5.8 Time-aware station possibilities

NOTE—Recent 802.1AS meetings helped clarify the functionality of 802.1AS stations. DVJ has attempted to summarize these findings, in the remainder of this subclause, in response to the 2007-09-18 request. This is highly preliminary text and subject to change.

5.8.1 Time-aware end-station possibilities

A time-aware end station can have combinations of ClockSource and ClockTarget components, as illustrated in Figure 5.14. A time-unaware station has neither ClockSource or ClockTarget entity (see Figure 5.14a); a simple time-aware station (such as an Ethernet speaker) could have only a ClockTarget entity (see Figure 5.14b). A traceable station could have an application-level GPS (see Figure 5.14c); a nontraceable station has a free-running application-level oscillator (see Figure 5.14d). A television or stereo receiver could provide application-level ClockSource and ClockTarget components, as illustrated in Figure 5.14e and Figure 5.14f.

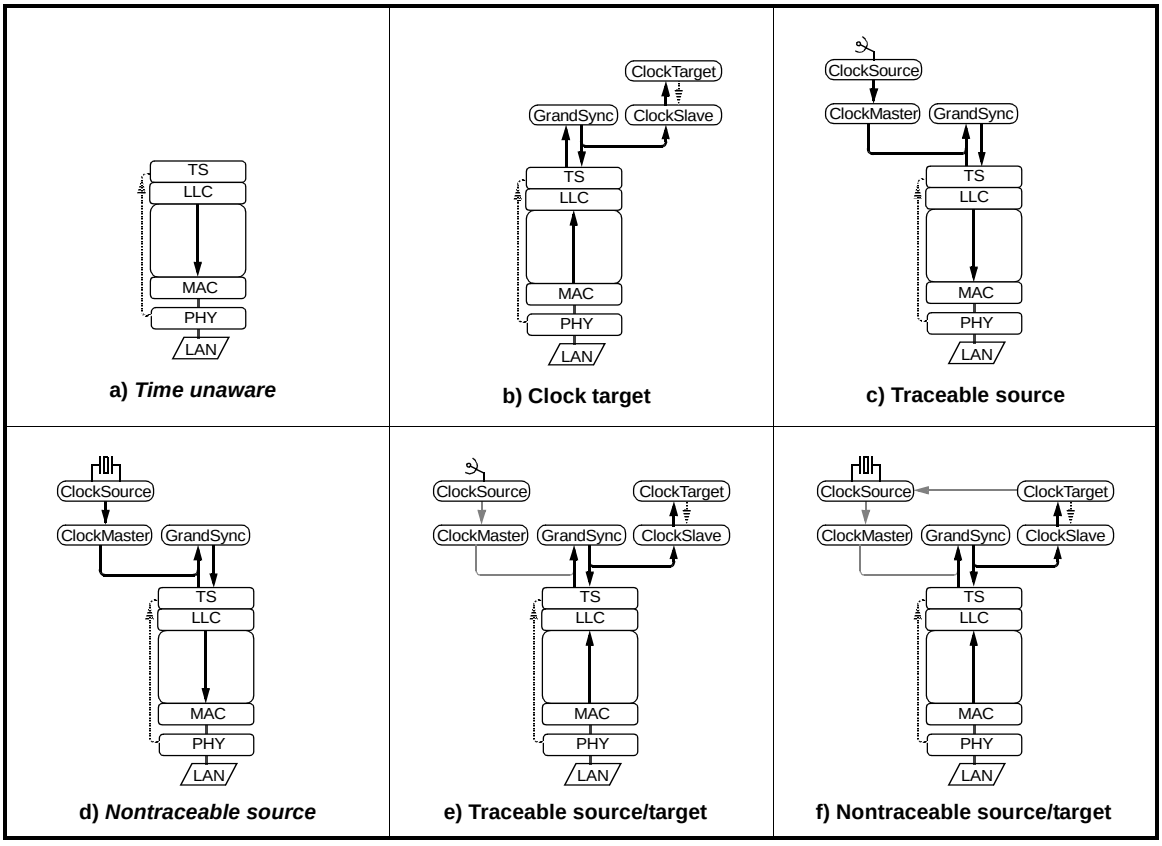

Figure 5.14—Time-aware end-station possibilities

A traceable ClockSource/ClockTarget station uses an external reference to drive its ClockSource entity, as illustrated in Figure 5.14e. A VCR that derives its time from the sideband PBS signal is one such example. Although its ClockSource is unaffected by the observed network time, its application clock is expected to be derived from the network-supplied clock, so as to minimize timing drifts and errors between stations when another station has been selected to become the grandmaster.

When not the grandmaster, a non-traceable ClockSource/ClockTarget station sets it ClockSource clock reference based on the time observed at its ClockTarget, as illustrated in Figure 5.14f. A clock radio is one such example. When (and if) this station becomes the grandmaster, its now free-running ClockSource entity provides network time.

A time-unaware end-station currently appears uninteresting. A nontraceable source (Figure 5.14d) has undesirable time-discontinuity properties and is *therefore explicitly disallowed*.

5.8.2 Time-aware bridge possibilities

Within the consumer environment, wiring constraints could be simplified by allowing devices to be cascaded. Consumer devices could thus include bridge-relay *and* end-station capabilities, as illustrated in Figure 5.15. Any of the ClockSource, ClockTarget, and ClockSource/ClockTarget combinations are possible, as illustrated in Figure 5.15a through Figure 5.15f. A time-aware bridge with neither ClockSource or ClockTarget capabilities (not illustrated) is also possible.

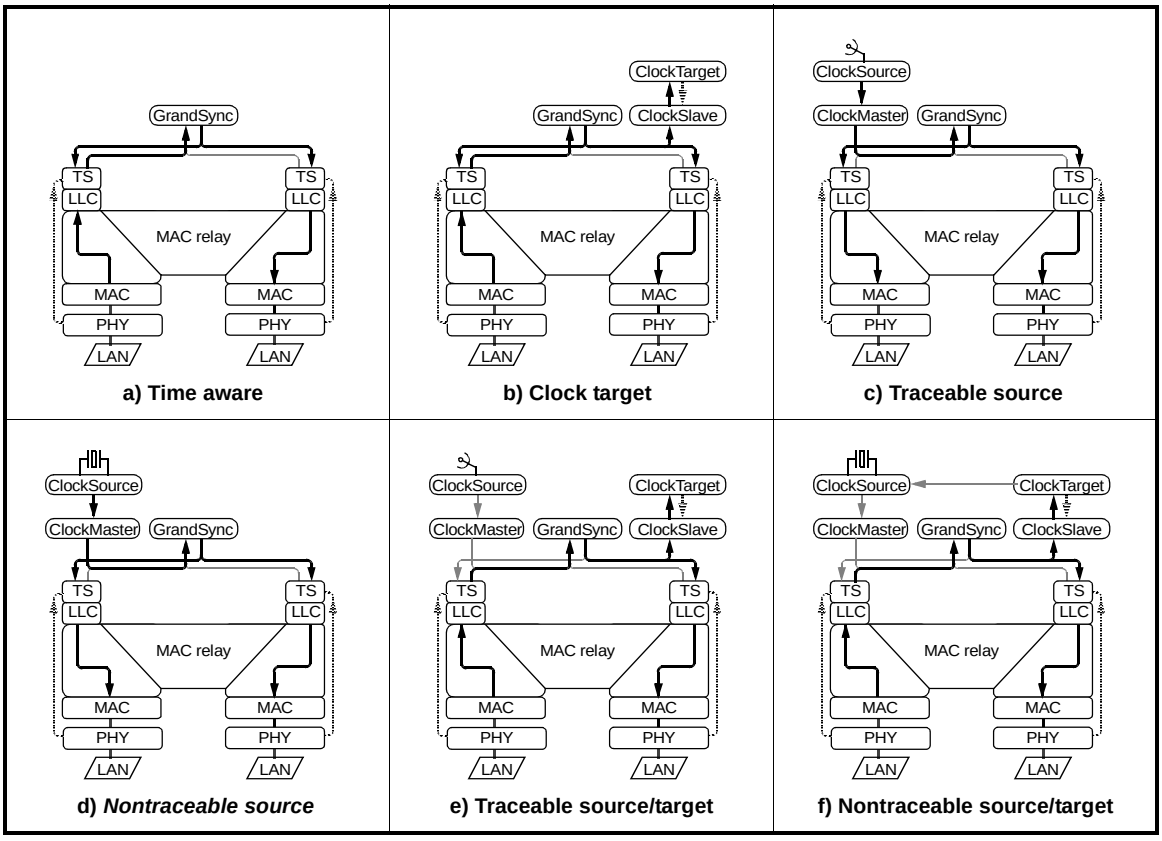

Figure 5.15—Clock-attached time-aware bridge possibilities

A time-aware bridge is a likely implementation, since it can forward the timing reference without supplying either ClockSource or ClockTarget entities. A nontraceable source (Figure 5.15d) still has undesirable time-discontinuity properties and is *therefore explicitly disallowed*.

5.8.3 Design option possibilities

A variety of design options are associated with a time-aware station, as listed below. The P1588 draft currently restricts the subset of possibilities, with only certain allowed combinations of properties, as visible in Table 5.1.

a) Ports. Either of the following are possible:
   1) One. An end-station has only one network port.
   2) More. A bridge station has two or more network ports.

b) Actions. Either of the following link-action mechanisms are possible:
   1) Peer-to-peer. Each master port calibrates delays to its directly attached slave port; the number of calibrations equals the number of direct-attach slave ports, always exactly 1.
   2) End-to-end. Each master port calibrates delays to each of its indirectly attached slave ports; the number of calibrations equals the number of end-to-end slave ports, typically more than 1.

c) Syncs. The transmission times of sync frames could depend on either of the following:
   1) Triggered. The clock-slave port's receipt of a sync frame triggers the transmissions.
   2) Periodic. Sync frame transmissions occurs periodically, independent of sync-frame receptions.

d) Announce. Either of the following Announce-forwarding mechanism are possible:
   1) Filtered. Announce packets are checked; only the best candidate is forwarded to others.
   2) Periodic. Announce packets are flooded everywhere, regardless of need.

e) Source. Either of the following grandmaster-capable clock-source presence selections are possible:
   1) Present. A ClockSource entity is present.
   2) Absent. No ClockSource entity is present.

f) Target. Either of the following clock-target presence selections are possible:
   1) Present. A ClockTarget entity is present.
   2) Absent. No ClockTarget entity is present

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Table 5.1—Possible time-aware station alternatives

Ports	Relay			Clock interfaces		Row	1588 name
	Master actions	Sync timing	Announce routing	Clock-Source	Clock-Target		
1	(1)	periodic	n/a	present	present	1	Ordinary clock
				absent	present	2	—
				present	absent	3	—
				absent	absent	4	(uninteresting)
	≥1	periodic	n/a	—	—	5-to-8	*E-to-E transparent present*
>1	1	periodic	filtered	present	present	9	Boundary clock
				absent	present	10	—
				present	absent	11	—
				absent	absent	12	—
			flooded	present	present	13	—
				absent	present	14	—
				present	absent	15	—
				absent	absent	16	—
	1	triggered	filtered	present	present	17	—
				absent	present	18	—
				present	absent	19	—
				absent	absent	20	—
			flooded	present	present	21	—
				absent	present	22	—
				present	absent	23	—
				absent	absent	24	Peer-to-peer transparent
	≥1	—	—	—	—	25	*E-to-E transparent present*

Notes:
n/a is an abbreviation for not applicable

Note that the IEEE P1588 design approach appears to constrain particular combinations of features. A preferred 802.1AS design approach removes these application restrictions by eliminating impractical or undesirable options, as discussed below.

The number of viable 802.1AS options can be quickly reduced by elimination of the uninteresting end-station and non-scalable bridge rows, leaving fewer entries in Table 5.2.

Table 5.2—Viable time-aware station alternatives

Ports	Relay		Clock interfaces		Row	1588 name
	Sync timing	Announce routing	Clock-Source	Clock-Target		
1	n/a	n/a	present	present	1	Ordinary clock
	n/a	n/a	absent	present	2	—
	n/a	n/a	present	absent	3	—
>1	periodic	filtered	present	present	4	Boundary clock
			absent	present	5	—
			present	absent	6	—
			absent	absent	7	—
		flooded	present	present	8	—
			absent	present	9	—
			present	absent	10	—
			absent	absent	11	—
	triggered	filtered	present	present	12	—
			absent	present	13	—
			present	absent	14	—
			absent	absent	15	—
		flooded	present	present	16	—
			absent	present	17	—
			present	absent	18	—
			absent	absent	19	Peer-to-peer transparent

Notes:
n/a is an abbreviation for not applicable

If the presence/absence of ClockSource and ClockTarget interfaces are recognized as an independent design issues, the number of distinct 802.1AS options is further reduced by elimination of many rows, leaving fewer entries in Table 5.3..

Table 5.3—Distinct time-aware station alternatives

Ports	Relay		Row	802.1AS name
	Sync timing	Announce routing		
1	n/a	n/a	1	End-station clock
>1	periodic	filtered	2	Boundary clock
		flooded	3	—
	triggered	filtered	4	—
		flooded	5	Transparent clock

Notes:
n/a is an abbreviation for not applicable

We recognize that the optimal sync-timing rate is media dependent and may differ for different technologies (802.3 full duplex, 802.3 EPON, or wireless) or for different operating modes of the same technology (normal vs. power-saving). Thus, a boundary-clock like design is necessary.

If this boundary-clock like design model meets our response-time and cumulative jitter requirements (as initial simulations appear to indicate), then the number of sufficient design alternatives is reduced, leaving fewer entries in Table 5.4..

Table 5.4—Sufficient time-aware station alternatives

Ports	Relay		Row	802.1AS name
	Sync timing	Announce routing		
1	n/a	n/a	1	End-station clock
>1	periodic	filtered	2	Boundary clock
		flooded	3	—

Notes:
n/a is an abbreviation for not applicable

The desire for quick response time, while avoiding broadcast storms in large configurations, appears to favor the use of filtered Announce-packet routing protocols. If the incremental costs filtering Announce packets are confirmed to be insignificant within time-aware bridges, the number of desired 802.1AS design alternatives is further reduced to an easily justifiable set, as illustrated in Table 5.5..

Table 5.5—Necessary time-aware station alternatives

Ports	Relay		Row	802.1AS name
	Sync timing	Announce routing		
1	n/a	n/a	1	End-station clock.
>1	periodic	filtered	2	Bridge clock.

Notes:
n/a is an abbreviation for not applicable