

IEEE Standard for Local and metropolitan area networks—

Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks—

Corrigendum 1: Technical and Editorial Corrections

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 802.1AS™-2011/Cor 1-2013
(Corrigendum to
IEEE Std 802.1AS-2011)

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

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IEEE-SA Standards Board**

Abstract: This corrigendum to IEEE Std 802.1AS provides technical and editorial corrections.

Keywords: best master, frequency offset, grandmaster, IEEE 802.1AS™, IEEE 802.1AS™/Cor 1, phase offset, synchronization, syntonization, time-aware system

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Introduction

This introduction is not part of IEEE Std 802.1AS-2011/Cor 1-2013, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks—Corrigendum 1: Technical and editorial corrections.

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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Corrigendum 1: Technical and Editorial Corrections

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(This corrigendum is based on IEEE Std 802.1AS™-2011.)

NOTE—The editing instructions contained in this corrigendum define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.¹

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 ~~strike through~~ (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.

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

2. Normative references

Change Clause 2 as follows:

The following referenced documents are indispensable for the application of this standard (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.

~~IEEE P802.11vTM (D15.0, September 2010), Draft 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—Amendment 8: IEEE 802.11TM Wireless Network Management.²~~

IEEE Std 802.1DTM-2004, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Bridges.^{3, 4}

IEEE Std 802.1QTM- ~~2005~~2011, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks.

IEEE Std 802.1agTM-2007, IEEE Standard for Local and metropolitan area networks—Virtual Bridged Local Area Networks—Amendment 5: Connectivity Fault Management.

IEEE Std 802.3TM-2008, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area network—Specific requirements, Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.

IEEE Std 802.3avTM-2009, IEEE Standard for Information technology—Part 3: Amendment 1: Physical Layer Specifications and Management Parameters for 10 Gb/s Passive Optical Networks.

IEEE Std 802.11TM-~~2007~~2012, 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.

IEEE Std 1588TM-2008, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.

IETF RFC 3410 (December 2002), Introduction and Applicability Statements for Internet Standard Management Framework, Case, J., Mundy, R., Partain, D., and Stewart, B.⁵

ITU-T Recommendation G.9960 (ex. G.hn), Unified high-speed wire-line based home networking transceivers—System architecture and physical layer specification, June 2010.⁶

²~~IEEE P802.11v/D16 (November 2010) was approved by the IEEE-SA Standards Board on 2 February 2011. It was published as IEEE Std 802.11v-2011 on 9 February 2011 and is available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org>).~~

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⁵IETF RFCs are available from the Internet Engineering Task Force Web site at <http://www.ietf.org/rfc.html>.

⁶ITU-T publications are available from the International Telecommunications Union, Place des Nations, CH-1211, Geneva 20, Switzerland/Suisse (<http://www.itu.int/>).

ITU-T Recommendation G.9961, Data link layer (DLL) for unified high-speed wire-line based home networking transceivers, June 2010.

ITU-T Recommendation G.984.3, Amendment 2 (2009-11) Gigabit-capable Passive Optical Networks (G-PON): Transmission convergence layer specification-Time-of-day distribution and maintenance updates and clarifications, November 2009.

MoCA[®] MAC/PHY Specification v2.0, MoCA-M/P-SPEC-V2.0-20100507, Multimedia over Coax Alliance (MoCA).⁷

⁷MoCA specifications are available from the Multimedia over Coax Alliance at <http://www.mocalliance.org/specs>.

3. Definitions

Change 3.10 as follows (i.e., the indicated text should not be bold):

3.10 grandmaster: ~~The time-aware system that contains the best clock, as determined by the best master clock algorithm (BMCA), in the generalized precision time protocol (gPTP) domain.~~ The time-aware system that contains the best clock, as determined by the best master clock algorithm (BMCA), in the generalized precision time protocol (gPTP) domain.

5. Conformance

5.3 Time-aware Bridge and end station requirements

Change 5.3 as follows:

An implementation of timing and synchronization in Bridges shall:

- a) Conform to the requirements of IEEE Std 802.1Q-~~2005~~;
- b) Implement the generalized precision time protocol (gPTP) requirements specified in 8.2, 8.4, 8.5, and 8.6;
- c) Support the media-independent slave clock at least on one port (10.2.12), and on each supported port, implement PortSyncSyncReceive function (10.2.7.3) and ClockSlaveSync function (10.2.12.3);
- d) Support the requirements where no best master is present in the domain (10.2.12.2);
- e) Support the following best master clock algorithm (BMCA) requirements (10.3):
 - 1) Support the Time-aware system attributes and requirements (8.6.2);
 - 2) Implement the BMCA (10.3.2);
 - 3) Implement PortAnnounceReceive function (10.3.10);
 - 4) Implement PortAnnounceInformation function (10.3.11);
 - 5) Implement PortRoleSelection function (10.3.12).
- f) Implement SiteSyncSync function (10.0.2).

5.5 MAC-specific timing and synchronization methods for IEEE Std 802.11-~~2007~~

Change 5.5, including the subclause heading above, as shown.

An implementation of Time-aware Bridges with IEEE 802.11 MAC services to physical ports shall:

- a) Conform to the requirements of IEEE 802.1Q MAC-specific bridging methods;
- b) Conform to the requirements of TIMINGMSMT as specified in ~~IEEE P802.11v (D15.0, September 2010)~~ IEEE Std 802.11;
- c) Support the requirements as specified in 12.2;
- d) Implement MDSync Message protocol, its message parameters and defaults (12.3).

6. Conventions

6.3 Data types and on-the-wire formats

6.3.1 General

Change 6.3.1 as follows:

The data types specified for the various variables and message fields define logical properties that are necessary for correct operation of the protocol or interpretation of IEEE 1588 precision time protocol (PTP) or ~~IEEE P802.11v~~ IEEE 802.11 message content.

NOTE—Implementations are free to use any internal representation of data types if the internal representation does not change the semantics of any quantity visible via communications using the IEEE 802.1AS protocol or in the specified operations of the protocol.

6.3.4 Protocol data unit (PDU) formats

6.3.4.1 General

Change 6.3.4.1 as follows:

The data types defined in 6.3.2 and 6.3.3 shall be mapped onto the wire according to the mapping rules for the respective medium, e.g., IEEE Std 802.3-2008 and IEEE Std 802.11-~~2007~~, and the terms of 6.3.4.

IEEE 802.1AS PDUs consist of the messages defined or referenced in Clause 10, Clause 11, Clause 12, and Clause 13, based on the data types defined in 6.3.2 and 6.3.3. The internal ordering of the fields of the IEEE 802.1AS PDUs is specified in 6.3.4.3 to 6.3.4.5.

7. Time synchronization model for a bridged local area network

7.3 Time synchronization

7.3.2 Delay measurement

Change 7.3.2, including Figure 7-3, as follows:

Each type of LAN or communication path has different methods for measuring propagation time, but they are all based on the same principal: measuring the time that a well-known part of a message is transmitted from one device and the time that the same part of the same message is received by the other device, then sending another message in the opposite direction and doing the same measurement as shown in Figure 7-3.

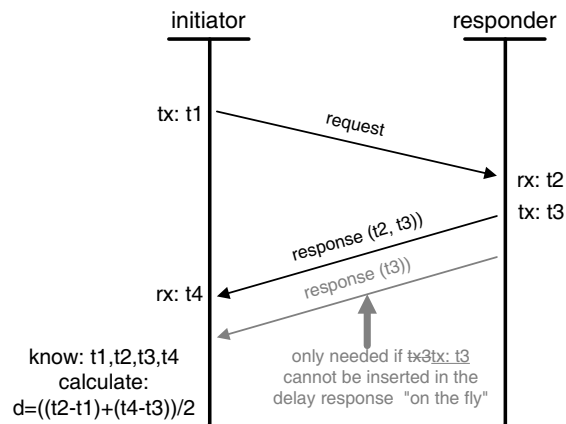


Figure 7-3—Example delay measurement

This basic mechanism is used in the various LANs in the following ways:

- Full-duplex Ethernet LANs use the two step peer-to-peer (P2P) path delay algorithm as defined in IEEE Std 1588-2008, where the messages are called Pdelay_Req, Pdelay_Resp, and Pdelay_Resp_Follow_Up.
- IEEE 802.11 wireless LANs use the Timing measurement procedure defined in ~~IEEE P802.11v (D15.0, September 2010)~~ IEEE Std 802.11, where the messages are the “Timing Measurement action frame” and its corresponding “ACK.”
- EPON LANs use the discovery process, where the messages are “GATE” and “REGISTER_REQ.”
- CSNs either use the same mechanism as full-duplex Ethernet, or use a method native to the particular CSN (similar to the way native methods are used by IEEE 802.11 and EPON).

7.3.4 Grandmaster (best master) selection and network establishment

Change 7.3.4 as follows:

All time-aware systems participate in best master selection so that the IEEE 802.1AS protocol can determine the synchronization spanning tree. This synchronization spanning tree may be different from the forwarding spanning tree determined by IEEE 802.1D and IEEE 802.1Q Rapid Spanning Tree Protocol (RSTP) since the spanning tree determined by RSTP can be suboptimal, or even inadequate for synchronization.

gPTP requires that all Bridges and end-stations in the gPTP domain be time-aware-systems, i.e., the protocol does not transfer timing over “ordinary Bridges” (those that meet the requirements of IEEE Std 802.1D-2004 or IEEE Std 802.1Q-2005, but do NOT meet the requirements of this standard). A time-aware system uses the peer delay mechanism on each port to determine if an “ordinary Bridge” is at the other end of the link or in between itself and the Pdelay responder. If, on sending Pdelay_Req

- a) no response is received,
- b) multiple responses are received, or
- c) the measured propagation delay exceeds a specified threshold, then

the protocol concludes that an “ordinary Bridge” or end-to-end TC (see IEEE Std 1588-2008) is present. In this case, the link attached to the port is deemed not capable of running gPTP, and BMCA ignores it. However, the port continues to attempt the measurement of propagation delay using the peer delay mechanism (for full-duplex IEEE 802.3 links), MPCP messages (for EPON), or ~~IEEE P802.11~~ IEEE 802.11 messages (for IEEE 802.11 links), and periodically checks whether the link is or is not capable of running IEEE 802.1AS.

7.4 Time-aware system architecture

Change 7.4 as follows:

The model of a time-aware system is shown in Figure 7-4.

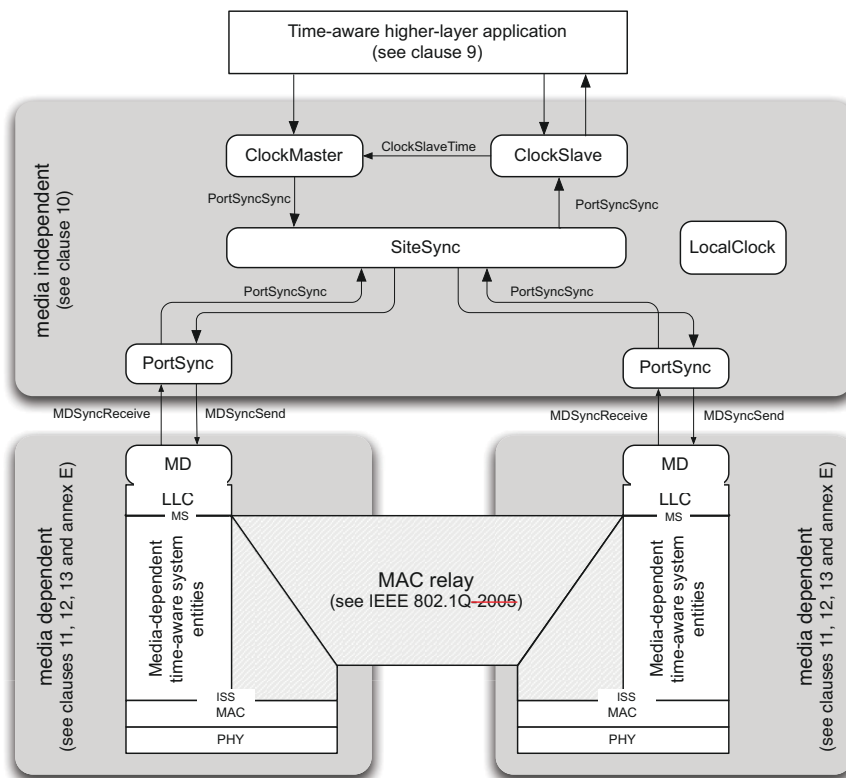


Figure 7-4—Time-aware system model

A time-aware system consists of the following major parts:

- a) If the time-aware system includes application(s) that either use or source time information, then they interface with the gPTP information using the application interfaces specified in Clause 9.
- b) A single media-independent part that consists of ClockMaster, ClockSlave, and SiteSync logical entities, one or more PortSync entities, and a LocalClock entity. The BMCA and forwarding of time information between logical ports and the ClockSlave and ClockMaster is done by the SiteSync entity, while the computation of port-specific delays needed for time synchronization correction is done by the PortSync entities.
- c) Media-dependent ports, which translate the abstract “MDSyncSend” and “MDSyncReceive” structures received from or sent to the media-independent layer and corresponding methods used for the particular LAN attached to the port.

In the case of full-duplex Ethernet ports, IEEE 1588 Sync and Follow_Up messages are used, with an additional TLV in the Follow_up used for communication of rate ratio and information on phase and frequency change when there is a change in grandmaster. The path delay is measured using the two-step IEEE 1588 peer delay mechanism. This is defined in Clause 11.

For IEEE 802.11 ports, timing information is communicated using the MAC Layer Management Entity to request a “timing measurement” [as defined in ~~IEEE P802.11v (D15.0, September 2010)~~ [IEEE Std 802.11](#)], which also sends everything that would be included in the Follow_up message for full-duplex Ethernet. The timing measurement result includes all the information to determine the path delay. This is defined in Clause 12.

For EPON, timing information is communicated using a “slow protocol” as defined in Clause 13. CSNs use the same communication system used by Ethernet full-duplex, as is defined in Annex E.

8. IEEE 802.1AS concepts and terminology

8.2 Timescale

8.2.2 Epoch

Change 8.2.2 as follows:

The epoch is the origin of the timescale of a gPTP domain.

The PTP epoch is 1 January 1970 00:00:00 TAI, which is 31 December 1969 23:59:51.999918 UTC.

NOTE—The PTP epoch is set such that a direct application of the POSIX algorithm to a PTP ~~time-scale~~ timescale timestamp yields the ISO 8601:2004 [B8] printed representation of TAI.

See Annex C for information on converting between common timescales.

8.5 Ports

8.5.2 Port identity

8.5.2.2 clockIdentity

8.5.2.2.1 General

Change Table 8-1 as follows:

Table 8-1—Illustration of formation of clockIdentity from EUI-48

OUI			EUI-48 assigned values		extension identifier		
octet[0] (most significant) ~~octet[1]~~	<u>octet[1]</u>	octet[2]	octet[3]	octet[4]	octet[5]	octet[6]	octet[7] (least significant)
0xAC	0xDE	0x48	0xFF	0xFE	0x23	0x45	0x67
10101100 (leftmost 1 is most significant)	11011110b	01001000b	11111111b	11111110b	00100011b	01000101b	01100111b (rightmost 1 is least significant)

8.6 Time-aware system characterization

8.6.2 Time-aware system attributes

8.6.2.1 priority1

Change NOTE 1 of 8.6.2.1 as follows:

NOTE 1—The BMCA, see 10.3, considers priority1 before other attributes; the priority1 attribute can therefore be used to force a desired ordering of time-aware ~~end-stations~~systems for best master selection.

8.6.2.4 offsetScaledLogVariance

Change 8.6.2.4 as follows:

The offsetScaledLogVariance is a scaled, offset representation of an estimate of the PTP variance. The PTP variance characterizes the precision and frequency stability of the ClockMaster. The PTP variance is the square of PTPDEV (see B.1.3.2).

The value shall be selected as follows:

- a) offsetScaledLogVariance is set to the value that reflects the combination of the LocalClock and ClockSource entities; else
- b) if the value that reflects these entities is not specified or not known, offsetScaledLogVariance is set to ~~+6640~~17258 (~~4100₁₆~~436A₁₆). This value corresponds to the value of PTPDEV for observation interval equal to the default Sync message transmission interval (i.e., observation interval of 0.125 s, see 11.5.2.3 and B.1.3.2).

See 7.6.3 of IEEE Std 1588-2008 for more detailed description of PTP variance and offsetScaledLogVariance (7.6.3.3 of IEEE Std 1588-2008 provides a detailed description of the computation of offsetScaledLogVariance from PTP variance, along with an example).

10. Media-independent layer specification

10.2 Time-synchronization state machines

Change Figure 10-2 as follows:

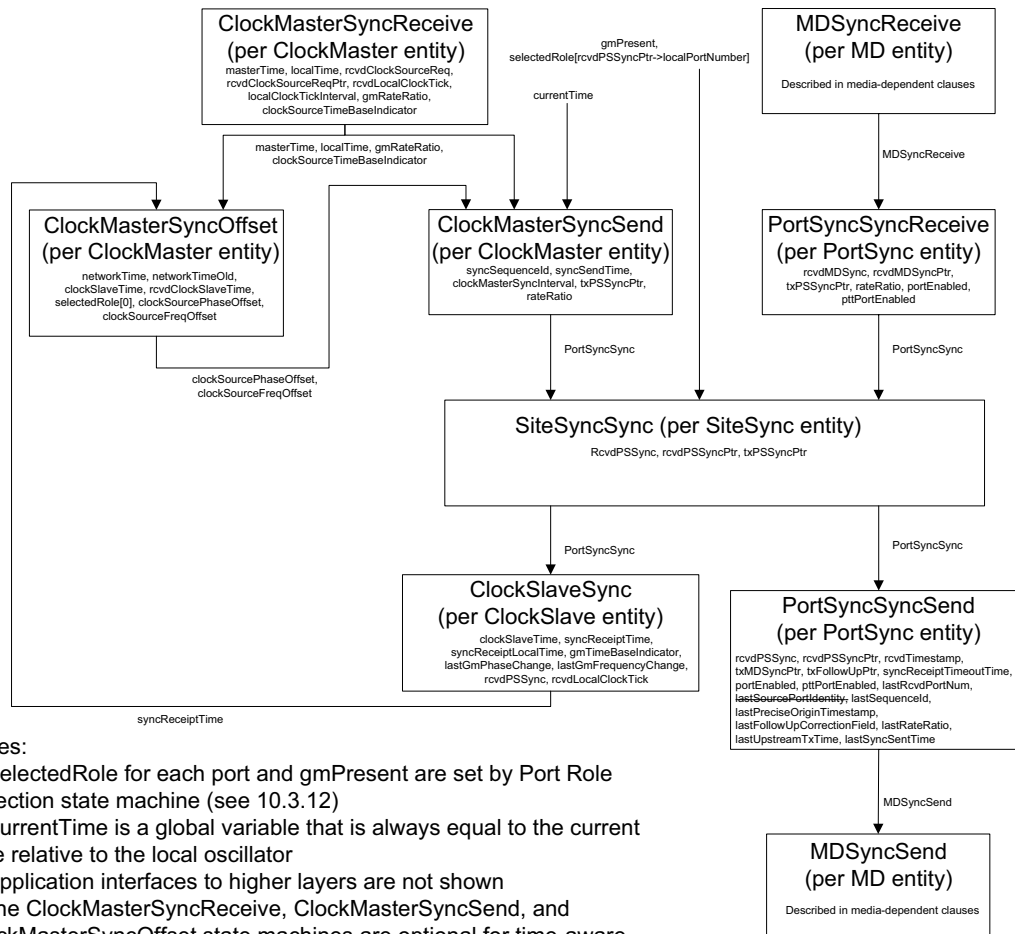


Figure 10-2—Time-synchronization state machines—overview and interrelationships

10.2.2 Data structures communicated between state machines

10.2.2.2 MDSyncReceive

10.2.2.2.1 General

Change 10.2.2.2.1 as follows:

This structure contains information that is sent by the MD entity of a port to the PortSync entity of that port. It provides the PortSync entity with master clock timing information and timestamp of receipt of a time-synchronization event message compensated for propagation time on the upstream link. The information is sent to the PortSync entity upon receipt of time-synchronization information by the MD entity of the port. The information is in turn provided by the PortSync entity to the SiteSync entity. The information is used by

the ~~SiteSync~~PortSyncSyncReceive state machine of the PortSync entity to compute the rate ratio of the local oscillator relative to the master and is communicated to the SiteSync entity, and then by the SiteSync entity to the other PortSync entities for use in computing master clock timing information.

The structure is:

```
MDSyncReceive {
    followUpCorrectionField,
    sourcePortIdentity,
    logMessageInterval,
    preciseOriginTimestamp,
    upstreamTxTime,
    rateRatio,
    gmTimeBaseIndicator,
    lastGmPhaseChange,
    lastGmFreqChange
}
```

The members of the structure are defined in the following subclauses.

10.2.6 SiteSyncSync state machine

10.2.6.2 State machine functions

Change 10.2.6.2.1 as follows:

10.2.6.2.1 setPSSyncSend (rcvdPSSync~~Ind~~Ptr): creates a PortSyncSync structure to be transmitted, and returns a pointer to this structure. The members are copied from the received PortSyncSync structure pointed to by rcvdPSSyncPtr.

10.2.7 PortSyncSyncReceive state machine

10.2.7.3 State diagram

Change Figure 10-4 as follows:

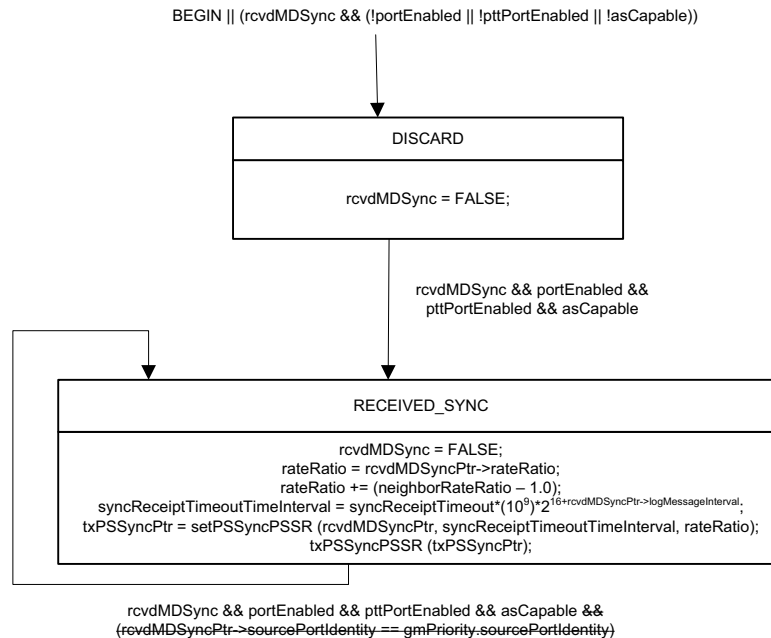


Figure 10-4—PortSyncSyncReceive state machine

10.2.10 ClockMasterSyncReceive state machine

10.2.10.2. State machine functions

Change 10.2.10.2.2 as follows:

10.2.10.2.2 updateMasterTime(): updates the global variable masterTime (see 10.2.3.21), based on information received from the ClockSource and LocalClock entities. It is the responsibility of the application to filter master times appropriately. As one example, masterTime can be set equal to the sourceTime member of the ClockSourceTime.invoke function when this function is received, and can be incremented by localClockTickInterval (see 10.2.3.18) ~~divided~~ **multiplied** by gmRateRatio (see 10.2.3.14) when rcvdLocalClockTick is TRUE.

10.2.11 PortSyncSyncSend state machine

10.2.11.1 State machine variables

Delete 10.2.11.1.3 and renumber remaining variables.

~~**10.2.11.1.3 lastSourcePortIdentity:** the sourcePortIdentity member of the most recently received PortSyncSync structure. The data type for lastSourcePortIdentity is PortIdentity.~~

10.2.11.2 State machine functions

Change 10.2.11.2.1 as follows:

10.2.11.2.1 setMDSync(): creates an MDSyncSend structure, and returns a pointer to this structure. The members are set as follows:

- a) sourcePortIdentity is set to the portIdentity of this port (see 8.5.2) ~~if the clockIdentity member of lastSourcePortIdentity (see 10.2.11.1.3) is equal to thisClock (see 10.2.3.22); otherwise, it is set to lastSourcePortIdentity~~
- b) logMessageInterval is set equal to the value of currentLogSyncInterval for this port (see 10.6.2.3)
- c) preciseOriginTimestamp is set equal to lastPreciseOriginTimestamp (see 10.2.11.1.4)
- d) rateRatio is set equal to lastRateRatio (see 10.2.11.1.6)
- e) followUpCorrectionField is set equal to lastFollowUpCorrectionField (see 10.2.11.1.5)
- f) upstreamTxTime is set equal to lastUpstreamTxTime (see 10.2.11.1.7)

10.2.12 ClockSlaveSyncReceive state machine

10.2.12.2 State machine functions

Change 10.2.12.2.1 as follows:

10.2.12.2.1 updateSlaveTime(): updates the global variable clockSlaveTime (see 10.2.3.3), based on information received from the SiteSync and LocalClock entities. It is the responsibility of the application to filter slave times appropriately (see B.3 and B.4 for examples). As one example, clockSlaveTime can be incremented by localClockTickInterval (see 10.2.3.18) ~~divided~~ multiplied by rateRatio member of the received PortSyncSync structure. If no time-aware system is grandmaster-capable, i.e., gmPresent is FALSE, then clockSlaveTime is set to the time provided by the LocalClock. This function is invoked when rcvdLocalClockTick is TRUE.

10.3 Best master clock selection and announce interval setting state machines

10.3.1 Best master clock algorithm overview

Change NOTE 2 in 10.3.1 as follows:

NOTE 2—The BMCA described in this standard is equivalent to a subset of the BMCA described in IEEE Std 1588-2008. It is also equivalent to a subset of the Rapid Spanning Tree Protocol (RSTP) described in IEEE Std 802.1D-~~2004~~ (though the full RSTP described in the latter standard is not equivalent to the full BMCA described in the former standard). The BMCA description here uses the formalism of the RSTP description in the latter standard.

10.3.7 Overview of best master clock selection and announce interval setting state machines

Change Figure 10-11 as follows:

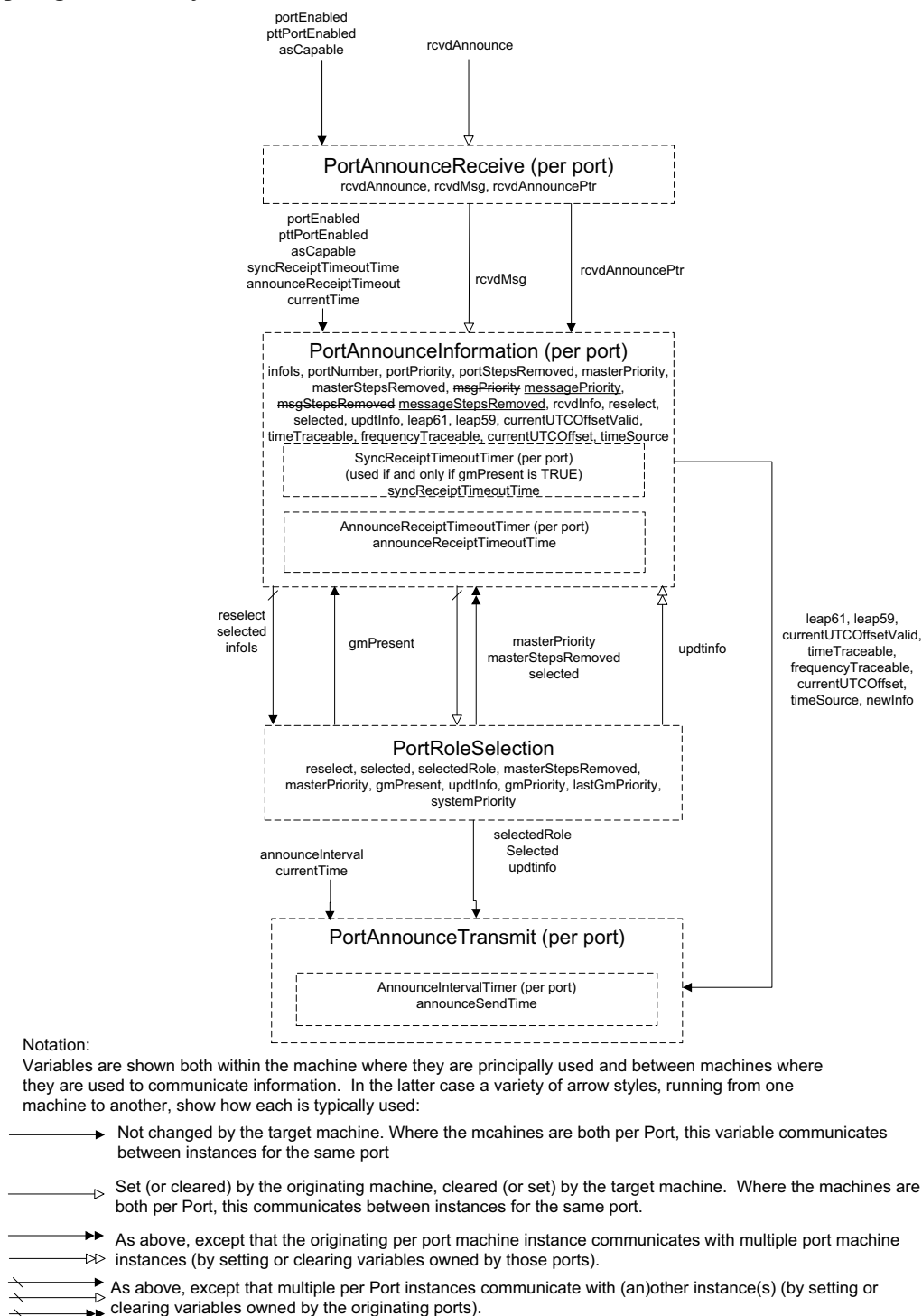


Figure 10-11—Best master clock selection state machines—overview and interrelationships

10.3.8 Per-time-aware system global variables

Change 10.3.8.1 as follows:

10.3.8.1 reselect: a Boolean array of length numberPorts (see 8.6.1). Setting reselect[j], where $0 \leq j \leq \text{numberPorts}$, to TRUE causes the ROLE_SELECTION block of the PortRoleSelection state machine (see 10.3.2) to be re-entered, which in turn causes the port role of each port of the time-aware system to be updated (via the function ~~updateRolesTree~~updtRolesTree()), see 10.3.12.1.4).

10.3.11 PortAnnounceInformation state machine

10.3.11.2 State machine functions

Change 10.3.11.2.1 as follows:

10.3.11.2.1 rcvInfo (rcvdAnnouncePtr): decodes the messagePriorityVector (see 10.3.4 and 10.3.5) and stepsRemoved 10.5.3.2.6) field from the Announce information pointed to by rcvdAnnouncePtr (see 10.3.9.11), and then does the following:

- a) Stores the messagePriorityVector and stepsRemoved field value in ~~msg~~messagePriority and ~~msg~~messageStepsRemoved, respectively,
- b) Returns SuperiorMasterInfo if the received message conveys the port role MasterPort, and the messagePriorityVector is superior to the portPriorityVector of the port,
- c) Returns RepeatedMasterInfo if the received message conveys the port role MasterPort, and the messagePriorityVector is the same as the portPriorityVector of the port,
- d) Returns InferiorMasterInfo if the received message conveys the port role MasterPort, and the messagePriorityVector is worse than the portPriorityVector of the port,
- e) Otherwise, returns OtherInfo.

