7.6.4 Data set comparison algorithm

The best master clock algorithm compares one clock to another by comparing data sets that represent those clocks. The data set comparison algorithm shall be as defined by Figure 17, Figure 18, Figure 19, and Figure 20. The data sets are indicated in these figures as set *A* and set *B*. The sources for data set values are given in Table 16.

NOTE—The general process followed in this comparison is as follows:

a) Find which clock derives its time from the better grandmaster. Choosing this, rather than which is the better clock, is essential for the stability of the algorithm.
b) If the grandmasters are equal or equivalent, choose the clock which is nearer in path length to its grandmaster, or which has heard from its grandmaster more recently.
c) If those properties are equivalent, use tie-breaking techniques.

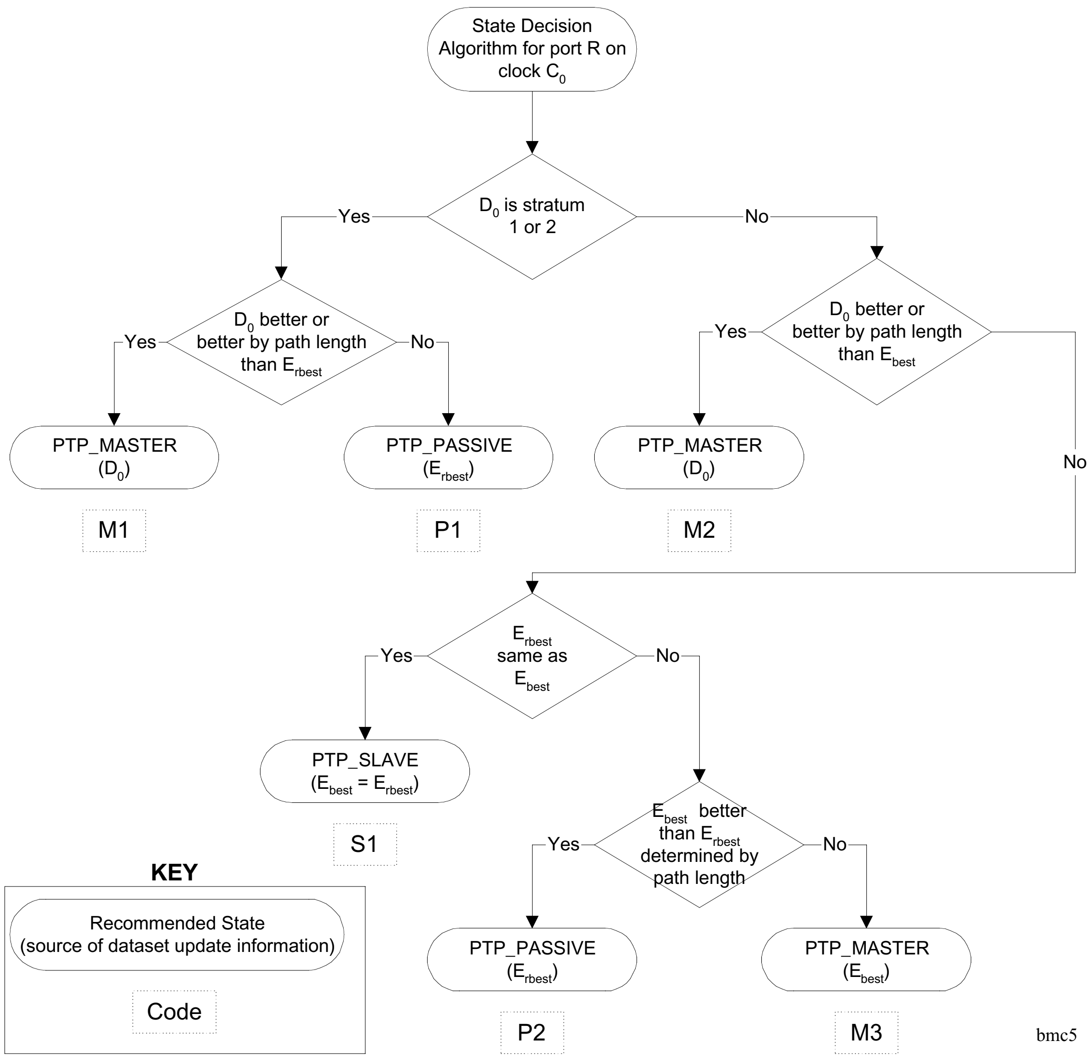

Figure 16—State decision algorithm

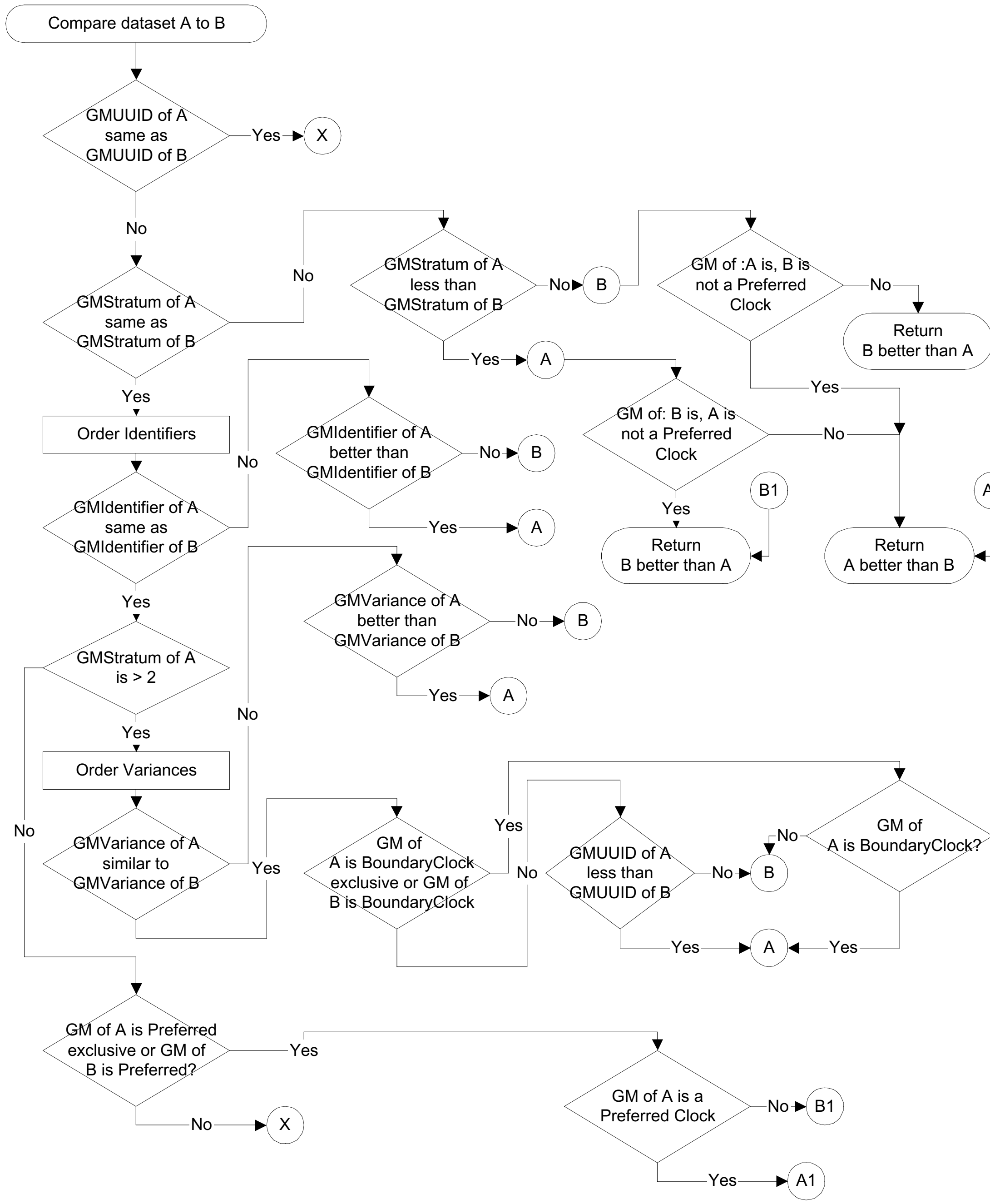

Figure 17—Data set comparison algorithm, part 1

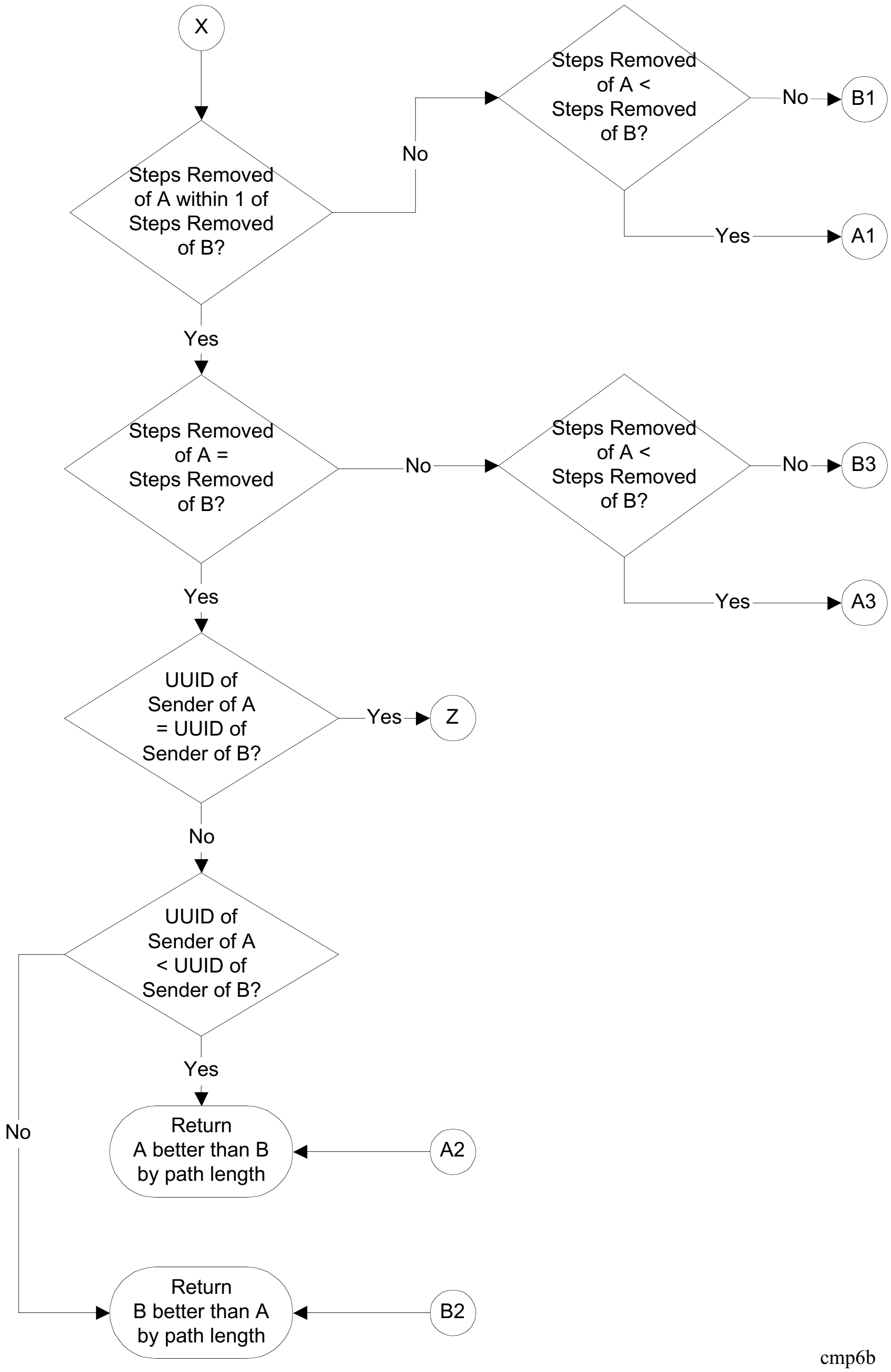

Figure 18—Data set comparison algorithm, part 2

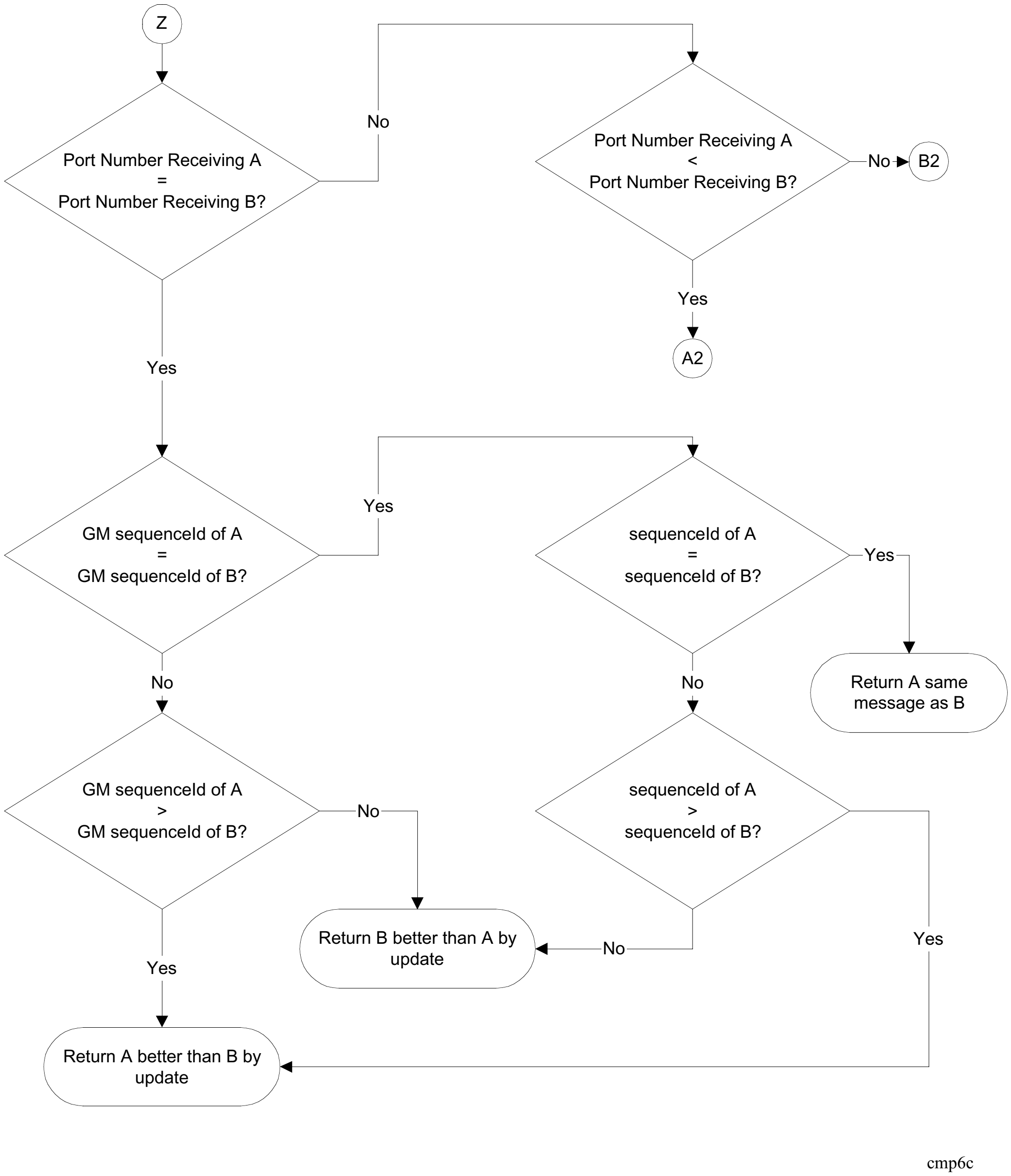

Figure 19—Data set comparison algorithm, part 3

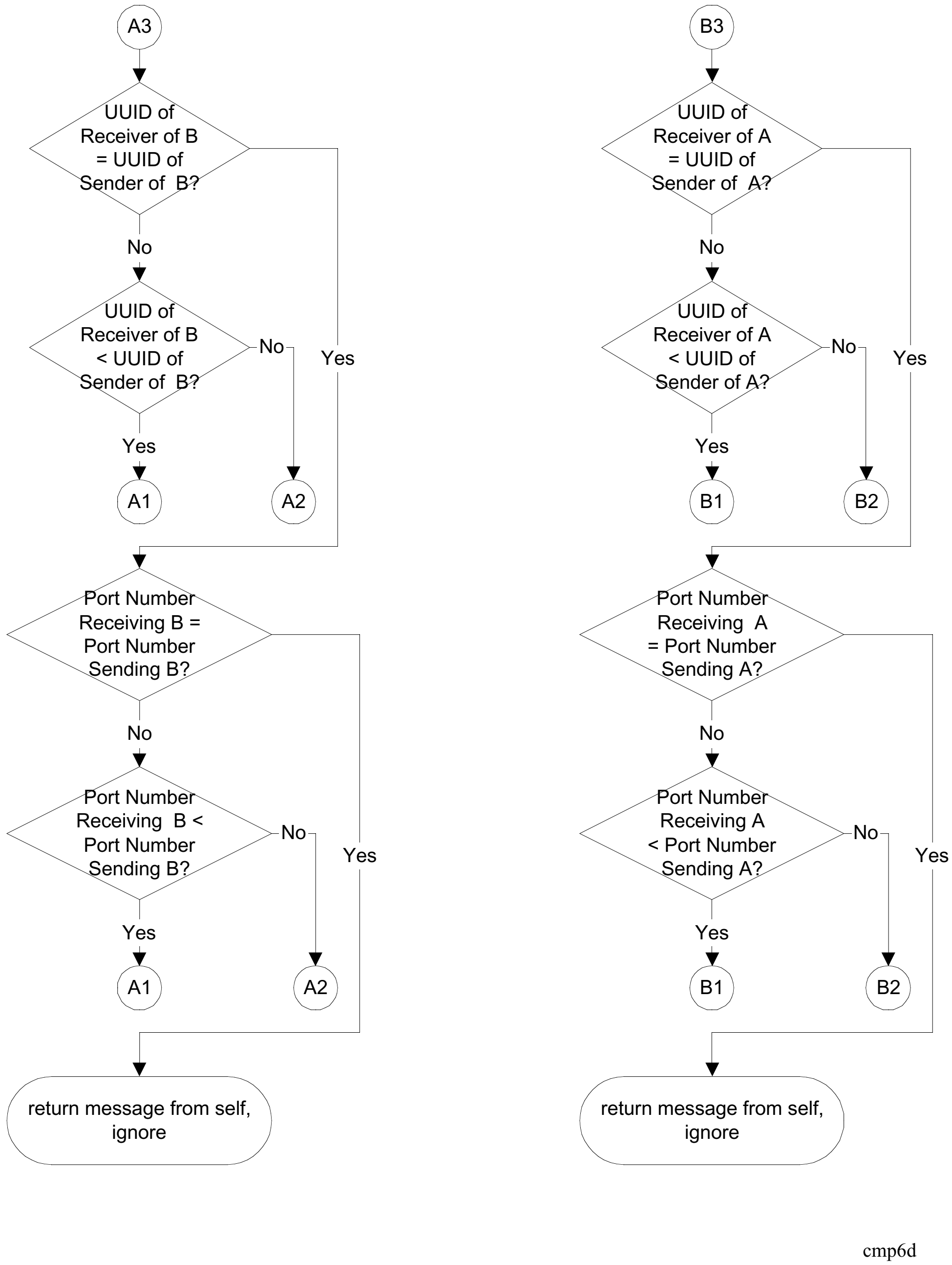

Figure 20—Data set comparison algorithm, part 4

Table 16—Information sources for data set comparison algorithm

When considering this property:	If the data set is E_{best} or E_{rbest}, use these fields of the associated message	If the data set is D_0, use these fields of the local clock
GMUUID	grandmasterCommunicationTechnology, grandmasterClockUuid, grandmasterPortId	clock_communication_technology, clock_uuid_field, clock_port_field
GMStratum	grandmasterClockStratum	clock_stratum
GMIdentifier	grandmasterClockIdentifier	clock_identifier
GMVariance	grandmasterClockVariance	clock_variance
GM is Boundary Clock	grandmasterIsBoundaryClock	is_boundary_clock
GM is Preferred Clock	grandmasterPreferred	preferred
Steps Removed	stepsRemoved	steps_removed
UUID of Sender	sourceCommunicationTechnology, sourceClockUuid, sourcePortId	clock_communication_technology, clock_uuid_field, clock_port_field
Port Number Receiving	port_id_field (of port database of port receiving message)	clock_port_field
GM sequenceId	grandmasterSequenceId	grandmaster_sequence_number of parent data set
sequenceId	sequenceId	grandmaster_sequence_number of parent data set
UUID of Receiver	port_communication_technology, port_uuid_field, port_id_field (all of port database of port receiving message)	clock_communication_technology, clock_uuid_field, clock_port_field
Port Number Sending	sourcePortId	clock_port_field

7.6.5 Update of data sets

The update of the current, parent, and global time data sets shall be as defined in Table 18, Table 19, Table 20, and Table 21 for the state decision codes, which are indicated by *Code* in Figure 16. The sources of update information are summarized in Table 17.

Table 17—Source of data set updates associated with state decision algorithm

State decision code	Source of update information
M1, M2	Default data set
M3	E_{best}
P1, P2, S1	E_{rbest}

Member port_state of the port configuration data set shall be updated as changes are made by the protocol engine of Figure 9 associated with each port in accordance with 7.5.8.

Data set fields which are not included in Table 18, Table 19, Table 20, and Table 21 are not updated due to requirements of this clause.

Table 18—Updates for state decision code M1 and M2

Update this field	From the indicated field of the default data set unless otherwise stated
Current data set	
steps_removed	set to 0
offset_from_master	set to 0
one_way_delay	set to 0
Parent data set	
parent_communication_technology	clock_communication_technology
parent_uuid	clock_uuid_field
parent_port_id	clock_port_field
parent_last_sync_sequence_number	set to 0
parent_followup_capable	clock_followup_capable
parent_external_timing	external_timing
parent_variance	clock_variance
grandmaster_communication_technology	clock_communication_technology
grandmaster_uuid_field	clock_uuid_field
grandmaster_port_id_field	clock_port_field
grandmaster_stratum	clock_stratum
grandmaster_identifier	clock_identifier
grandmaster_variance	clock_variance
grandmaster_preferred	preferred
grandmaster_is_boundary_clock	is_boundary_clock
grandmaster_sequence_number	see 7.4.4.20
Port configuration data set	
port_state	see 7.3.1

Table 19— Updates for state decision code M3

Update this field	From the indicated source
Port configuration data set	
port_state	see 7.3.1

Table 20—Updates for state decision code P1 and P2

Update this field	From the indicated source
Port configuration data set	
port_state	see 7.3.1

Table 21—Updates for state decision code S1

Update this field	From the indicated source
Current data set	
steps_removed	1 + value of localStepsRemoved of E_{best}
Parent data set	
parent_communication_technology	sourceCommunicationTechnology of E_{best}
parent_uuid	sourceUuid of E_{best}
parent_port_id	sourcePortId of E_{best}
parent_last_sync_sequence_number	sequenceId of E_{best}
parent_followup_capable	logical value of PTP_ASSIST bit of flags field of E_{best}
parent_external_timing	logical value of PTP_EXT_SYNC bit of flags field of E_{best}
parent_variance	localClockVariance of E_{best}
grandmaster_communication_technology	grandmasterCommunicationTechnology of E_{best}
grandmaster_uuid_field	grandmasterClockUuid of E_{best}
grandmaster_port_id_field	grandmasterPortId of E_{best}
grandmaster_stratum	grandmasterClockStratum of E_{best}
grandmaster_identifier	grandmasterClockIdentifier of E_{best}
grandmaster_variance	grandmasterClockVariance of E_{best}
grandmaster_preferred	grandmasterPreferred of E_{best}
grandmaster_is_boundary_clock	grandmasterIsBoundaryClock of E_{best}
grandmaster_sequence_number	grandmasterSequenceId of E_{best}
Global time properties data set	
current_utc_offset	currentUTCOffset of E_{best}
leap_59	logical value of PTP_LI_59 bit of flags field of E_{best}

Table 21—Updates for state decision code S1 *(continued)*

Update this field	From the indicated source
leap_61	logical value of PTP_LI_61 bit of flags field of E_{best}
epoch_number	epochNumber of E_{best}
Port configuration data set	
port_state	see 7.3.1

7.6.6 Ordering in the data set comparison algorithm

The ordering of two UUIDs shall be as specified in 6.2.4.1.

The ordering of two clock_identifiers shall be as specified in Figure 21. The clock_identifiers specified in Figure 21 are the only clock_identifiers allowed by 6.2.4.5. Implementations using other clock_identifiers shall assign an order number of 4 (see Figure 21). The behavior of systems containing clocks with non-conformant clock_identifiers is outside the scope of this standard.

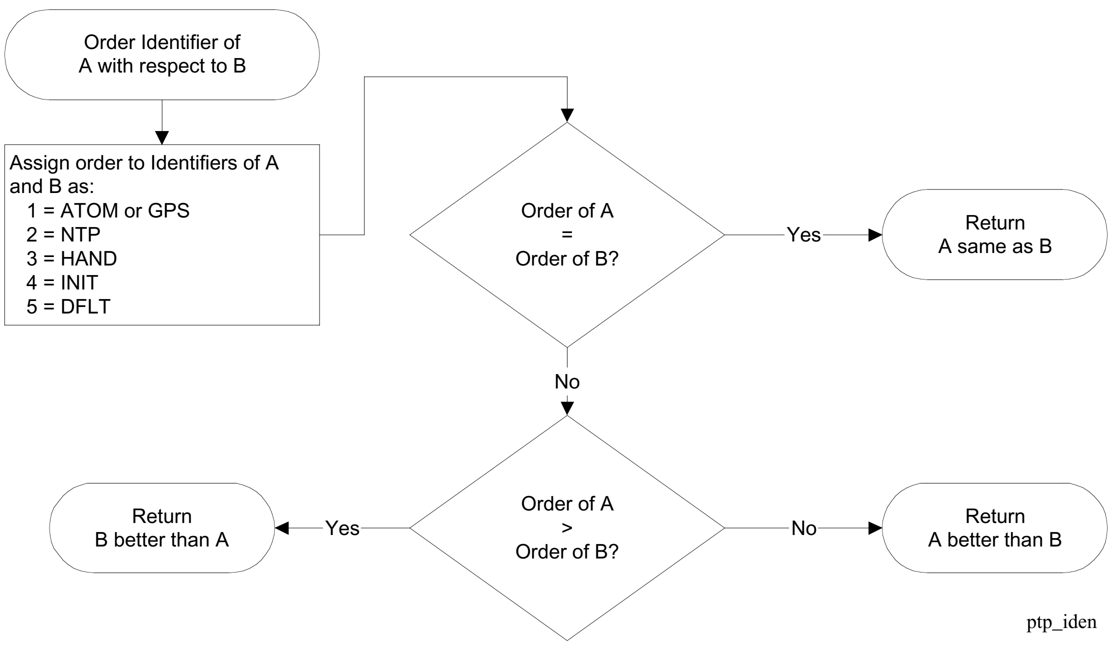

Figure 21—Ordering of clock_identifiers

The ordering of two variances shall be as specified in Figure 22. Note that the ordering algorithm operates on the scaled, logarithmic representations of the variances (see 7.7.2).

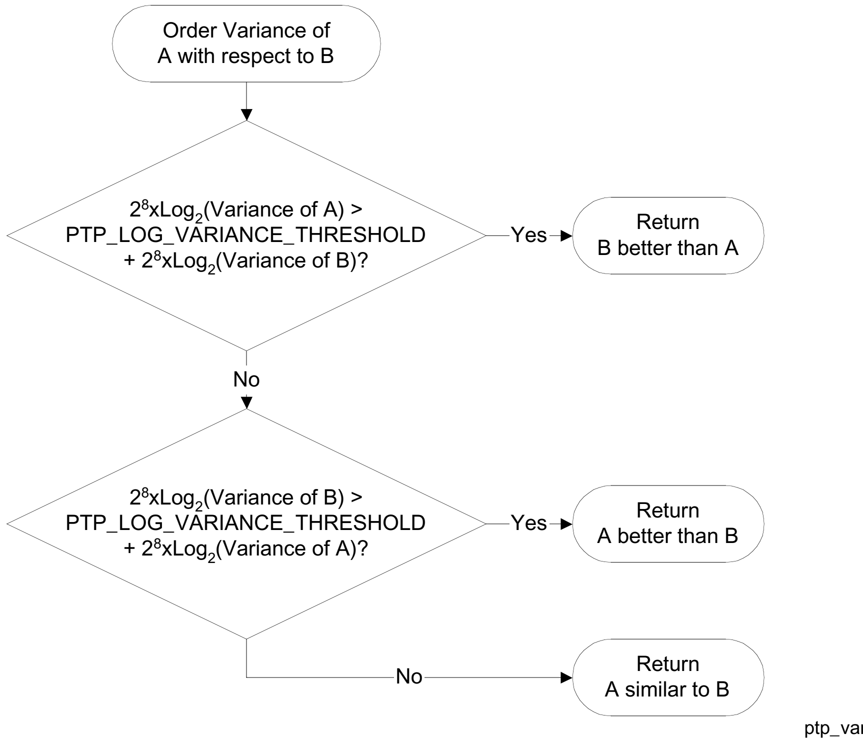

Figure 22—Ordering of variances

7.7 Clock variance computation

This clause defines the methods of computing the statistical properties of PTP clocks used in certain message field values and algorithms.

7.7.1 Variance algorithm

The PTP variance representing the performance of the appropriate clock shall be computed based on the theory of Allan deviation as follows:

The Allan deviation $\sigma_y(\tau)$ is defined as follows [B5]:

$$\sigma_y(\tau) = \left[\frac{1}{2(N-2)\tau^2} \times \sum_{k=1}^{N-2} (x_{k+2} - 2x_{k+1} + x_k)^2\right]^{\frac{1}{2}}$$

where x_k, x_{k+1}, and x_{k+2} are time residual measurements made at times t_k, $t_k + \tau$, and $t_k + 2\tau$ and τ is the sample period between measurements. The term residual implies that any consistent systematic effects have been removed from the data.

The Allan deviation as stated gives a statistic on the variation of the frequency of the oscillator used as the basis of the time base. PTP algorithms are based on statistics of the time differences as measured against a reference clock, rather than Allan frequency statistics.

The PTP variance, $\sigma^2_{PTP} = \tau^2 \times \frac{1}{3}\sigma_y^2$, shall be as follows:

$$\sigma^2_{PTP} = \frac{1}{3}\left[\frac{1}{2(N-2)} \times \sum_{k=1}^{N-2}(x_{k+2} - 2x_{k+1} + x_k)^2\right]$$

where x_k, x_{k+1}, and x_{k+2} are time residual measurements, made at times t_k, $t_k + \tau$, and $t_k + 2\tau$, between the time provided by the measured clock and a local reference clock. For PTP variances τ, the sample period shall be the sync interval.

Implementations may compute a conservative estimate of the PTP variance rather than computing the exact value given here. Note that this may be necessary in implementations with limited computational or memory resources [B9].

NOTE—The dependence of the Allan deviation on the sample period provides information on the type of the underlying noise processes. The Allan deviation is not sensitive to systematic offsets in time or in frequency, even though those offsets may be important in some applications of this standard. In addition, the Allan deviation does not provide a useful diagnostic when the noise spectrum contains *bright lines*—power line– induced variations at 60 Hz, for example. Finally, the Allan deviation is computed as an average over the ensemble of observations, and it is most useful when the data are statistically stationary. The deviation does not provide a good measure of the frequency or amplitude of occasional glitches, even though those sorts of events might also be important in some applications of this standard.

7.7.2 Variance representation

Variances shall be represented as follows:

- An estimate of the variance σ^2_{PTP} specified in 7.7.1 shall be computed.
- The value of the logarithm to the base 2 of this computed estimate shall be computed. The computation of the logarithm need not be more precise than the precision of the estimate of the variance.
- This value shall be multiplied by 2^8 to produce a scaled value.
- This scaled value shall be modified per the hysteresis specification of this clause to produce the reported value.
- This reported value, represented as an Integer16, shall be the value of the variances specified in 7.4.2.6 and 7.4.4.9.

This representation ensures that the ordering of variances algorithm of 7.6.6 produces identical results in all implementations. (This cannot be guaranteed with a floating-point representation).

Since variance values are used in the selection of the best master clock (see 7.6.6), implementations shall include hysteresis in the estimation of the variance to preclude thrashing in the process of selecting the master clock. The magnitude of this hysteresis shall be PTP_LOG_VARIANCE_HYSTERESIS and shall be applied to the scaled values of the logarithm of the estimate to generate the reported scaled values of the logarithm of the estimate as shown in Figure 23. Sufficient local state shall be maintained to allow correct implementations of the hysteresis properties for both increasing and decreasing trends in the actual variance estimate.