Question 13/15 – Network synchronization and time distribution performance

(Continuation of Question 13/15)

1 Motivation

Network synchronization performance specifications are essential for successful operation of digital transmission networks including the support of, for example, mobile networks. Network timing performance standards are necessary to define the feasibility and most effective means of implementing a time reference distribution service. This includes the distribution of both precision time and frequency.

Continuing effort needs to be put into the study of synchronization issues in packet based and new TDM networks.

Requirements for the network synchronization related OAM and Management functions need to be further studied.

Requirements from new network architectures and applications should be considered (e.g., as related to the IoT, IMT2020/5G and the evolution to IMT-2030/6G, new emerging applications that may require accurate timing such as support for enhanced security solutions, etc.). New applications with particularly stringent timing requirements may need to be considered (e.g., quantum key distribution (QKD) related applications).

Resilient, robust and reliable network synchronization solutions with controlled and limited dependency on satellite-based systems like GNSS or LEO (Low Earth Orbit) are needed. Related synchronization network architecture and clock systems need to be addressed.

There is increased need to provide timing to support the needs of other industries and applications (e.g., industrial automation, broadcast, power, datacentres, time sync for end-users) that may rely on the transport and synchronization solutions and techniques defined within this study group. SDN/NFV implications on the synchronization networks should also be studied.

Enhancements drawing on and looking to enable artificial intelligence/machine learning (AI/ML) should be studied.

The advances in network synchronization related technologies should be addressed. This includes potential evolution of the timing protocols.

New transmission technologies, services and facilities are regularly being introduced. Inter-operator links need to be efficiently installed, commissioned, brought into service and maintained. Test and measurement instrumentation is required for the installation, commissioning, bringing into service and maintenance of telecommunications equipment and networks. The measurement of the same parameter made with different measuring instruments should give reliable, repeatable and comparable results. Test equipment specification needs continuous review to take account of technology changes and improvements of jitter, wander and precision time measurement.

The following major Recommendations and other documents, in force at the time of approval of this Question, fall under its responsibility:

– Definitions and Architecture: G.781, G.781.1, G.810, G.8260, G.8264, G.8265, G.8275
– PTP Profiles: G.8265.1, G.8275.1, G.8275.2
– Network Performance: G.8251, G.822, G.823, G.824, G.825, G.8261, G.8261.1, G.8271, G.8271.1, G.8271.2
– Clocks: G.811, G.811.1, G.812, G.813, G.8262, G.8262.1, G.8263, G.8272, G.8272.1, G.8272.2, G.8273, G.8273.2, G.8273.3, G.8273.4
– Test equipment: O.171, O.172, O.173, O.174 and O.182

2 Questions

Study items to be considered include, but are not limited to:

– What are the requirements for jitter and wander for the future OTN interfaces, e.g., beyond 1 Tbit/s?

– What is the network functionality required to provide real-time distribution of absolute time-of-day reference services and/or phase synchronization? What network capabilities are required to support the performance levels necessary to satisfy a selected set of time-of-day and/or phase synchronization user applications?

– How can network synchronization performance be enhanced through the use of synchronization status messages or other techniques?

– What network synchronization characteristics, for both normal and degraded mode, should be recommended for services carried over packet networks?

– What is the dependence on synchronization of performance of various methods of service clock recovery with respect to service requirements (e.g., jitter, wander, time error, etc.)?

– What network synchronization characteristics should be recommended for services carried over Metro Transport Network (MTN) based networks?

– How can resilient, robust, and reliable network synchronization solutions be provided (e.g., as back up for satellite-based systems like GNSS)?
"Coherent network PRTC" (cnPRTC) concept is one option to be considered.

  • How can high-accuracy time synchronization be used in this context to back-up satellite-based systems?

– What advances of the synchronization technologies (e.g., new type of clocks, evolution of timing protocols) should be considered in the overall network synchronization solutions?

– What are the synchronization aspects of transport via satellite networks? How are the related vulnerabilities dealt with?

– What jitter and wander requirements are needed for wireless network applications (e.g., radio relay, satellite)?

– Synchronization aspects related to supporting mobile network operations: what synchronization requirements are related to supporting the operation of the mobile network (e.g., backhaul and fronthaul) and of the related applications (e.g., LTE, LTE-A, IMT2020/5G and the evolution to IMT-2030/6G)? What solutions are suitable to meet these requirements? How can the accuracy be improved?

– What jitter and wander requirements are needed for access networks (e.g., DSL, PON, Microwave)?

– What jitter and wander specification requirements are needed in the evolution of OTN and in MTN?

– What are the synchronization aspects (frequency, phase, and time) of packet networks, e.g., Ethernet, MPLS, IP networks?

– What mechanism can be used to add security to the transport of timing?

– Synchronization aspects related to new applications, e.g., as related to the Internet of things (IoT) and security mechanisms that depend on accurate timing?

– What are the synchronization related requirements for OAM and Management functions?

– What is the implication of SDN/NFV concepts to the synchronization network architectures and requirements?

– Use of AI/ML in synchronization networks?

– Can the Recommendations on synchronization be enhanced to allow the timing solutions and techniques specified to be used by other industries and applications (e.g., industrial automation, broadcast, power, data centres, time sync for end-users)?
– What synchronization aspects of Quantum Key Distribution Networks (QKDN) should be specified?
– What manual and automatic test and measurement instrumentation and techniques to assess transmission performance need to be specified by ITU-T and what should be the specifications?

3 Tasks

Tasks include, but are not limited to:

– The study of instrumentation and techniques, for example:
  • Measurement and evaluation of error performance parameters and objectives.
  • Test instrumentation and techniques associated with various technologies (e.g., PON, OTN, Ethernet, MTN, FlexE, submarine systems and beyond 400 Gbit/s).
  • Test instrumentation and techniques associated with Layer 1 Transmission technologies for metallic and optical media like 1G access, beyond 400 Gbit/s.
  • Jitter and wander test instrumentation and techniques associated with various technologies (e.g., PON, OTN, Ethernet, MTN, FlexE and beyond 400 Gbit/s).
  • Test instrumentation and techniques associated with optical phase modulations (e.g., ODB, DQPSK and DP-QPSK).
– cnPRTC inbuild cooperation between distributed clock combiners.
– Usage of UTC(k) for synchronization networks.
– Timing and synchronization network DRM (Disaster Recovery Management).
– Keeping O-Series Recommendations up to date.
– Continue development of recommendations related to the transport of frequency through networks, G.826x-series including G.8260, G.8261, G.8261.1, G.8262, G.8262.1, G.8263, G.8264, G.8265, G.8265.1, and G.8266.
– Continue development of recommendations related to the transport of phase and time through networks, G.826x- and G.827x-series including G.8260, G.8271, G.8271.1, G.8271.2, G.8272, G.8272.1, G.8272.2, G.8273, G.8273.1, G.8273.2, G.8273.3, G.8273.4, G.8275, G.8275.1, G.8275.2.
– Revision and enhancements of the related supplements and technical reports: G-series Supplements 65 and 68, G-Suppl.ePTS, GSTR-GNSS.
– Revisions and enhancements to Recommendations G.825 and G.8251.
– Maintenance and enhancement of G.81X-series.
– Continue work on the transport of clients through OTN (e.g., PTP, CBR, etc.).
– Consider need for new Recommendation on jitter and wander instrumentation for packet-based networks (O-series), e.g., O.175.
– Consider need for new Recommendation on physical layer test instrumentation associated with advanced Optical modulation techniques (ODB, DQPSK, DP-QPSK and 16QAM).
– Work on Recommendation for frequency and time synchronization layer functions (G.781, G.781.1).
– Work on sync in the MTN (G. mtn-sync).
– The generalization of the synchronization Recommendations to allow the solutions and techniques specified to be reused by other industries and applications.

An up-to-date status of work under this Question is contained in the SG15 work programme (https://www.itu.int/ITU-T/workprog/wp_search.aspx?sp=18&q=13/15).

4 Relationships

Recommendations:

– Q.551, G.703, G.709, G.783, G.798, G.800, G.805, G.80XX series, G.81XX series, G.83XX series

Questions:

– 2/15, 3/15, 4/15, 6/15, 8/15, 10/15, 11/15, 12/15, and 14/15

Study Groups:

– ITU-T SG2 on telecommunication management
– ITU-T SG13 responsible for future networks, with focus on IMT-2020 and the evolution to IMT-2030, cloud computing and trusted network infrastructure
– ITU-T SG17 on security
– ITU-T SG20 on IoT, smart cities and communities
– ITU-T SG21 on broadband cable and tv
– ITU-R SG4 on satellites
– ITU-R SG5 on terrestrial services
– ITU-R SG6 on broadcasting service
– ITU-R SG7 on science services

Other bodies:

– ATIS SYNC
– IETF TICTOC
– IETF NTP
– MEF on circuit emulation over Ethernet and frame delay measurements
– MEF mobile backhaul/fronthaul
– MEF on transport services for mobile networks
– IEEE 1588
– IEEE P1952
– IEEE P3335
– IEEE 802.3
– IEEE 802.1
– IEEE 802.16 (Wireless MAN)
– IEEE IC Timing in data centres
– 3GPP RAN, SA
– Broadband Forum
– IEC TC86
– OIF
– ETSI
– O-RAN WG4, WG5, WG9, WG11
– CPRI

– OCP
– MOPA