International Telecommunication Union

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Amendment 1

(08/2013)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Packet over Transport aspects – Quality and availability targets

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Definitions and terminology for synchronization in packet networks

Amendment 1

Recommendation ITU-T G.8260 (2012) – Amendment 1

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Recommendation ITU-T G.8260

Definitions and terminology for synchronization in packet networks

Amendment 1

Summary

Amendment 1 to Recommendation ITU-T G.8260 (2012):

- Adds a reference in clause 2.
- Modifies definition 3.1.8, "packet-based method with timing support from the network".
- Adds a number of definitions in clause 3.1.
- Adds new clause I.5.1 to Appendix I, describing the determination of floor delay and discussion of the impact of re-route events.
- Adds new clause I.5.2 to Appendix I, describing the impact of exceptional events on packet network limit.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.8260	2010-08-12	15
2.0	ITU-T G.8260	2012-02-13	15
2.1	ITU-T G.8260 (2012) Amd. 1	2013-08-29	15

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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Recommendation ITU-T G.8260

Definitions and terminology for synchronization in packet networks

Amendment 1

1) Clause 2, References

Add the following reference:

[ITU-T G.823] Recommendation ITU-T G.823 (2000), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy*.

2) Clause 3.1, Terms defined in this Recommendation

a) Replace definition 3.1.8:

3.1.8 packet-based method with timing support from the network: Packet-based method (frequency or time-phase synchronization) requiring that all the network nodes on the path of the synchronization flow implement one of the two following types of functional support:

- termination and regeneration of the timing (e.g., NTP stratum clocks, PTP boundary clock);
- a mechanism to measure the delay introduced by the network node and/or the connected links (e.g., PTP transparent clock) so that the delay variation can be compensated using this information.

with the following:

3.1.8 packet-based method with full timing support to the protocol level from the network: Packet-based method (frequency or time-phase synchronization) requiring that all the network nodes on the path of the synchronization flow implement one of the two following types of timing support:

- termination and regeneration of the timing (e.g., NTP stratum clocks, PTP boundary clocks);
- a mechanism to correct for the delay introduced by the network node and/or the connected links (e.g., PTP transparent clocks).

b) Add the following additional definitions at the end of clause 3.1:

3.1.18 packet-based method with partial timing support to the protocol level from the network: Packet-based method (frequency or time-phase synchronization) where not all of the network nodes on the path of the synchronization flow implement timing support.

3.1.19 packet timing monitor: A device capable of analysing the packet flow (e.g., PTP) including precise measurement of the sending times and arrival times of timing event messages utilizing an accurate, stable clock. A tapped monitor does not substantively impact the transmission of packets between the communicating clocks; an in-line monitor introduces a fixed, symmetric, delay for packets in the two directions of transmission and thereby does not substantively impact the transfer of timing between the communicating clocks.

3.1.20 time error (Based on [ITU-T G.810]):

- **Constant time error**: With reference to the time error model provided in [ITU-T G.810], the constant time error is the term x_0.
- **Constant time error estimate**: Given a time error sequence $\{x(n); n = 0,1,\ldots,(N-1)\}$, an estimate of the constant time error is the average of the first M samples of the time error sequence. M is obtained from the observation interval providing the least value for TDEV as computed for the given time error sequence. If a frequency offset is present then a linear regression method in accordance with Appendix II of [ITU-T G.823] can be applied. Considerations for measurement data containing transients is for further study.

  NOTE – In some cases due to the frequency components of the noise of the signal being measured it might be difficult to identify a stable, consistent observation interval. These cases must be addressed case by case.

3) Clause I.3.2, Packet selection methods

Replace clauses I.3.2 through I.3.2.3 with the following:

I.3.2 Packet selection methods

Four examples of packet selection methods are described in the clauses that follow. The first two, minimum packet selection and percentile average packet selection, focus on packet data at the floor. The second two, band average packet selection and cluster range packet selection, can be applied either at the floor or at some other region.

I.3.2.1 Minimum packet selection method

The minimum packet selection method involves selecting a minimum within a section of data. This can be represented as follows:

$$x_{\min}(i) = \min[x_j] \text{ for } (i \le j \le i + n - 1) \qquad \text{(I-2)}$$

I.3.2.2 Percentile average packet selection method

The percentile average packet selection method is related to the minimum packet selection method, except that instead of selecting the minimum, some number (or some percentage) of minimum values are chosen and averaged together. It is a special case of the band average packet selection method described below with the lower index set to zero.

I.3.2.3 Band average packet selection method

The band average packet selection method can be used to select a section of packet data at the floor or from some other region such as the ceiling or somewhere else above the floor. To perform the band average packet selection, it is first necessary to represent the sorted packet time-error sequence. Let x' represent this sorted phase sequence from minimum to maximum over the range $i \le j \le i + n - 1$. Next, it is necessary to represent the indices which are themselves set based on the selection of two percentile levels.

Let a and b represent indices for the two selected percentile levels. The averaging is then applied to the x' variable indexed by a and b. The number of averaged points m is related to a and b: $m = b - a + 1$.

$$x'_{band\_avg}(i) = \frac{1}{m} \sum_{j=a}^{b} x'_{j+i} \qquad \text{(I-3)}$$

A percentile level is selected by using rounding to find the closest index from the desired percentile value. The additional constraint is that the index value has a minimum of the first index and a maximum of the last index. Thus, for example, a set of ten points with a percentile set to 2% (0.02) would be set to the minimum index so that at least a single point would be selected.

4) Clause I.5, PDV metrics studying floor delay packet population

Add the following text at the end of clause I.5:

I.5.1 Determination of observed floor delay

When calculating the floor population metrics, it is first necessary to determine the value of the "observed floor delay". Whereas it is permissible for the user to specify a suitable value for the floor delay, two data-driven methods of determining this value are described here. The first method, called the *overall minimum* method, is to use the minimum delay observed over the entire measurement period. The second method, called the *progressive minimum* method, is to use the minimum observed delay in the measurement period up to the time window over which the individual floor population metric value is calculated. Refer to clause I.5.1.3 for information concerning the impact of packet network re-route events on the determination of observed floor delay.

I.5.1.1 Minimum floor delay over the entire measurement

In the *overall minimum* method, the "observed floor delay" used in computing the floor population metrics is the minimum delay value over the entire measurement data set according to clause I.5, equation (I-33).

As the overall minimum delay for a measurement period may not be known until the end of the period, calculation of floor population metric values over a given time window may depend upon delay values that have not yet been observed. This dependency upon future observations makes it more difficult to provide an early indication of floor population conformance for long-term tests.

I.5.1.2 Progressive determination of floor delay

In applications where it is not practical to wait till the end of the measurement period to determine the observed floor delay, the following causal estimation procedure can be used. At each floor population metric computation point *n,* the observed floor delay is estimated as the smallest delay value in the measurement period up to (and including) the window over which the metric is computed. This running estimate of floor delay is then used when calculating the floor population metric. This enables calculation of the floor population metric value at any given time depends only upon delay values that have already been observed.

To accommodate the dynamic notion of "observed floor delay", the floor population metrics defined in clause I.5 are modified to use the current retrospective estimate of the floor delay rather than the minimum over the whole data set. The terminology used is $FPx_M(n,W,\delta,d_{min}(n))$ where "x" represents the metric ("count", "rate", "percent"), the subscript M indicates that the formula used is a modified form of the ITU-T G.8260 definition, and $d_{min}(n)$ is the current running estimate of the floor delay.

In terms of equation (I-33) above, the observed floor delay at time n (where n is always a sample index at the end of an observation window) can be estimated as:

$$d_{\min}(n) = \min_{0 \le i < n} x[i] \qquad \text{(I-40)}$$

The value of the floor packet metrics in equations (I-35) to (I-37) at time n are then calculated using $d_{min}(n)$ instead of d_{min} in equation (I-33).

As an example for a specific implementation, the floor delay at time *n* can be iteratively estimated as according to the following algorithm:

1) Denote $d(n)$ *as* the minimum packet delay of the most recent observation window;
2) Compare $d(n)$ to the current estimate of the "observed floor delay" $d_{min}(n)$

   a) If $d(n) < d_{min}(n) \quad \Rightarrow \quad d_{min}(n) = d(n)$

   b= Otherwise $\quad \Rightarrow \quad d_{min}(n)$ remains unchanged (I-41)

The progressive floor determination method continually refines the estimate of the observed floor delay value during the measurement period. At each Floor Population metric computation point *n*, the observed floor delay is estimated as the smallest delay value, $d_{min}(n)$, in the measurement period up to (and including) the window over which the metric is computed. The running value of this estimate is then used when calculating the (estimated) Floor Population metric. The windows could be sliding, overlapping, or jumping.

Starting from the first observation window and for each subsequent window, the Floor population metrics are computed as $FPx_M(n,W,\delta,d_{min}(n))$.

An initial *settling-time* (*S* seconds) should be allowed to ensure a good estimate of the floor has been established, resulting in valid calculations only occurring after this time has elapsed. The objective is to select a value of *S* after which the estimation of the observed floor delay would be close enough to the "true" delay floor, allowing for reliable FP*x* conformance tests to be calculated for the subsequent observation windows. The settling time can be either based on a predefined fixed value (based, for example, on some worst-case assumption) or calculated in real-time based on the specific properties of the packet delay. The specific method/value is for further study. It has been demonstrated that for test cases of Appendix VI of [ITU-T G.8261], a value of *S*=600s should suffice.

I.5.1.3 Re-route events and impact on observed floor delay

I.5.1.3.1 Re-route events

Re-route events are defined as a change in the path taken by packets through a network. Such a re-route event can result in a change to the observed floor delay of a given PTP flow.

Significant re-route events that occur in a given network are expected to have the following attributes:

1) Re-route events are infrequent. In a well-engineered telecom network, such re-route events (usually as a result of some equipment malfunction or routine maintenance) should be quite rare.
2) A single re-route event may cause multiple floor delay changes over a short time period. (e.g., a network maintenance activity that results in a short-term network re-route event that is restored through a second re-route event after a relatively short period of time). Such a series of proximate re-route events should be regarded as a single event. It is typically assumed that such "network route instability" can last between a few minutes (due to SW upgrade of the routers) up to a few hours (as a result of some failure in the network).
3) The consequent floor delay changes are abrupt. The floor delay changes occur within only a few packet interval durations (as it is very short, the specific duration is not critical).

I.5.1.3.2 Re-route event impact on packet network limit

Unlike network loading variations, congestion and other extreme conditions, observed floor delay changes due to re-route events are not part of the packet network limit and do not consume part of the packet network limit budget.

When a re-route event occurs the packet network is considered to not comply with the packet network limit. The packet network limit measurement should be re-started and a new observed floor delay computed. It should be noted that between re-route events, the network observed floor delay is considered to be fixed and thus, the FPP calculation procedures described in clause I.5.1 apply.

I.5.1.3.3 Determination of re-route events

The methods of determination of re-route event occurrences and related observed floor delay change are for further study. These methods are applicable to network analysis equipment and are not applicable to packet slave clocks.

I.5.2 Exceptional events and impact on packet network limit

Exceptional events and other severe, unexpected network phenomenon may occur from time to time in a packet network. These events may reduce the number of packets that arrive within the defined cluster range, thereby causing a temporary failure of the packet network to comply with the defined FPP network limit. To accommodate such exceptional events, a small number of non-overlapping failing windows (X) may be allowed over a measurement period (Y). To ensure that such exceptional events have limited time duration, the maximum number of consecutive non-overlapping failing windows may also be specified (Z). The values of X, Y and Z are defined in the relevant Recommendations.

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