International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.8271/Y.1366

Amendment 2
(01/2015)

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

Packet over Transport aspects – Synchronization, quality and availability targets

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Internet protocol aspects – Transport

Time and phase synchronization aspects of packet networks

Amendment 2

Recommendation ITU-T G.8271/Y.1366 (2012) – Amendment 2

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ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T G.8271/Y.1366

Time and phase synchronization aspects of packet networks

Amendment 2

Summary

Amendment 2 to Recommendation ITU-T G.8271/Y.1366 (2012) provides the following update:

– Additional information on the delay asymmetry and asymmetry compensation aspects.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.8271/Y.1366	2012-02-13	15	11.1002/1000/11527
1.1	ITU-T G.8271/Y.1366 (2012) Amd. 1	2013-08-29	15	11.1002/1000/12033
1.2	ITU-T G.8271/Y.1366 (2012) Amd. 2	2015-01-13	15	11.1002/1000/12391

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Recommendation ITU-T G.8271/Y.1366

Time and phase synchronization aspects of packet networks

1) Clause I.6, Derivation of delay asymmetry

Replace clause I.6 with the following:

I.6 Derivation of delay asymmetry

Figure I.1 illustrates the delays between a packet slave clock function, or requestor (denoted as slave throughout this clause), and a packet master clock function, or responder (denoted as master throughout this clause). The mean propagation delay is measured at the slave after exchange of event messages. If the Delay Request and the Delay Response mechanism is used (see [IEEE 1588-2008]), the slave sends Delay_Req and the master sends Delay_Resp and, separately, Sync and Follow_Up (i.e., the sending of Sync and Follow_Up are not part of the Delay_Req/Delay_Resp exchange; the Follow_Up message is sent if, and only if, the clock is two-step). If the Peer Delay mechanism is used (see [IEEE 1588-2008]), the slave sends Pdelay_Req and the master sends Pdelay_Resp and, if the clock is two-step, Pdelay_Resp_Follow_Up.

The figure shows the effective points in the protocol stack of each clock where timestamps are generated, after any corrections for ingress and egress latencies are made (see section 7.3.4 and Figure 19 of [IEEE 1588-2008]). These points would ideally be at the reference plane, i.e., the boundary point between the PHY and the network physical medium. However, in practice, the corrections for ingress and egress latencies are not perfect, and the effective points at which the timestamps are generated differ from the reference plane. The delays between the effective points where timestamps are taken and the reference plane are denoted $d_{tx}^{PHY,M}$ and $d_{rx}^{PHY,M}$ for egress and ingress, respectively, at the master, and $d_{tx}^{PHY,S}$ and $d_{rx}^{PHY,S}$ for egress and ingress, respectively, at the slave. In this notation, the subscript *t* (transmit) is used for egress and the subscript *r* (receive) is used for ingress. In general, these four quantities can all be different.

The figure also shows the link delays, which are measured from the reference plane of one clock to the reference plane of the other clock. The delay from the master to the slave is denoted d_{ms}^{link}, and the delay from the slave to the master is denoted d_{sm}^{link}.

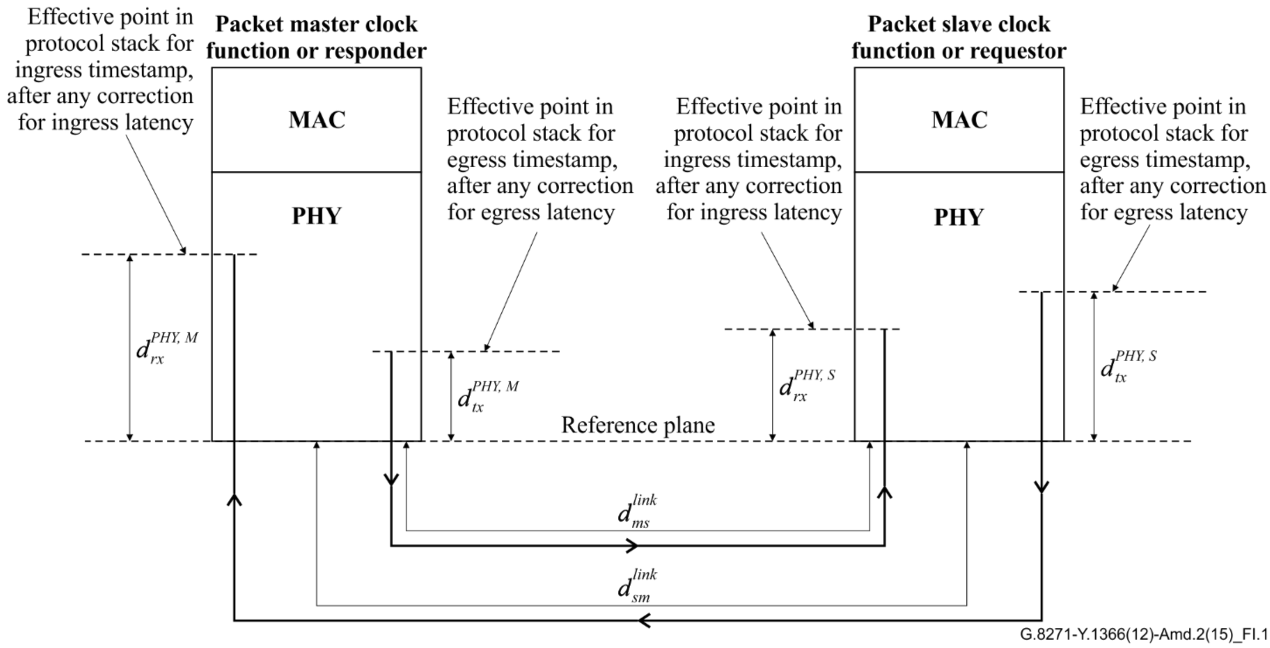

Figure I.1 – Illustration of delays between a packet slave clock function, or requestor, and a packet master clock function, or responder

The total delay from the master to the slave, t_{ms}, is the sum of the delays in that direction:

$$t_{ms} = d_{tx}^{PHY,M} + d_{ms}^{link} + d_{rx}^{PHY,S} \quad \text{(I-1)}$$

Similarly, the total delay from the slave to the master, t_{sm}, is the sum of the delays in that direction:

$$t_{sm} = d_{tx}^{PHY,S} + d_{sm}^{link} + d_{rx}^{PHY,M} \quad \text{(I-2)}$$

For the sign convention for the delay asymmetry, the same convention as in section 7.4.2 of [IEEE 1588-2008] is adopted. Let D_{mean} denote the measured mean path delay (i.e., the measured result of the exchange of Delay_Req and Delay_Resp or of Peer Delay messages), and D_{asym} denote the total delay asymmetry. Then, D_{asym} is defined to be positive when the delay from the master to the slave is larger than the delay from the slave to the master. Likewise, D_{asym} is defined to be negative when the delay from the master to the slave is smaller than the delay from the slave to the master. Then:

$$\begin{aligned} t_{ms} &= D_{mean} + D_{asym} \\ t_{sm} &= D_{mean} - D_{asym} \end{aligned} \quad \text{(I-3)}$$

Equations (I-3) imply that:

$$D_{mean} = \frac{t_{ms} + t_{sm}}{2} \quad \text{(I-4)}$$

as required. Substituting equations (I-1) and (I-2) into equation (I-4) gives:

$$D_{mean} = \frac{(d_{tx}^{PHY,M} + d_{ms}^{link} + d_{rx}^{PHY,S}) + (d_{tx}^{PHY,S} + d_{sm}^{link} + d_{rx}^{PHY,M})}{2} \quad \text{(I-5)}$$

Either of the two equations (I-3) may be used with equation (I-4) to obtain the delay asymmetry in terms of the component delays. Using the first of equations (I-3) produces:

$$
\begin{aligned}
D_{asym} &= t_{ms} - D_{mean} \\
&= (d_{tx}^{PHY,M} + d_{ms}^{link} + d_{rx}^{PHY,S}) - \frac{(d_{tx}^{PHY,M} + d_{ms}^{link} + d_{rx}^{PHY,S}) + (d_{tx}^{PHY,S} + d_{sm}^{link} + d_{rx}^{PHY,M})}{2} \\
&= \frac{d_{tx}^{PHY,M} - d_{rx}^{PHY,M}}{2} + \frac{d_{ms}^{link} - d_{sm}^{link}}{2} + \frac{d_{rx}^{PHY,S} - d_{tx}^{PHY,S}}{2} \\
&= e_{phy}^{M} + e_{link-asym} - e_{phy}^{S}
\end{aligned}
\tag{I-6}
$$

where:

$$e_{phy}^{M} = \frac{d_{tx}^{PHY,M} - d_{rx}^{PHY,M}}{2} \tag{I-7}$$

$$e_{link-asym} = \frac{d_{ms}^{link} - d_{sm}^{link}}{2} \tag{I-8}$$

$$e_{phy}^{S} = \frac{d_{tx}^{PHY,S} - d_{rx}^{PHY,S}}{2} \tag{I-9}$$

Equations (I-7) and (I-9) are the errors due to PHY latency asymmetry at the master and slave respectively. Equation (I-8) is the error due to link asymmetry. Equation (I-6) indicates that, in computing the total asymmetry, the errors due to PHY latency at the master and due to the link are added, while the error due to PHY latency at the slave is subtracted.

2) Appendix IV, Link and network asymmetry compensation

Add the following new Appendix:

Appendix IV

Link and network asymmetry compensation

(This appendix does not form an integral part of this Recommendation.)

In order to compensate for link delay asymmetry, it might be desirable to have in place some automatic link asymmetry calibration procedure. This could be based on calculating the propagation delays by means of two-way measurements made on the fibres used by the traffic.

The procedure can be done separately on both fibres (in the fibre used in the forward direction and in the fibre used for the reverse direction) providing the forward propagation delay d_f and the reverse propagation delay d_r. This is shown in Figure IV.1.

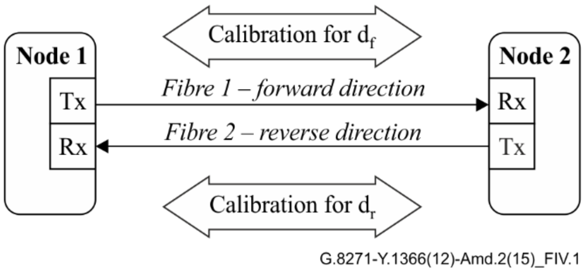

Figure IV.1 – Link asymmetry calibration process (performed separately on both fibres)

Alternatively the round trip measurement could be done in two steps on both fibres by reversing the direction of transmission. This is shown in Figure IV.2.

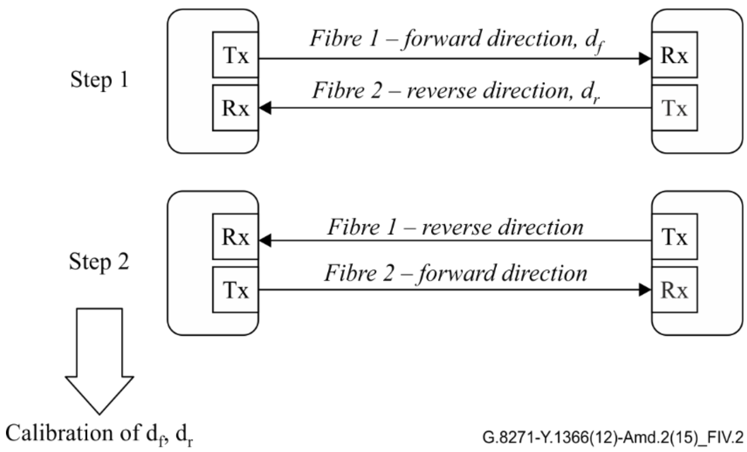

Figure IV.2 – Link asymmetry calibration process (performed on both fibres at the same time)

NOTE 1 – In the case of the connection between master and slave, as shown in Figure I.1, the following would apply:

$$d_f = d_{ms}$$

$$d_r = d_{sm}$$

The link asymmetry calibration mechanism must meet an accuracy objective for d_f and d_r estimations. This limit is for further study.

NOTE 2 – In the case during the asymmetry calculation procedure where one node enters holdover (e.g., caused by the fibres-swapping if this is required by the procedure), the effect of the frequency holdover needs to be taken into account as it might impact the accuracy of the measurement.

Several implementations are possible, e.g., based on optical switches or fixed or tunable add drop filters. Depending on the implementation, it may not be required to interrupt the traffic during the calibration process and hence in-service operation might be possible. However, the asymmetry compensation is a process that is only required at start-up or during rearrangements in the network.

This measurement is applicable for WDM systems (including OTN) and non-WDM systems. In the case of wavelength-division-multiplexing (WDM) systems, this measurement should also take into account possible delay due to dispersion-compensating fibre (DCF).

NOTE 3 – In the case of WDM systems, the asymmetry due to the use of different wavelengths in the two directions should also be taken into account. Indeed, the use of different wavelengths on the two fibres, (or in a single fibre in the case of a transmission system using a single fibre), would result in different delays even if the fibres have the same length. Note also that a compensation related to the same aspect would be required if the wavelength used during the link asymmetry calibration process is different from the wavelength used by the traffic. Suitable methodologies to address this point are introduced in Appendix III.

The difference ($d_f - d_r$) can be used in the evaluation of the delay asymmetry to be used in the time recovering process. In particular the *delayAsymmetry* parameter as defined in section 7.4 of [IEEE 1588-2008] would be half of that difference.

NOTE 4 – If a T-BC is implemented in every node, the compensation can be triggered directly by the T-BC, which would know the difference ($d_f - d_r$). If this is not the case, some means have to be provided in order to make the difference ($d_f - d_r$) available at the points in the network where the precision time protocol (PTP) messages are processed. This is for further study.

NOTE 5 – In the case of a time synchronization carried by PTP, the PTP connection may have asymmetry due to a variety of reasons, including network paths, loading levels or cable lengths. The asymmetry of a PTP connection may be evaluated at a PTP network element, if the network element has access to a second time synchronization source that is not significantly impacted by asymmetry (such as a GNSS receiver, or a time synchronization reference carried via timing protocols such as PTP with proper accuracy) as shown in Figure IV.3. If the asymmetry of the PTP connection is evaluated using such a second time synchronization source, then the offset caused by the asymmetry may be compensated by the network element. The same principle could be applied between network elements in a chain.

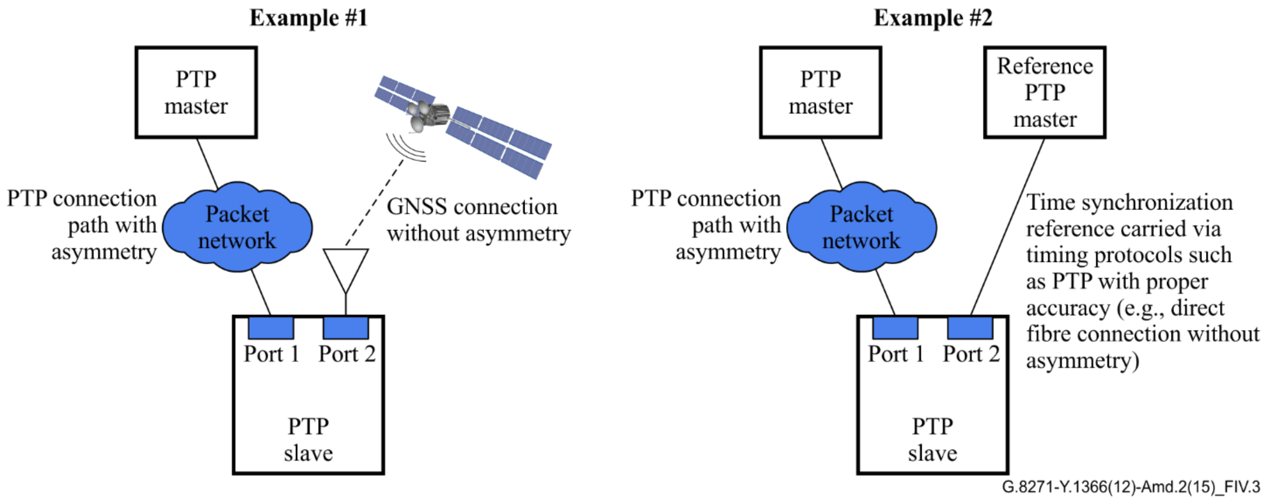

Figure IV.3 – PTP slave evaluating PTP connection asymmetry

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