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Recommendation

ITU-T G.8371 (07/2025)

SERIES G: Transmission systems and media, digital systems and networks

Packet over Transport aspects – Mobile network transport aspects

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Synchronization aspects of metro transport network

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Recommendation ITU-T G.8371

Synchronization aspects of metro transport network

Summary

Recommendation ITU-T G.8371 describes the synchronization function of metro transport network (MTN) equipment and network in order to meet the frequency, phase and time requirement of IMT-2020/5G wireless applications.

History*

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T G.8371	2025-07-22	15	11.1002/1000/16326

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MTN, time synchronization.

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Recommendation ITU-T G.8371

Synchronization aspects of metro transport network

1 Scope

This Recommendation covers the synchronization aspects of metro transport network (MTN) transport network, including MTN synchronization requirements, aspects of MTN synchronization architecture, requirements on MTN synchronization messaging encapsulation, requirements on timestamp generation, and PTP profiles for MTN. This Recommendation includes the physical layer frequency synchronization and the PTP phase/time synchronization.

NOTE – Synchronization aspects related to the transport of CBR over fgMTN are for further study.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.781] Recommendation ITU-T G.781 (2024), *Synchronization layer functions for frequency synchronization based on the physical layer.*

[ITU-T G.810] Recommendation ITU-T G.810 (1996), *Definitions and terminology for synchronization networks.*

[ITU-T G.8260] Recommendation ITU-T G.8260 (2022), *Definitions and terminology for synchronization in packet networks.*

[ITU-T G.8261] Recommendation ITU-T G.8261/Y.1361 (2019), *Timing and synchronization aspects in packet networks.*

[ITU-T G.8262.1] Recommendation ITU-T G.8262.1/Y.1362.1 (2022), *Timing characteristics of enhanced synchronous equipment slave clock.*

[ITU-T G.8264] Recommendation ITU-T G.8264/Y.1364 (2017), *Distribution of timing information through packet networks.*

[ITU-T G.8271.1] Recommendation ITU-T G.8271.1/Y.1366.1 (2022), *Network limits for time synchronization in packet networks with full timing support from the network.*

[ITU-T G.8272] Recommendation ITU-T G.8272 (2025), *Timing characteristics of primary reference time clocks.*

[ITU-T G.8272.1] Recommendation ITU-T G.8272.1 (2024), *Timing characteristics of enhanced primary reference time clocks.*

[ITU-T G.8273.2] Recommendation ITU-T G.8273.2/Y.1368.2 (2023), *Timing characteristics of telecom boundary clocks and telecom time synchronous clocks for use with full timing support from the network.*

[ITU-T G.8275.1] Recommendation ITU-T G.8275.1/Y.1369.1 (2022), *Precision time protocol telecom profile for phase/time synchronization with full timing support from the network.*

[ITU-T G.8300] Recommendation ITU-T G.8300 (2020), *Characteristics of transport networks to support IMT-2020/5G.*

[ITU-T G.8310] Recommendation ITU-T G.8310 (2020), *Architecture of the metro transport network.*

[ITU-T G.8312] Recommendation ITU-T G.8312 (2020), *Interfaces for metro transport networks.*

[ITU-T G.8312.20] Recommendation ITU-T G.8312.20 (2024), *Overview of fine grain MTN.*

[ITU-T G.8321] Recommendation ITU-T G.8321 (2022), *Characteristics of metro transport network equipment functional blocks.*

[ITU-T G.8331] Recommendation ITU-T G.8331 (2022), *Metro transport network linear protection.*

[ITU-T G.8350] Recommendation ITU-T G.8350 (2022), *Management and control of metro transport networks.*

[OIF FLEXE IA] Optical Internetworking Forum, IA Flex Ethernet 2.2 (2021), *Implementation agreement.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

Terms related to synchronization are defined in [ITU-T G.810] and [ITU-T G.8260].

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

1PPS One Pulse Per Second

C-RAN Centralized Radio Access Network

DM Delay Measurement

D-RAN Distributed Radio Access Network

ePRC Enhanced Primary Reference Clock

ePRTC Enhanced Primary Reference Time Clock

ESMC Ethernet Synchronization Messaging Channel

FlexE Flex Ethernet

GNSS Global Navigation Satellite System

MTN Metro Transport Network

MTNS MTN Section

PHY Physical layer entity

PMA Physical Medium Attachment

PRC Primary Reference Clock

PRTC Primary Reference Time Clock

PTP Precision Time Protocol

SSM Synchronization Status Message

SyncE Synchronous Ethernet

T-BC Telecom Boundary Clock

T-GM Telecom Grandmaster

TOD Time of Day

TR TimeReceiver or TIME_RECEIVER

TT TimeTransmitter or TIME_TRANSMITTER

T-TSC Telecom Time Synchronous Clock

5 Conventions

None.

6 General

MTN (metro transport network) is a transport technology for metro networks, consisting of several non-recursive digital layers: the fgMTN path (fgMTNP) layer, the MTN path (MTNP) layer and the MTN section (MTNS) layer. It supports the transport of distributed radio access network (D-RAN) and centralized radio access network (C-RAN) traffic. This technology leverages existing and emerging pluggable Ethernet modules and reuses flex Ethernet (FlexE) implementation logic.

Interface specifications of MTN and fgMTN are defined in [ITU-T G.8312]. The architecture of MTN is defined in [ITU-T G.8310]. Equipment functional blocks of MTN are defined in [ITU-T G.8321]. Linear protection specification of MTN is defined in [ITU-T G.8331]. Management and control aspects of MTN are defined in [ITU-T G.8350]. The overview of fine grain MTN is defined in [ITU-T G.8312.20].

To support mobile services, i.e., distributed radio access network (D-RAN) and distributed radio access network (C-RAN) traffic, MTN needs to support the distribution of time and frequency. This Recommendation defines the synchronization aspects of MTN including end-to-end synchronization requirements, and synchronization architecture and related solutions.

7 MTN synchronization requirements

MTN supports the physical layer frequency synchronization and the precision time protocol (PTP) phase/time synchronization. PTP frequency synchronization is not used in MTN.

MTN synchronization requirements come from, but not limited to the following applications:

1) 5G wireless transport: MTN standard is established to meet the requirements of IMT-2020/5G wireless transport [ITU-T G.8300], which should meet the requirements of time synchronization and frequency synchronization of wireless base stations.
2) One-way delay measurement: One-way delay measurement (DM) as defined in clauses 8.2.2.2.2 and 9.3.3.3.2 of [ITU-T G.8312] needs time synchronization.
3) Idle block insertion and removal: In principle, time synchronization between two MTN ports is not needed for idle block insertion and removal as defined in clauses 8.3 and 8.4 of [ITU-T G.8312], but if the frequency is synchronized, the occurrence of idle block insertion and removal is less frequent.

4) Timing service for industries: The MTN network requires time synchronization to meet the time synchronization requirements of the fgMTN or MTN clients. These clients could be, for example, from power, finance or transportation industries.

8 MTN synchronization architecture

The frequency synchronization of MTN is distributed by the physical layer, and the phase/time synchronization of MTN is distributed by PTP.

MTN synchronization uses the full-timing distribution architecture defined in [ITU-T G.8275]. MTN PTP clocks in MTN synchronization networks are T-GM with performance as specified in [ITU-T G.8272] or [ITU-T G.8272.1], and T-BC and telecom time synchronous clock (T-TSC) with performance as specified in [ITU-T G.8273.2].

The overall synchronization network is shown in Figure 8-1. The first MTN T-BC gets time synchronization from a T-GM that is integrated into the PRTC / ePRTC, via Ethernet interfaces (e.g., 1GE, 10GE, etc.). Other MTN T-BCs distribute time synchronization via MTN interfaces (e.g., 50GBASE-R, 100GBASE-R, 200GBASE-R and 400GBASE-R as defined in [ITU-T G.8312], or a grouping of these interfaces).

MTN synchronization network also supports a stand-alone T-GM, which gets time synchronization from an ePRTC/PRTC via 1PPS+TOD.

The frequency distribution is not necessarily congruent with the time distribution for MTN, and MTN nodes can also get frequency reference from another ePRC/PRC synchronization chain as shown in Figure 8-1.

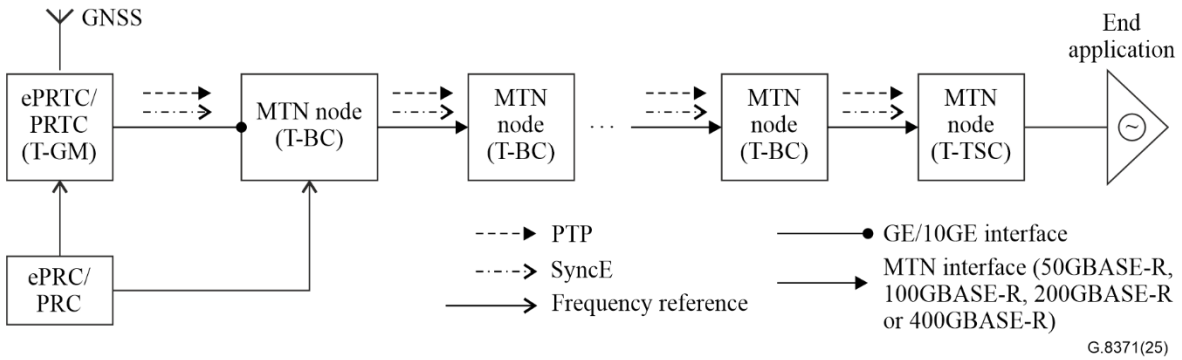

Figure 8-1 – MTN synchronization internetworking for T-GM integrated PRTC / ePRTC

Synchronization messaging channel and encapsulation of MTN interfaces for PTP and ESMC messages are specified in clause 9.1.

9 MTN synchronization solution requirements

9.1 MTN synchronization messaging channel and encapsulation

The mapping of SSM/PTP messages over MTN is performed as per [ITU-T G.8312].

The MTN synchronization messaging channel is provided in the sixth block of the MTNS overhead frame. The synchronization messaging channel is allocated across all the overhead frames of the multi-frame, and it provides a channel to transport SSM and PTP messages.

An MTN group consists of one or more physical layer entities (PHYs). For the PHY that is being used for synchronization, the synchronization configuration bit in the first block of the MTNS overhead frame in the first instance is always set to 1.

The SSM messages are encapsulated as ESMC Ethernet messages as specified in [ITU-T G.8264] and they are inserted in the synchronization messaging channel. The general PTP messages are encapsulated as Ethernet messages as specified in [ITU-T G.8275.1] and are inserted in the MTN synchronization messaging channel.

PTP event messages are timestamped and encapsulated as Ethernet messages as specified in [ITU-T G.8275.1]. PTP event messages are inserted into the MTN synchronization messaging channel.

SSM messages and PTP general messages are inserted into the MTN synchronization messaging channel as lower priority compared with PTP event messages.

The synchronization requirement when there is a PHY faulty within a MTN group is for further study.

9.2 Timestamp generation for MTN

The timestamp generation for MTN is consistent with the [OIF FLEXE IA] specification.

The message timestamp point for a PTP event message transported over the synchronization messaging channel of MTN overhead frame is the start of the MTNS overhead multi-frame, in which the first 66B block (the /S/ block) of the PTP event message is carried. The PTP event message can be inserted in the overhead of any frame of this multi-frame, if there is only one PTP event message in the overhead multi-frame. When there are multiple PTP event messages transported by MTNS overhead multi-frame, those PTP event messages should be allocated in different overhead frames. A PTP message may cross the multi-frame boundary. Figure 9-1 shows a timestamp diagram example and the relationship to the PTP message.

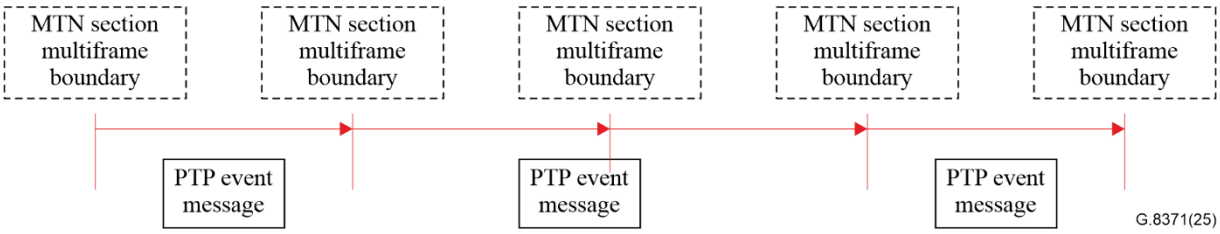

Figure 9-1 – Timestamp diagram example and the relationship to the PTP message for MTNS

All PTP event messages are timestamped on egress and ingress interfaces. The timestamp is the time at which the event message timestamp point passes the reference plane.

The message timestamp point needs to be at the alignment marker position or at an even lower position (e.g., physical medium attachment (PMA)). In the case of a multi-lane PHY, the PTP path data delay is measured using the timestamps of the lane with the maximum media propagation delay. In practice:

– In the transmit direction, after the start of the MTNS overhead multi-frame are detected, the position is marked. The timestamp can be generated and inserted into the PTP event messages as the timestamps of the messages when the start of the MTNS overhead multi-frame is processed by egress at the alignment marker or PMA positions. Since the alignment markers for all lanes are transmitted at the same time conceptually, any marker in any lane can be used for timestamping.

– In the receive direction, all the candidate timestamp positions are recorded, and this information must be propagated up through the PHY functions so that once the start of the MTNS overhead multi-frame can be identified, the timestamp can be recorded as the receiving timestamp of all the PTP event messages in this MTNS overhead multi-frame. Alignment markers are present in all the lanes, but different lanes may be skewed from each other. The last received marker across all the lanes shall be used for timestamping.

In the implementation, the timestamps may be generated at a point removed from the reference plane. Furthermore, the time offset from the reference plane is likely to be different for inbound and outbound event messages. To meet the accuracy requirement, the generated timestamps should be corrected for these offsets. Based on this model, the appropriate corrections are as follows:

<egressTimestamp> = <egressMeasuredTimestamp> + egressLatency

<ingressTimestamp> = <ingressMeasuredTimestamp> – ingressLatency

where the actual timestamps <egressTimestamp> and <ingressTimestamp> measured at the reference plane are computed from the detected, i.e., measured, timestamps by their respective latencies. Failure to make these corrections results in a time offset between the time receiver (TR) and time transmitter (TT) clocks.

9.3 PTP profile for MTN

MTN networks shall use [ITU-T G.8275.1] for PTP time synchronization. Specific information for MTN is described in Annex I of [ITU-T G.8275.1].

For SyncE, the SSM message carried by MTN is Ethernet encapsulation, and shall follow the definition in [ITU-T G.8264]. Additional SyncE protocol requirements are as specified in [ITU-T G.781] and [ITU-T G.8264].

9.4 MTN synchronization network limit

MTN networks shall meet the enhanced physical layer network limit specified in clause 9.2.1.4 of [ITU-T G.8261], and the PTP network limit specified in clause 7.3.2 of [ITU-T G.8271.1].

9.5 MTN clock specification

The MTN nodes shall meet the eSEC specification defined by [ITU-T G.8262.1] and the T-BC Class C specification defined by [ITU-T G.8273.2].

The use of T-BC class D for MTN transport network is for further study.

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