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Abstract

This document contains the draft of Amendment 1 to the ITU-T Recommendation G.8271 that was agreed by Q13 during the meeting in Geneva, 19 – 30 June, 2017.

It is intended for consent at the SG15 plenary meeting, June 2017.

Draft Amendment 1 to Recommendation ITU-T G.8271/Y.1366 (2016)

Time and phase synchronization aspects of telecommunications networks: Amendment 1

Summary

Amendment 1 to Recommendation ITU-T G.8271 (2016) provides the following updates:

- Updated Title and Scope
- Updated Conventions clause
- Updated Table 1 and addition of Table 2, describing applications for high-accuracy time synchronization
- Revised notes in clause 7 and 7.1
- Revised clause 8, updating reference point descriptions
- Correction to the definition of the FCS field in the serial communication channel
- Replacement of Table A.7 with a new version and associated notes
- Revision to Tables II.1 and II.2 of Appendix II
- Correction to Appendix V

***Note to ITU Editor:** Figures 4 and 5 have been changed from the original published version by editing them as a picture, since the source for the published version is not available. Please ensure that the new version of the figures are used (i.e. don't put back the original figures from the current published version).*

Draft Amendment 1 to Recommendation ITU-T G.8271/Y.1366 (2016)

Time and phase synchronization aspects of telecommunications networks: Amendment 1

1 Title

The title of this Recommendation has been changed to "Time and phase synchronization aspects of telecommunications networks."

2 Clause 1: Scope

Replace the text of clause 1 with the following:

This Recommendation defines time and phase synchronization aspects in telecommunications networks. It specifies the suitable methods to distribute the reference timing signals that can be used to recover the phase synchronization and/or time synchronization according to the required quality. It also specifies the relevant time and phase synchronization interfaces and related performance.

The telecommunications networks that are in the scope of this Recommendation are currently limited to the following scenarios:

- Ethernet ([IEEE 802.3] and [IEEE 802.1Q]).
- MPLS ([IETF RFC 3031] and [ITU-T G.8110]).
- IP ([IETF RFC 791] and [RFC 2460]).
- OTN (ITU-T G.709).

The physical layers that are relevant to this specification are the Ethernet media types, as defined in [IEEE 802.3] and, for OTN, the Optical OCh layer with OTU frame as defined in [ITU-T G.709].

3 Clause 5: Conventions

Replace the text of clause 5 with the following:

Within this Recommendation, the following conventions are used: The term precision time protocol (PTP) is the protocol defined by [IEEE 1588]. As an adjective, it indicates that the modified noun is specified in or interpreted in the context of [IEEE 1588].

4 Clause 6

Replace Table 1 and subsequent text in clause 6 with the following:

Table 1 – Time and phase requirement classes

Level of accuracy	Time error requirements (Note 1)	Typical applications (for information)
1	500 ms	Billing, alarms
2	100 µs	IP Delay monitoring Asynchronous Dual Connectivity
3	5 µs	LTE TDD (large cell) Synchronous Dual Connectivity (for up to 7 km propagation difference between eNodeBs)
4	1.5 µs	UTRA-TDD, LTE-TDD (small cell) Wimax-TDD (some configurations) Synchronous Dual Connectivity (for up to 9 km propagation difference between eNodeBs)
5	1 µs	Wimax-TDD (some configurations)
6	x ns (Note 3)	Various applications, including Location based services and some LTE-A features (Note 2)
NOTE 1 – The requirement is expressed in terms of error with respect to a common reference. NOTE 2 – The performance requirements of the LTE-A features are under study. For information purposes only, values between 500 ns and 1.5 µs have been mentioned for some LTE-A features. Depending on the final specifications developed by 3GPP, LTE-A applications may be handled in a different level of accuracy. NOTE 3 – For the value x, refer to Table 2 below and Table II.2 of Appendix II.		

Based on Table II.2, it is possible to classify the class 6 level of accuracy into further three sub-classes, as shown in Table 2 below.

Table 2 – Time and phase requirements for cluster based synchronisation

Level of accuracy	Maximum Relative Time error requirements (Note 1)	Typical applications (for information)
6A	260ns	Intra-band non-contiguous carrier aggregation with or without MIMO or TX diversity, and inter-band carrier aggregation with or without MIMO or TX diversity
6B	130ns	Intra-band contiguous carrier aggregation, with or without MIMO or TX diversity
6C	65ns	MIMO or TX diversity transmissions, at each carrier frequency
NOTE 1 – The maximum relative time error requirements represent the peak-to-peak time difference measured between the elements in the cluster only. See Appendix VII of [ITU-T G.8271.1] for illustration of how requirements are specified in a cluster. In 3GPP terminology this is equivalent to time alignment error (TAE), which is defined as the largest timing difference between any two signals.		

This Recommendation deals mainly with the Class 4, 5 6A level of accuracy requirements, indicated as in Table 2.

5 Clause 7

Replace the following text at the end of clause 7:

NOTE – The use of packet-based methods without timing support of intermediate nodes, and the definition of which class of requirements in Table 1 they can support, are for further study.

The following clauses provide details on the characteristics for the different synchronization methods.

With the following:

NOTE 1 – additional solutions may be considered as a complement to the above solutions. As an example, timing may be carried over the radio interface of mobile systems. Applicability to the general HRMs is for further study.

NOTE 2 – The use of packet-based methods with limited timing support, or without timing support of intermediate nodes, is considered capable of addressing applications corresponding to class 4.

The following clauses provide details on the synchronization methods based on the distributed PRTC approach, and packet based methods with timing support of intermediate nodes.

6 Clause 7.1

Replace the last sentence of clause 7.1:

In terms of performance, the accuracy that can be achieved by means of a PRTC system is for further study.

with the following:

In terms of performance, the accuracy that can be achieved by means of a PRTC system is defined in [ITU G.8272].

7 Clause 8

Replace clauses 8 and 8.1 with the following:

8 Network reference model

Figure 4 describes the network reference model used to define the time and phase synchronization performance objectives when the reference timing signal is carried over the transport network:

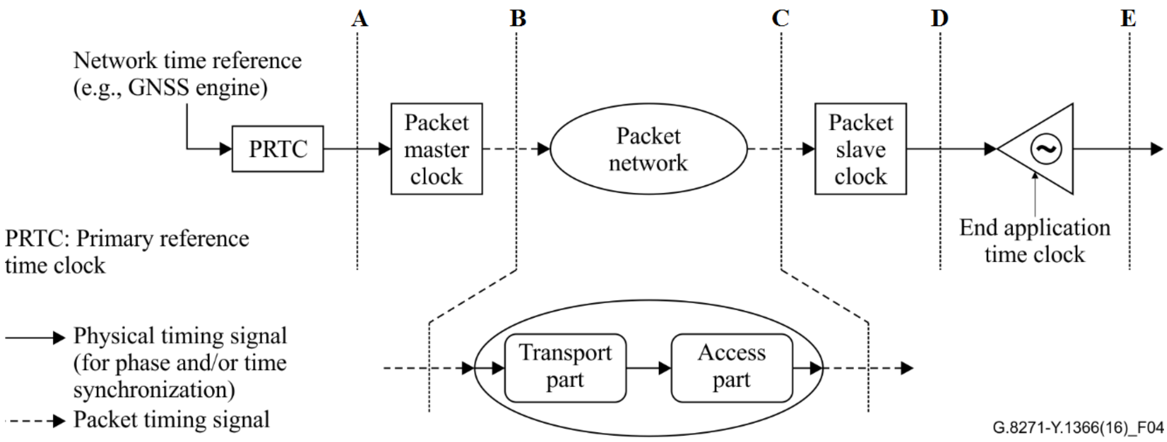

Figure 4 – Network reference model

The following reference points are defined. All the requirements related to these reference points are defined with respect to a common time reference, i.e., any recognized time reference such as GPS time.

- A: PRTC output
- B: Packet master clock output
- C: Packet slave clock input
- D: Packet slave clock output
- E: End application output

Some specific access technologies may need to be considered in the network reference model in some cases. For instance, the network between points B and C can be composed in some cases of a transport part and an access part. Each part would then have its own phase/time budget derived from the media specific mechanisms that have been developed to transport frequency and time synchronization.

NOTE 1 – In Figure 4 the packet master clock could correspond to a T-GM and the packet slave clock could correspond to a T-TSC (telecom time slave clock).

NOTE 2 – The performance studies documented in [ITU-T G.8271.1] are based on a full timing support in the network with hardware timestamping (e.g., T-BC in every node in the case of [IEEE 1588]), and with physical layer frequency synchronization support (e.g., synchronous Ethernet support). The case of partial timing support, where some or all of the nodes are not capable of providing timing support to the PTP layer, is covered in [ITU-T G.8271.2].

NOTE 3 – Some specific access technologies may need to be considered in the network reference model in some cases. For instance, the packet network between points R2 and R3 can be composed in some cases of a transport part and an access part. Each part would then have its own phase/time budget. In some radio access networks (RAN) scenarios, for instance when the RAN is split based on different radio functions, from the point of view of timing, the starting point for the RAN may be present between points B and C shown in Figure 4. Alternatively, the entire network model may be present within the RAN. Details are for further study.

NOTE 4 – Additional detail for the network reference model of Figure 4 for the case of PTP over non-packet technologies (e.g. OTN, GPON, microwave) is for further study.

The overall budget relates to measurement point 'E' (i.e., the time error at E with respect to the common time reference).

'A', 'B', 'C' and 'D' define the other relevant measurement reference points and related network limits, that also indicate the budget of the noise that can be allocated to the relevant network segments (e.g., 'A to C', 'A to D', etc.).

The measurement points that are of interest for a specific application may depend on where the network administrative domain borders apply.

Also, as described above, the measurement in some cases needs to be performed on a two-way timing signal, which would require a specific test set-up and metrics to be used.

The measurement set-up for two-way timing signals as well as the noise that can be added by the measurement test equipment is an item for further study.

Another possibility is to perform the measurement using an external dedicated output phase/time reference, such as a 1PPS interface. Annex A in this Recommendation provides guidance about this type of interface.

8.1 Access section of HRM with PTP/native access IWF

The general network reference model in Figure 4 can be further expanded to illustrate different types of access technology that may be used at the edge of the network such as microwave, DSL or PON.

Generally access technologies can be categorized as either point-to-multipoint shared technologies or point-to-point technologies. An example of a point-to-multipoint shared media technology is a PON with a single multi-port head end and multiple end devices. An example of a point to point technology is a microwave system. Figure 5 expands the access section to show the media conversion that occurs between the Ethernet technology that forms the existing synchronization HRM of the transport section and the technologies in the access section of the HRM. The time error budget of this section may depend on the specific type of technology.

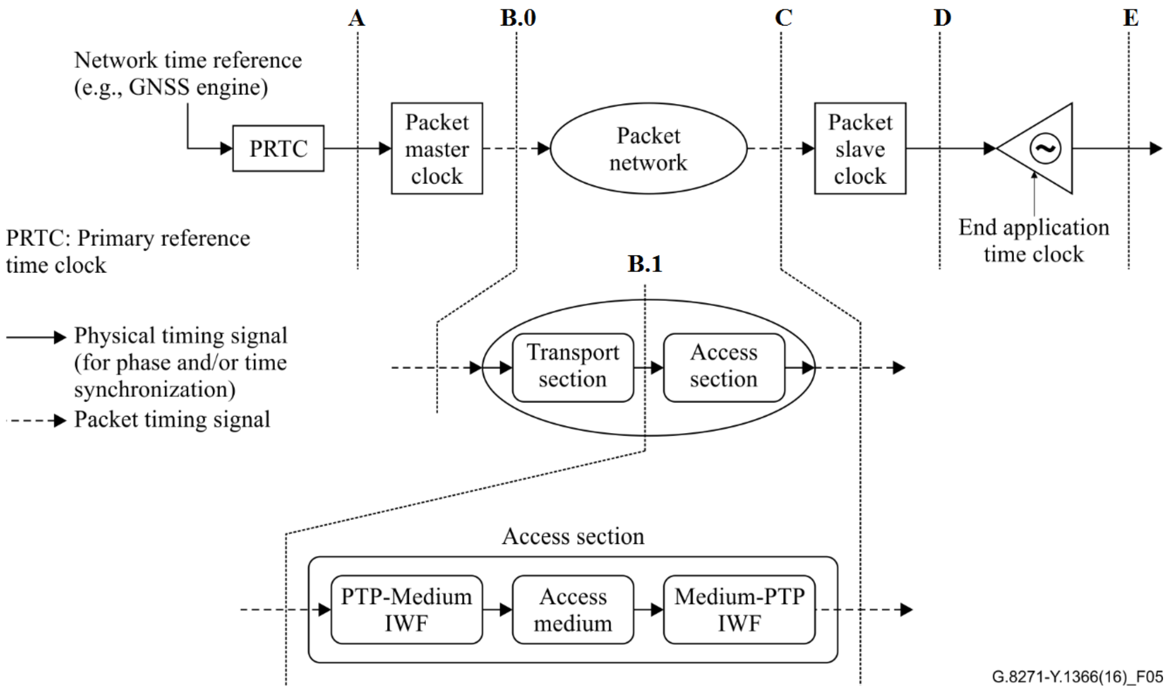

Figure 5 – Network reference model with access section

For example, between B.0 and B.1 the transport section consists of a network chain from [ITU-T G.8271.1] comprised of full timing aware ITU-T G.8273.2 T-BCs using PTP & SyncE. Between B.1 and C of the access section, there may also be T-BCs, and in this case they are connected to and from native access clocks. These native access clocks provide the direct connection to the medium. Essentially, the T-BC and native access clock provides an Interworking Function (IWF) that converts between Ethernet carrying PTP and the access medium.

The access section will have a time error that is a combination of the constant and dynamic components of the medium as well as contribution from the clocks in the access section.

8 Annex A

Replace point 5 in clause A.1.3.2 with the following:

5. FCS

The FCS has one octet. The checksum includes message Header, Length and Payload fields. The polynomial for generating FCS is $G(x) = x^8 + x^5 + x^4 + 1$. The initial value of the field should be set to 0xFF. The right shift operation should be used. There should be no bit inversion of the input and output value. The transmission of the octet should follow the same bit order as other data octets.

Further details are for further study.

9 Annex A

Replace Table A.7 with the following table and associated notes:

Table A.7 – GNSS status message payload

Offset	Length (octets)	Name	Notes
0	1	Types of time source	0x00: Beidou (Compass) 0x01: GPS 0x02: PTP 0x03: Galileo 0x04: Glonass 0x05: QZSS 0x06: IRNSS 0x07: GNSS (Combination of constellations) 0x08: Unknown (in case there is no information about which GNSS timescale is really used and no possible action to compel the module to work with a specific GNSS timescale) 0x09 ~ 0xFF: Reserved
1	1	Status of time source	GNSS Fix Type: 0x00: Position unknown 0x01: dead reckoning only (see Note 1) 0x02: 2D-fix 0x03: 3D-fix

Table A.7 – GNSS status message payload

Offset	Length (octets)	Name	Notes
			0x04: GNSS + dead reckoning combined 0x05: Time only fix 0x06: A-GNSS 0x07: GNSS + SBAS 0x08: GNSS + GBAS 0x09 ~ 0xFF: reserved
3	2	Alarm Status Monitor	Time source alarm status: Bit 0: not used Bit 1: Antenna open Bit 2: Antenna shorted Bit 3: Not tracking satellites Bit 4: Reserved Bit 5: Survey-in progress Bit 6: no stored position Bit 7: Leap second pending Bit 8: In test mode Bit 9: GNSS solution (i.e., derived position and time) is uncertain (see Note 2) Bit 10: Reserved Bit 11: Almanac not complete Bit 12: PPS was generated Bit 13 ~ Bit 15: Reserved
4	4	Reserved	Reserved

NOTE 1: Dead Reckoning Only – Position from GNSS is lost. Current position is estimated from the last-known position, plus knowledge of the velocity and acceleration of the antenna since the GNSS-based position was known.

NOTE 2: GNSS solution is uncertain. When this bit is 1, it indicates that the accuracy of the position derived from GNSS is uncertain, possibly due to not being able to see enough satellites. This alarm may indicate that the antenna has been moved or fallen from place since the unit completed the last self-survey.

10 Appendix II

Table II.1 should be replaced with the new version below:

Table II.1 – Time and phase end-application requirements

Application/ Technology	Accuracy	Specification
CDMA2000	±3 µs with respect to CDMA System Time, which uses the GPS timescale (which is traceable and synchronous to UTC except for leap second corrections) ±10 µs with respect to CDMA System Time for a period not less than 8 hours (when the external source of CDMA system time is disconnected)	[b-3GPP2 C.S0002] section 1.3 [b-3GPP2 C.S0010] section 4.2.1.1
TD-SCDMA (NodeB TDD mode)	3 µs maximum deviation in frame start times between any pair of cells on the same frequency that have overlapping coverage areas	[b-3GPP TS 25.123] section 7.2
WCDMA-TDD (NodeB TDD mode)	In TDD mode, to support Intercell Synchronization and Handoff, a common timing reference among NodeB is required, and the relative phase difference of the synchronization signals at the input port of any NodeB in the synchronized area shall not exceed 2.5 µs	[b-3GPP TS 25.402] sections 6.1.2 and 6.1.2.1
W-CDMA MBSFN	12.8 µs for MBMS over a single frequency network, where the transmission of NodeB is closely time synchronized to a common reference time	[b-3GPP TS 25.346] sections 7.1A and 7.1B.2.1
LTE MBSFN	Values < ±1 µs with respect to a common time reference (continuous timescale) have been mentioned	Under study
W-CDMA (Home NodeB TDD mode)	Microsecond level accuracy (no hard requirement listed)	[b-3GPP TR 25.866] section 8
WiMAX	1) The downlink frames transmitted by the serving base station and the Neighbour base station shall be synchronized to a level of at least 1/8 cyclic prefix length *(which is equal to 1.428 µs)*. At the base station, the transmitted radio frame shall be time-aligned with the 1PPS timing pulse 2) The base station transmit reference timing shall be time-aligned with the 1PPS pulse with an accuracy of ± 1 µs	[b-IEEE 802.16] Table 6-160, section 8.4.13.4 [b-WMF T23-001] section 4.2.2
LTE-TDD (Wide-Area Base station)	3 µs for small cell (< 3 km radius) 10 µs for large cell (> 3 km radius) maximum absolute deviation in frame start timing between any pair of cells on the same frequency that have overlapping coverage areas	[b-3GPP TS 36.133] section 7.4.2

Table II.1 – Time and phase end-application requirements

Application/ Technology	Accuracy	Specification
LTE-TDD (home-area base station)	1) 3 µs for small cell (< 500m radius). For large cell (> 500 m radius), 1.33 + $T_{propagation}$ µs time difference between base stations, where $T_{propagation}$ is the propagation delay between the Home base station and the cell selected as the network listening synchronization source. In terms of the network listening synchronization source selection, the best accurate synchronization source to GNSS should be selected. If the Home base station obtains synchronization without using network listening, the small cell requirement applies. 2) The requirement is 3.475 µs but in many scenarios a 3 µs sync requirement can be adopted.	[b-3GPP TS 36.133] section 7.4.2 [b-3GPP TR 36.922] section 6.4.1.2
LTE-TDD to CDMA 1xRTT and HRPD handovers	eNodeB shall be synchronized to GPS time. With external source of CDMA system time disconnected, the eNodeB shall maintain the timing accuracy within ±10 µs with respect to CDMA system time for a period of not less than 8 hours	[b-3GPP TS 36.133] section 7.5.2.1
LTE-A	Phase/Time requirements for the applications listed below are currently under study: • Carrier aggregation • Coordinated multipoint transmission (also known as Network-MIMO) • Relaying function	[b-3GPP TS 36.814]
IP network delay monitoring	The requirement depends on the level of quality that shall be monitored. As an example ±100 µs with respect to a common time reference (e.g., UTC) may be required. ±1 ms has also been mentioned	NOTE – There is no standard requirement yet. Requirements are operator dependent (depending on the application)
Billing and alarms	±100 ms with respect to a common time reference (e.g., UTC)	
NOTE 1 – In the case of mobile applications, the requirements are generally expressed in terms of phase error between base stations. In the case of a centralized master, the requirement could be expressed as ± half of the accuracy requirement applicable to the specific technology. NOTE 2 – The requirements are generally valid during normal conditions. The applicable requirements during failure conditions are for further study.		

Table II.2 should be replaced with the new version below:

Table II.2 – Other time and phase requirements

Typical applications (for information)	Synchronization requirements	Specification
Asynchronous dual connectivity (note, applicable only for FDD-FDD inter-band dual connectivity)	500 µs (Note 4)	[b-3GPP TS 36.133]
Synchronous dual connectivity (note, applicable only for TDD-TDD and FDD-FDD inter-band dual connectivity)	33 µs (Note 4)	[b-3GPP TS 36.133] section 7.13 and 7.15.2
Intra-band non-contiguous carrier aggregation with or without MIMO or TX diversity, and inter-band carrier aggregation with or without MIMO or TX diversity	260 ns (Note 3)	[b-3GPP TS 36.104] section 6.5.3.1
Intra-band contiguous carrier aggregation, with or without MIMO or TX diversity	130 ns (Note 3)	[b-3GPP TS 36.104] section 6.5.3.1
Location Based Services using OTDOA (Note 2)	100 ns	
MIMO or TX diversity transmissions, at each carrier frequency	65 ns (Note 3)	[b-3GPP TS 36.104] section 6.5.3.1
More emerging LTE-A features that require multiple antenna co-operation within a cluster.	x ns (Note 1) (Note 3)	
NOTE 1 – The performance requirements of the LTE-A features are under study. The value for x is for further study. NOTE 2 – 100 ns supports approximately 30-40m of location accuracy when using OTDOA with a minimum of three base stations. NOTE 3 – The requirements are expressed in terms of time alignment error (TAE) in the 3GPP specifications, which is defined as the largest timing difference between any two signals (i.e. radio signal transmitted from base station sectors). In ITU-T terminology, this is equivalent to maximum relative time error between any two radio signals (i.e. base station sectors), both of which have the same timing reference. Although phase/time accuracy requirements for CA and CoMP are generic and are not defined for any particular network topology, this level of phase error budget in general could be achieved by antennas that are co-located with or connected to the same BBU via direct links. The support of some of these synchronization requirements for scenarios where the antennas are neither co-located (e.g. as related to Inter-site carrier aggregation) nor connected via direct links to the same BBU is under study. NOTE 4- maximum absolute timing mismatch between subframes which are transmitted by Master eNB (MeNB) and Secondary eNB (SeNB) and are scheduled for the same UE. This means that part of this budget should be allocated to propagation time difference between MeNB and SeNB. As an example 9 km propagation difference accounts for approximately 30 µs, which leaves 3 µs time error between the eNBs. 7 km propagation difference accounts for approximately 23 µs, which leaves 10 µs time error between the eNBs.		

11 Appendix V

At the end of Appendix V, replace last equation and the definitions with the followings:

The general term for the delay asymmetry caused by the speed mismatch:

$$< delayPathAsymmetry > = (L_{PKT} + L_{FCS}) \times 8 \times (\frac{V_{Master} - V_{Slave}}{2}) + (L_{Pre-amble}) \times 8 \times (\frac{V_{Master} - V_{Slave}}{2}) \quad \text{(V-8)}$$

Where:

L_{PKT} is the length of the packet (excluding the preamble and FCS) in bytes

L_{FCS} is the length of the packet FCS in bytes

$L_{Pre-amble}$ is the length of the packet preamble in bytes

V_{Master} is the timestamp interface bit period on the PTP Master Clock in seconds/bit

V_{Slave} is the timestamp interface bit period on the PTP Slave Clock in seconds/bit