 Propagation delay measurement over half-duplex links

The measurement of propagation delay on a half-duplex shared media (HDE) PTP Link using the peer-to-peer delay mechanism is illustrated in Figure 11-1 and as described in 11.1.2 with the exception that peer delay initiator is always the timeReceiver (e.g. end station) and the timeTransmitter does not initiate the peer-to-peer delay mechanism, therefore pdelayReqSendDisabled and pdelayRespSendDisabled shall be set as follows:

a) timeTransmitter shall set pdelayReqSendDisabled set to TRUE and pdelayRespSendDisabled shall be set to FALSE

b) timeReceiver shall set pdelayReqSendDisabled set to FALSE and pdelayRespSendDisabled shall be set to TRUE.

19.1.3 Transport of time-synchronization information

The transport of time-synchronization information by a PTP Instance, using Sync and Follow_Up messages, is illustrated in Figure 11-2.

Half-duplex shared media (HDE) links shall use two-step time transport as described in clause 11.1.3.

19.1.4 Model of operation

A PTP Instance contains one MD entity per PTP Instance, per PTP Port. This entity contains functions generic to all media, which are described in Clause 10, and functions specific to the respective medium for the PTP Link. Functions specific to half-duplex shared media (HDE) links are described in the current clause.

NOTE—HDE refers to IEEE 802.3 links using the Clause 4 MAC in half-duplex mode and are in the category of links specified in this clause.

The model for a PTP Instance of a time-aware system with full-duplex point-to-point links is shown in Figure 11-3. This (HDE) Clause reuses Figure 11-3 (as its structure is unchanged for this clause), where all references in Figure 11-3 to Clause 11 is to be replaced by Clause 19 (this clause). It assumes the presence of one half-duplex shared media MD entity per PTP Port. The media-independent entities shown in Figure 11-3 are described in 10.1.2.

A general, media-independent description of the generation of timestamps is given in 8.4.3. A more specific description for PTP event messages is given in 11.3.2.1. A PTP event message is timestamped relative to the LocalClock entity when the message timestamp point (see 3.17) crosses the timestamp measurement plane (see 3.33). The timestamp is corrected for any ingressLatency or egressLatency (see 8.4.3) to produce a timestamp relative to the reference plane (see 3.26). The corrected timestamp value is provided to the MD entity.

The MD entity behavior and detailed state machines specific to full-duplex point-to-point links, which are described in 11.2, are reused for half-duplex HDE shared media links subject to the conditions defined in 19.2. The behavior of the MD entity that is generic to all media is described in Clause 10.

19.2 State machines for half-duplex shared media (HDE) links

<<Editor's note: Need to check the changes made in P802.1ASdm to clause 11.2 and its subclauses whether or not they have any implications for half-duplex.>>

19.2.1 General

The state machines for half-duplex links are described in 11.2.1.

19.2.2 Determination of asCapable and asCapableAcrossDomains

<<Editor's note: Need text in this clause for half-duplex.>>

19.2.3 Use of MAC Control PAUSE operation

<<**Editor's note: Is this applicable for half-duplex? Comments are requested.**>>

19.2.4 Use of priority-based flow control

<<**Editor's note: Is this applicable for half-duplex? Comments are requested.**>>

19.2.5 Use of link aggregation

<<**Editor's note: Is this applicable for half-duplex? Comments are requested.**>>

19.2.6 Service interface primitives and data structures communicated between state machines

Service interface primitives and data structures communicated between state machines is described in 11.2.6.

19.2.7 DL-UNITDATA.request

<<**Editor's note: Is service primitive described in 2.2.1.1.1 of ISO/IEC 8802-2:1998 applicable for half-duplex? Comments are requested.**>>

19.2.8 DL-UNITDATA.indication

<<**Editor's note: Is service primitive described in 2.2.1.1.1 of ISO/IEC 8802-2:1998 applicable for half-duplex? Comments are requested.**>>

19.2.9 MDTimestampReceive

19.2.9.1 General

The structure that provides the timestamp, relative to the timestamp measurement plane, of the event message that was just sent or just received is described in 11.2.9.1.

19.2.9.2 timestamp (UScaledNs)

The member of the timestamp structure is described in 11.2.9.2.

19.2.10 MDSyncReceive

This structure is specified in 11.2.10.

19.2.11 MDSyncSend

This structure is specified in 11.2.11.

19.2.12 Overview of MD entity global variables

The overview of MD entity global variables is given in 11.2.12.

19.2.13 MD entity global variables

19.2.13.1 currentLogPdelayReqInterval: This variable shall be as specified in 11.2.13.1.

19.2.13.2 initialLogPdelayReqInterval: This variable shall be as specified in 11.2.13.2.

19.2.13.3 pdelayReqInterval: This variable shall be as specified in 11.2.13.3.

19.2.13.4 allowedLostResponses: This variable shall be as specified in 11.2.13.4.

19.2.13.5 allowedFaults: This variable shall be as specified in 11.2.13.5.

19.2.13.6 isMeasuringDelay: This variable shall be as specified in 11.2.13.6.

19.2.13.7 meanLinkDelayThresh: This variable shall be as specified in 11.2.13.7.

19.2.13.8 syncSequenceId: This variable shall be as specified in 11.2.13.8.

19.2.13.9 oneStepReceive: This variable shall be as specified in 11.2.13.9. It shall be set to FALSE for half-duplex shared media (HDE).

19.2.13.10 oneStepTransmit: This variable shall be as specified in 11.2.13.10. It shall be set to FALSE for half-duplex shared media (HDE).

19.2.13.11 oneStepTxOper: This variable shall be as specified in 11.2.13.11. It shall be set to FALSE for half-duplex shared media (HDE).

19.2.13.12 asCapableAcrossDomains:

<<**Editor's note: Need text in this clause for half-duplex.**>>

19.2.14 MDSyncReceiveSM state machine

The MDSyncReceiveSM state machine shall be as specified in 11.2.14.

19.2.15 MDSyncSendSM state machine

The MDSyncSendSM state machine shall be as specified in 11.2.15.

19.2.16 OneStepTxOperSetting state machine

This state machine is not used for half-duplex shared media (HDE).

19.2.17 Common Mean Link Delay Service (CMLDS)

The Common Mean Link Delay Service (CMLDS) is not used for half-duplex shared media (HDE).

Half-duplex shared media (HDE) uses the Instance-specific peer-to-peer delay mechanism for all domains. Therefore, if the time-aware system implements other domain, that is not doaminNumber 0, then Instance-specific peer-to-peer delay mechanism is used.

19.2.18 Common Mean Link Delay Service (CMLDS) global variables

The Common Mean Link Delay Service (CMLDS) is not used for half-duplex shared media (HDE).

19.2.19 MDPdelayReq state machine

The MDPdelayReq state machine shall be as specified in 11.2.19.

The variable pdelayReqSendDisabled defined in 11.2.19.2.14 shall be set as follows:

a) timeTransmitter shall set pdelayReqSendDisabled set to TRUE
b) timeReceiver shall set pdelayReqSendDisabled set to FALSE

19.2.20 MDPdelayResp state machine

The MDPdelayResp state machine shall be as specified in 11.2.20.

The variable pdelayRespSendDisabled defined in 11.2.20.2.6 shall be set as follows:

a) timeTransmitter shall set pdelayRespSendDisabled shall be set to FALSE
b) timeReceiver shall set pdelayRespSendDisabled shall be set to TRUE.

19.2.21 LinkDelayIntervalSetting state machine

<<Editor's note: The LinkDelayIntervalSetting state machine is used when useMgtSettableLogPdelayReqInterval is set to FALSE. Is there a need to use this state machine for half-duplex? Comments are requested.>>

19.3 Message attributes

Message attributes shall be as specified in 11.3.

<<**Editor's note: Is clause 11.3.3 (VLAN tag) applicable for half-duplex? Comments are requested.**>>

19.4 Message formats

Message formats shall be as specified in 11.4.

<<**Editor's note: Clause 11.4.2.4 states: "The domainNumber for Pdelay_Req, Pdelay_Resp, and Pdelay_Resp_Follow_Up messages shall be 0", do we need to modify this for half-duplex? Comments are requested.**>>

19.5 Protocol timing characterization

19.5.1 General

This subclause specifies timing attributes for the media-dependent sublayer specified in this clause.

19.5.2 Message transmission intervals

19.5.2.1 General interval specification

The mean time interval between successive Pdelay_Req messages is represented as the logarithm to the base 2 of this time interval measured in seconds. The value of this logarithmic attribute shall be as specified in 19.5.2.2.

The mean time interval between successive Sync messages shall be as specified in 10.7.2.1, 10.7.2.3, and 19.5.2.3.

19.5.2.2 Pdelay_Req message transmission interval

<<Editor's note: Clause 11.5.2.2 uses message interval request TLV attached to a signaling message, need to modify this for half-duplex, as signaling messages are not used.>>

19.5.2.3 Sync message transmission interval default value

The Sync message transmission interval default value shall be as specified in 11.5.2.3.

19.5.3 allowedLostResponses

The variable allowedLostResopnses shall be as specified in 11.5.3.

19.5.4 allowedFaults

The variable allowedFaults shall be as specified in 11.5.4.

19.6 Control of computation of neighborRateRatio

The control of computation of neighborRateRatio shall be as specified in 11.6.

19.7 Control of computation of meanLinkDelay

The control of computation of meanLinkDelay shall be as specified in 11.7.

19.8 Half-duplex Ethernet (HDE) configuration

PTP Instances operating in half-duplex mode shall set externalPortConfigurationEnabled to TRUE.

Both GptpCapableTransmit and GptpCapableReceive state machines shall be disabled, and therefore gptpCapableStateMachinesEnabled shall beset to FALSE.

<<Editor's note: This subclause will capture configurations and settings that are specific for half-duplex.>>