

Synchronization transport operations and management

Enhanced SyncE and PTP synchronization operations, administration and management capabilities in optical transport networks

White paper

Service providers and network operators are required to meet stringent specifications for frequency and phase/time synchronization in 5G mobile transport networks. In addition, they must address the challenges involved in planning, provisioning, operating, maintaining and providing service assurance for robust and resilient synchronization distribution networks. To succeed, they need new tools that will enable them to automate these functions, simplify network operations and ultimately improve synchronization performance.

This white paper summarizes the advanced synchronization protocol control, maintenance and operations capabilities, and synchronization operation, administration and maintenance (OAM) functions provided by the Nokia 1830 PSS Network Elements, which fully implement the recent editions of ITU-T synchronization standards. It also introduces the WaveSuite Synchronizer application, which is part of an optical network management system that provides a holistic view of the end-to-end synchronization services and topology in support of Synchronization as a Service (SyncaaS).

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Introduction

Mobile transport infrastructure for 5G demands both frequency and phase/time synchronization distribution. The stringent accuracy requirements for centralized RAN (C-RAN) fronthaul networks compared with midhaul and backhaul networks and the resulting synchronization network engineering guidelines have been discussed extensively over the past several years [1, 2]. ITU-T Study Group 15 has documented the functional requirements of these networks in its Question 13 Recommendations.

Many telecommunications equipment vendors have developed synchronization solutions based on Synchronous Ethernet (SyncE) and the Precision Time Protocol (PTP) to address the accuracy and protocol performance challenges posed by the transition to 5G synchronization networks. These increasingly stringent requirements have been met by commercial offerings that feature organically developed products or integrate commercial protocol stacks and servos. The end result has been compliance with ITU-T Recommendations G.8275.1 [3] or G.8275.2 [4] for PTP telecom profiles and G.8273.2 [5] for telecom boundary clock (T-BC) and telecom time slave clock (T-TSC) performance (for all five metrics).

The impressive performance of these offerings highlights the evolution of the technology, its maturity, the important strides made in integrating synchronization in each network element (e.g., optical, packet-optical, IP/MPLS routers, fixed access FTTH, microwave), and the dependence of the transport network on highly accurate frequency and phase/time distribution. Although vendors' products have achieved varying levels of standards compliance, the performance aspects have become less of a focus moving into 2022.

Today, the challenges for service providers and network operators considering synchronization distribution go beyond technology maturity and product availability. They now include planning, initial end-to-end provisioning, and the ongoing operations and maintenance of robust and resilient synchronization distribution networks.

The use of SyncE for frequency distribution may be familiar to those who have operated SONET/SDH networks in the past. However, IEEE 1588v2 PTP for phase/time distribution is a more complex protocol that adds new requirements and an additional layer of operational complexity. PTP must now be configured on a node-by-node basis using a command line interface (CLI) or the web graphical interface (WebUI) of a traditional element management system (EMS), which exposes the user to a large number of parameters and attributes. This requires expert knowledge of PTP, which is often a barrier within service provider operations organizations. A misconfiguration can result in timing islands or inaccurate advertisements of clock accuracy, causing a cascade of errors throughout the network.

The set of PTP-related ITU-T standards has numerous inherent mechanisms and algorithms that allow for the protection, resiliency, and operations, administration and maintenance (OAM) of the synchronization signal, alarm reporting and consequent actions. However, the ability to design a fully managed, reliable synchronization network that yields the best accuracy requires specific knowledge of these standards and the configuration of the corresponding equipment parameters.

What is required are new tools for the configuration and monitoring of timing distribution networks. Recent amendments to ITU-T standards have added new capabilities to aid network operators in real-world scenarios. Additionally, there is a need for network-layer management applications dedicated to synchronization that support this new functionality and provide a level of abstraction, simplification and automation.

This white paper explains how the Nokia 1830 PSS Network Element supports the recent ITU-T synchronization standards. It also describes how the new WaveSuite Synchronizer network application manages frequency and phase/time distribution for Synchronization as a Service (SynaaS).

Capabilities of 1830 PSS Network Elements

This section describes the specific features implemented on the 1830 PSS Network Elements to enhance the management and operations of PTP and SyncE. The list is not exhaustive.

Compliance with the recent editions of Recommendation ITU-T G.8275.1 PTP telecom profile for phase/time synchronization

Recommendation ITU-T G.8275.1/Y.1369.1 [3] specifies the ITU-T profile of IEEE 1588v2 PTP for phase and time distribution with full “on-path” timing support for the network. It provides the necessary details to utilize PTP in a manner consistent with the architecture described in Recommendation ITU-T G.8275 [6] and hypothetical reference models (HRMs), network limits and other architectural aspects defined in Recommendations ITU-T G.8271 [7] and G.8271.1 [8].

ITU-T published the Edition 1.0 of the standard in July 2014 and has since made several amendments and revisions. Some of these amendments are quite important when it comes to management and traceability.

The 1830 PSS implementation initially supported Edition 1.0, which is still the version implemented by most equipment suppliers. Later, it was upgraded to Edition 2.0 (published in June 2016) and complemented by Amendment 1 (August 2017), known as Edition 2.1. Table 1 shows the new features introduced in Edition 2.1.

Table 1. New capabilities in Recommendation ITU-T G.8275.1 Edition 2.1

New features
Increment profile version and identifier (because of ePRTC support)
Support for new clockAccuracy and offsetScaledLogVariance values for the ePRTC
Clarifications about the use of the masterOnly attribute for a T-BC
New Annex D (optional) on Path trace function
New Annex E (optional) on the addition of the synchronizationUncertain flag
Update to Appendix III on the choice of the PTP Ethernet multicast destination MAC address
New Appendix VI on clarifications regarding the use of the profile over link aggregation (LAG)
New Annex F on the use of maxStepsRemoved to limit reference chain
New Appendix X on the use cases for the priority2 attribute
New Appendix XII on the monitoring of alternate master time information
Backward compatibility with Edition 1.0

It is important to distinguish the edition of Recommendation ITU-T G.8275.1 from the profile version (called “profileVersion” in Annex A – Clause A.1, Profile identification). If the profile version is not incremented in the ITU-T Recommendation, it means the changes are either informative or normative, but they do not affect protocol aspects such as attributes and default values. This is what occurred with Amendments 2 and 3 to the 2016 version, called Editions 2.2 and 2.3, respectively, where the profileVersion remained at 2.1.

Recommendation ITU-T G.8275.1 underwent further minor changes in 2020 and 2021.

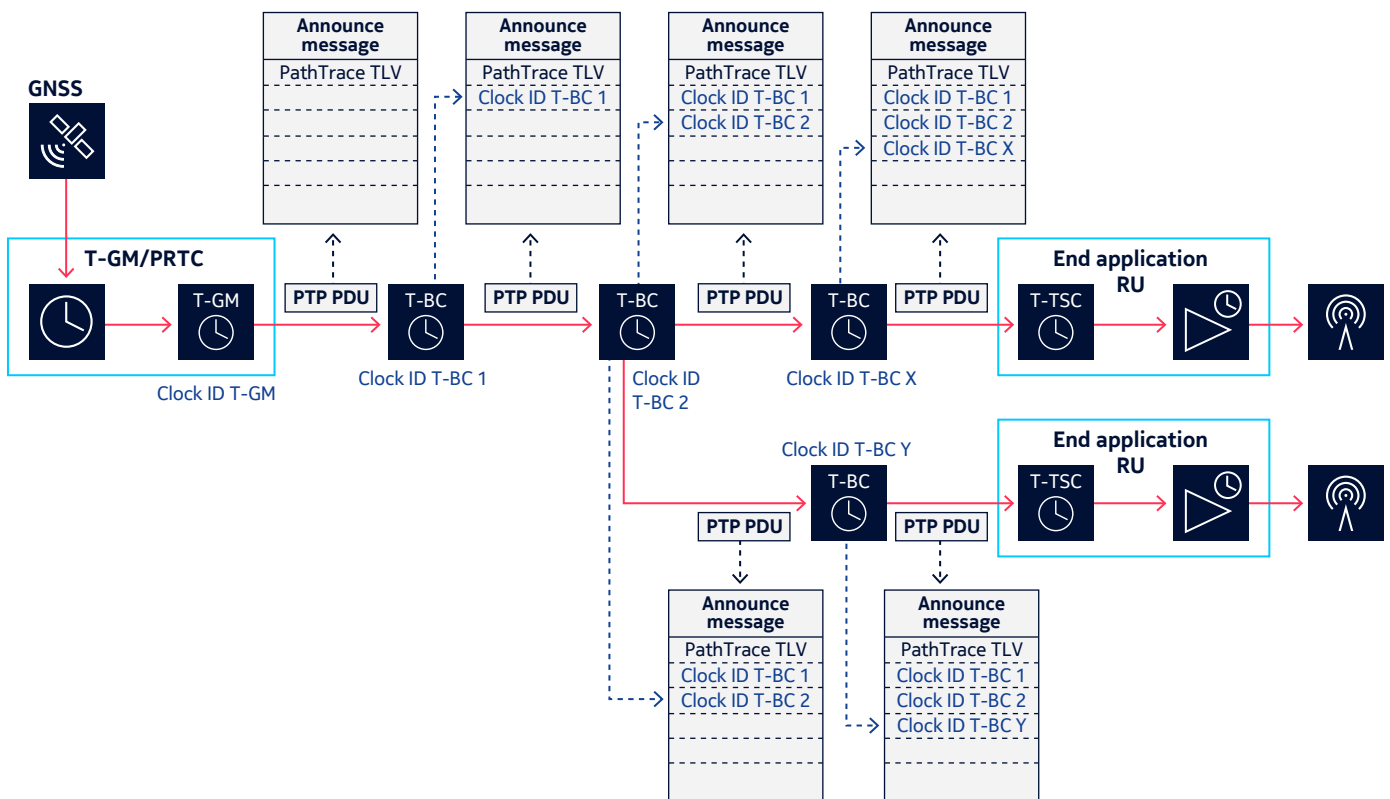
- In the March 2020 version of Recommendation ITU-T G.8275.1, the profileVersion remained at 2.1.
- The profileVersion was updated in two amendments to the 2020 version. The profileVersion 2.2 was defined in Amendment 1 (November 2020) to add further functionality. The profileVersion 2.3 was defined in Amendment 2 (June 2021) to add details on the use of IEEE 1588-2019.
- Thus, profileVersion 2.2 is for an implementation based on IEEE Std 1588-2008, while profileVersion 2.3 is for an implementation based on IEEE Std 1588-2019.

- A new Amendment 3 was approved in December 2021 but the profileVersion remained at 2.3.

Several of these features were added specifically to help with the management of PTP networks. The 1830 PSS currently implements all of them. Some of these features are described below.

- Annex D – **Path trace** function per clause 16.2 of IEEE Std 1588-2008 to track the actual path of the PTP synchronization chain in the network. Figure 1 shows the principle and processing in each T-BC. The Path trace type-length-value (TLV) is appended at the end of the PTP Announce messages and each PTP clock in the synchronization path adds its clockIdentity to the field. As a result, the actual route taken by the PTP frames can be determined everywhere in the network. The most important capability of the Path trace function may be that it provides full traceability information at any given time, not just when troubleshooting failures in the network.

Figure 1. Principle of the Path trace function defined in Recommendation ITU-T G.8275.1 (Annex D) and IEEE Std 1588-2008 (Clause 16.2)



- Annex E – **Synchronization uncertain indication**. When a PTP clock slave port selects a new clock as a synchronization time source, the PTP port associated with that clock is placed in the uncalibrated state. During this period, the PTP clock may exhibit large or rapid changes in frequency and phase as it converges to the new reference. While it is still desirable to update the information being propagated downstream to allow the topology to settle, it may not be desirable for the downstream PTP clocks to react to this timing information too quickly. The synchronizationUncertain flag in the Announce message transmitted from a PTP port in the uncalibrated state is used to delay rearrangement at downstream PTP clocks. This allows the downstream clocks to deal with the delay between network topology settling time and T-BC clock chain settling time. The use of the synchronizationUncertain indication can help downstream nodes take relevant countermeasures during that period.

- **Annex F – Use of stepsRemoved to limit the reference chain and prevent loops.** The user can configure a new maxStepsRemoved attribute on the T-BC, which will disqualify any Announce message with a stepsRemoved field set to a value greater than the provisioned maxStepsRemoved. The value configured is typically the same in all clocks in the PTP domain. It is recommended to set the value to 21 to align with the HRM of Recommendation ITU-T G.8271.1 [8]. This helps the operator ensure that the network performance limit and the T-BC chain length are not exceeded. For example, in a ring application, this setting can enable the operator to quickly detect cyclic paths and identify and terminate rogue frames.

Amendment 1 to the 2020 version of the standard defined a new optional functionality. It is mentioned here only to illustrate the fact that the focus of ITU-T Q13/15 was not to add more protocol features, but rather to add capabilities that improve the management and operations of the PTP network.

The new defect and alarm packet timing signal fail (PTSF) was introduced to indicate a failure of the PTP packet timing signal received by a PTP port. It defines three types of PTSF that may be raised in a PTP clock to provide the fault management and monitoring status for the timing signal failure:

- PTSF-lossSync: lack of reception of PTP timing message from a master
- PTSF-unusable: unusable PTP packet timing signal received by the slave or passive port of a PTP clock, exceeding the input tolerance of the PTP clock
- PTSF-syncUncertain: uncertain timing signal received by the slave or passive port of a PTP clock

The 1830 PSS product is currently fully compliant with Recommendation ITU-T G.8275.1 Edition 2.1 (profileVersion 2.1). The most recent versions are Recommendation ITU-T G.8275.1 Amendments 2 (06/2021) and 3 (02/2022), which correspond to Editions 3.2 and 3.3, respectively, of the latest base 03/2020 Edition 3.0. The 1830 PSS is slated to become fully compliant with this latest edition and profileVersion 2.2 through the addition of PTSF support for the coming release by the end of 2022. It is one of the most advanced platforms on the market with respect to PTP functionality. The 1830 PSS also simplifies and enhances synchronization management and operations.

Compliance with the most recent edition of Recommendation ITU-T G.8264 and Recommendation ITU-T G.781 for improved traceability of an eEEEC chain

Frequency distribution remains important in 5G. First, SyncE itself has evolved and been replaced by enhanced SyncE (eSyncE) with the definition of enhanced synchronous Ethernet Equipment Clocks (eEECs) in Recommendation ITU-T G.8262.1 [9]. The motivation for, and benefits of, eEECs are covered in another white paper [10]. Second, several new capabilities have been added since the SDH/SONET synchronization era to improve the management of SyncE networks. These are all currently implemented by the 1830 PSS. Some of the features are highlighted here.

A new set of enhanced quality levels (QLs) has been defined in the recent version of Recommendation ITU-T G.781 [11] (04/2020) and the new Recommendation ITU-T G.781.1 [12] to reflect the new clock sources required to meet the needs of high-accuracy frequency synchronization. It includes QL-ePRTC, QL-PRTC, QL-ePRC and QL-eSEC.¹ The new QLs are used to distribute traceability information for these clock sources relative to the frequency distribution (eSyncE) plane.

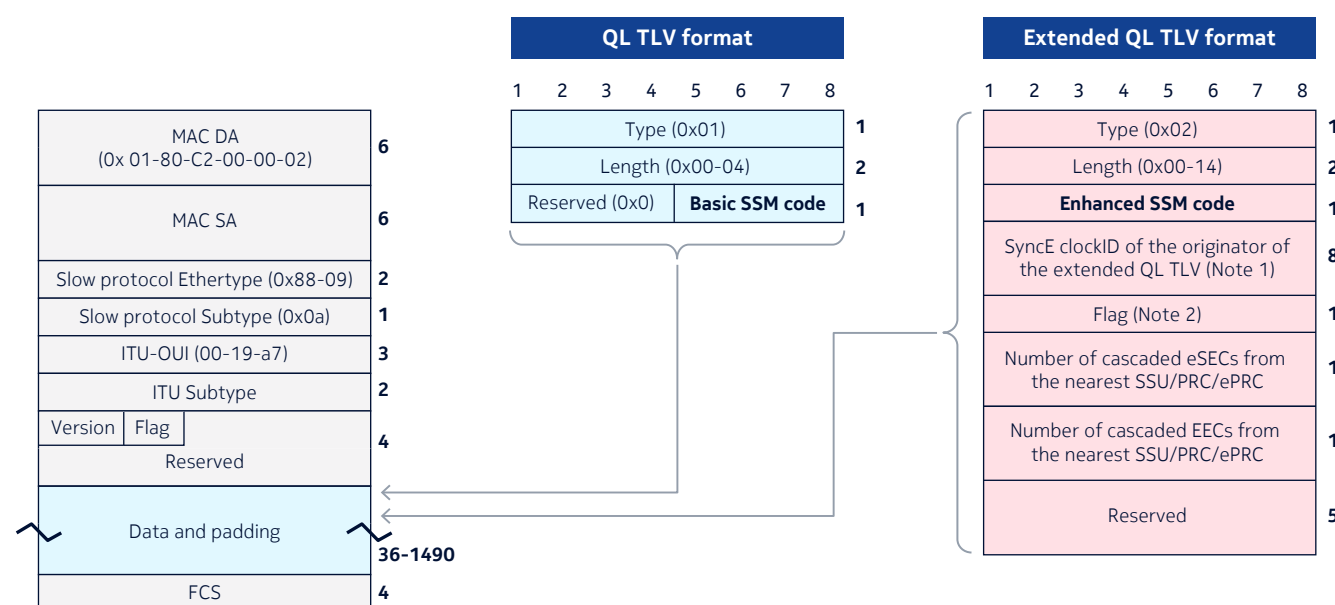
¹ ITU-T Q13/15 decided to replace the terms EEC/eEEEC by SEC/eSEC to cover more future synchronous equipment clocks (OEC, future sync_mtn). This term has officially been introduced in ITU-T G.781 (04/2020) edition. With respect to QLs, the QL-eEEEC is replaced by QL-eSEC and moving forward ITU-T will only use QL-eSEC to cover both eEEEC and enhanced synchronous OTN Equipment Clock (eOEC).

To support new clocks and associated functionality, an optional extended QL TLV was defined in Amendment 2 to Recommendation ITU-T G.8264 [13] 2014 version and later modified in Amendment 1 to the 2017 version. The extended QL TLV contains the following new information in dedicated fields:

- The SyncE clockID field indicates the originator of the extended QL TLV, which refers to the clock that starts or re-starts the counts of cascaded clocks.
- The Flag field indicates whether all clocks are eEECs and whether the count of the EEC/eEEC is complete
- The count fields provide the number of cascaded EECs and eEECs from the nearest SSU/PRC/ePRC.

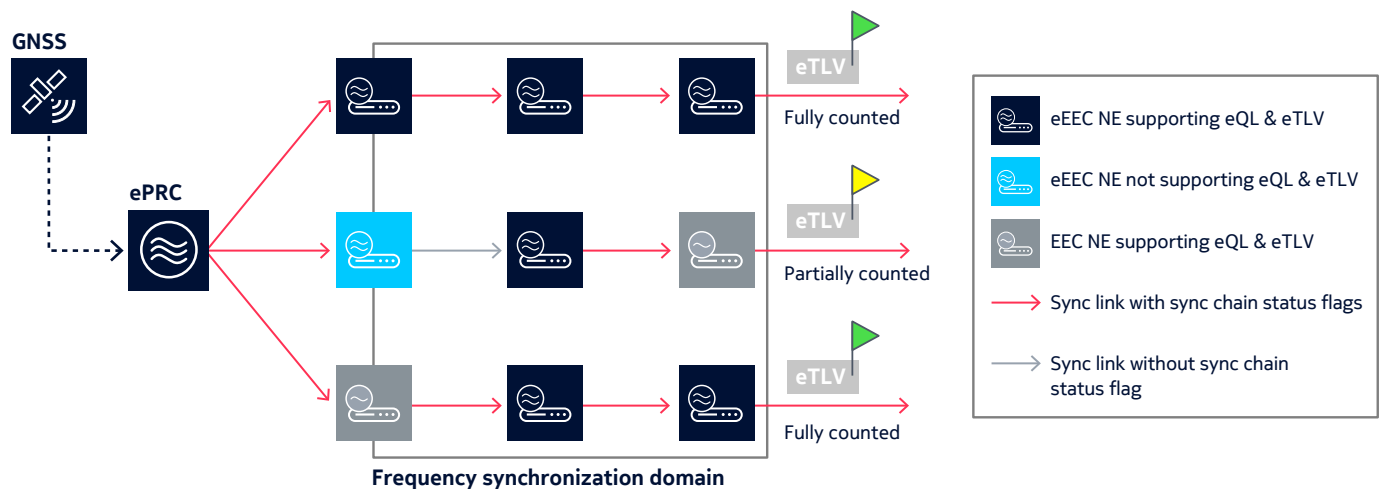
Figure 2 shows the original QL TLV and extended QL TLV formats.

Figure 2. Original QL TLV and Extended QL TLV formats per ITU-T G.781/G.8264



These new fields allow the management plane to analyze the synchronization topology and path change for SyncE, provided that the enhanced QLs and extended QL TLV are supported and enabled on all (e)EECs within the network. For service providers that do not use new enhanced primary reference clock (ePRC) or enhanced primary reference time clock (ePRTC) external equipment, a Network Element that supports this information allows the management system to build an up-to-date picture of the SyncE clock chain, both in terms of composition (eEEC or EEC type) and the number of eEEC/EEC nodes crossed. Figure 3 shows a view of the frequency synchronization for an example application that supports enhanced QL and extended QL TLV formats.

Figure 3. Frequency synchronization for an application that supports enhanced QL and extended QL TLV formats



ITU-T Synchronization OAM (ITU-T G Suppl. 68)

Optical transport technologies defined in ITU-T SG15 distinguish themselves from technologies defined in other standards development organizations (SDOs) by providing strong fault management (FM) and performance monitoring (PM) capabilities. The excellent reputation of SDH/SONET for OAM and network management is largely based on these ITU-T SG15 technologies. For example, ITU-T defines detailed FM processes for defect detection (including persistency checks and other mechanisms for robustness), consequent actions, and defect correlation into alarms. Similarly, for PM, it defines detailed processes for counter accumulation with rules for binning and threshold crossing alerts.

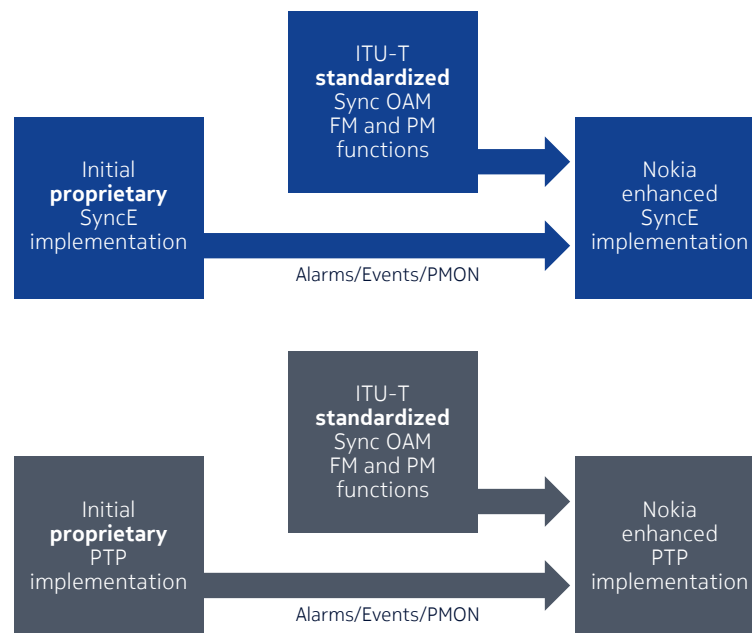
These operational practices have been in place for more than 40 years for PDH, SDH/SONET, DWDM, and were inherited by OTN (Recommendation ITU-T G.798) and packet transport (Recommendation ITU-T G.8021 and G.8121). For packet networking, these "ITU-T transport-grade" FM and PM additions complement the protocol specifications defined in other SDOs, including IEEE Std 802.1Q (PB, PBB, CFM, etc.) and IETF (MPLS, MPLS-TP, etc.). These additions are the difference between the Packet Transport Network (PTN), or "P-OTN," defined by ITU-T and the Packet Switched Network (PSN) defined by IEEE/IETF.

Service provider feedback has indicated the same need for strong OAM and network management for both time and frequency in the synchronization layer. IEEE Std 1588-2008 and Recommendation ITU-T G.8275.1 define the architecture and protocols but do not sufficiently cover the alarms and performance monitoring parameters. Each equipment vendor has therefore chosen to implement its own proprietary alarms and PM parameters. Although SyncE has existed for a long time and is widely deployed, vendors that did not strictly follow Recommendation ITU-T G.781 have also implemented their own alarms and counters.

Work to remedy this gap took place between ITU-T SG15 Q13 (Synchronization) and Q14 (Management), resulting in the February 2020 publication of Supplement 68 to the ITU-T G Series Recommendations [14] (abbreviated as ITU-T G Suppl.68, and called "ITU-T Sync OAM").

ITU-T Sync OAM greatly facilitates monitoring and simplifies the operation, administration and maintenance of synchronization layer networks while enabling homogeneity across different vendor implementations. It makes it easier to monitor the synchronization service and resolve issues with service level specification (SLS) compliance. All the alarms and performance monitoring parameters defined in ITU-T G Suppl. 68 have been implemented on the 1830 PSS, in the frequency (SyncE) and phase/time (PTP) domains. Figure 4 shows the evolution of this enhanced SyncE and PTP management capability.

Figure 4. Evolution from proprietary to ITU-T standardized frequency and time synchronization OAM



These transport-grade OAM capabilities play a fundamental role in the Nokia optical networks portfolio. Although the ITU-T G Suppl. 68 was published in February 2020, Nokia demonstrated technology leadership with early implementation on the 1830 PSS and commercial release in 2018. This was possible because the draft specification had been stable since 2017.

Hard isolation for synchronization plane also benefits OAM

As explained in [15] the concept of hard and soft isolation can be extended to the synchronization plane. Phase/time synchronization has stringent performance requirements, such as uniform, bidirectional latency symmetry, and no interference from other services. Using hard isolation with a dedicated wavelength, the 1830 PSS leverages a dedicated optical timing channel (OTC), to transport synchronization over a WDM network. This approach provides the determinism and accuracy required by the time recovery algorithms. The use of a bidirectional OTC eliminates fixed and variable link asymmetry, which are significant contributors to time inaccuracy in WDM networks.

All the SyncE Ethernet Synchronization Message Channels (ESMCs) and PTP protocol data units (PDUs), as well as the ITU-T G.Suppl.68 Synchronization OAM functions defined in the previous section, are carried over the hard isolated OTC.

Synchronization management

Effective synchronization management is critical for network synchronization, just as end-to-end network management is critical for traffic connectivity or traffic engineering in optical transport networks, which have historically been characterized by strong management systems. When something goes wrong in the synchronization chain, it is not humanly possible to sift through the logs – node by node, clock by clock – to identify the root cause, or to inspect the performance monitoring counters on each node to detect a time error degradation. Troubleshooting to identify the downstream impact along with other correlated issues is

difficult for those who are not SyncE/PTP experts. To alleviate common operator concerns and to centralize the management of the synchronization layer, Nokia has introduced the **WaveSuite Synchronizer** (WS-S).

The WS-S is the network management application part of the Network Functions Manager-Transport (NFM-T), now referenced as WaveSuite Network Operations Center (NOC). It supports the network management of time and frequency distribution in 1830 PSS-based networks. The WS-S provides a network-wide view of the synchronization layer to the operator. It delivers real-time intelligence on the various synchronization elements, sync key performance indicators (KPIs) and fault conditions, thereby enabling the operator to act proactively to avoid synchronization distribution errors in the network, or to quickly localize failures and take corrective actions.

Synchronization as a Service

SyncaaS is a new service provider offering enabled by the WS-S. SyncaaS is built on a standardizable set of services and service attributes for a pure synchronization service, delivered independently from MEF L1/L2/L3 services. A “subscriber,” such as an MNO, can choose from three synchronization distribution service types offered by the service provider:

- Frequency/SyncE
- Phase/Time PTP with Full Timing Support (FTS)
- Phase/Time PTP with Partial Timing Support (PTS)

The subscriber and the service provider need to agree on many service attributes prior to the deployment of SyncaaS. These include high-level attributes such as management identifiers and more detailed attributes such as physical port rates, Layer 2 control protocol parameters and processing (i.e., for SyncE and PTP messaging). As with any service agreement, these service attributes only represent externally visible aspects, so they must be translated into per-node values and provisioned in the equipment within the service provider’s network. This is one of the key roles that WS-S provides to facilitate the deployment of SyncaaS.

WaveSuite Synchronizer functionality

The WS-S provides a solution to reduce the complexity and time involved in provisioning PTP and SyncE throughout the network, as well as configuring the subsequent operations and management. It allows the user to create a PTP or SyncE service, which is a collection of nodes that are bound to a common T-GM/PRTC or PRC. These nodes can be provisioned with custom templates, which reduce the time involved in provisioning parameters. The NFM-T map supports a new synchronization layer that enables service providers to view the PTP/SyncE service and manage the configuration of the nodes in the service by toggling between the network map and WS-S.

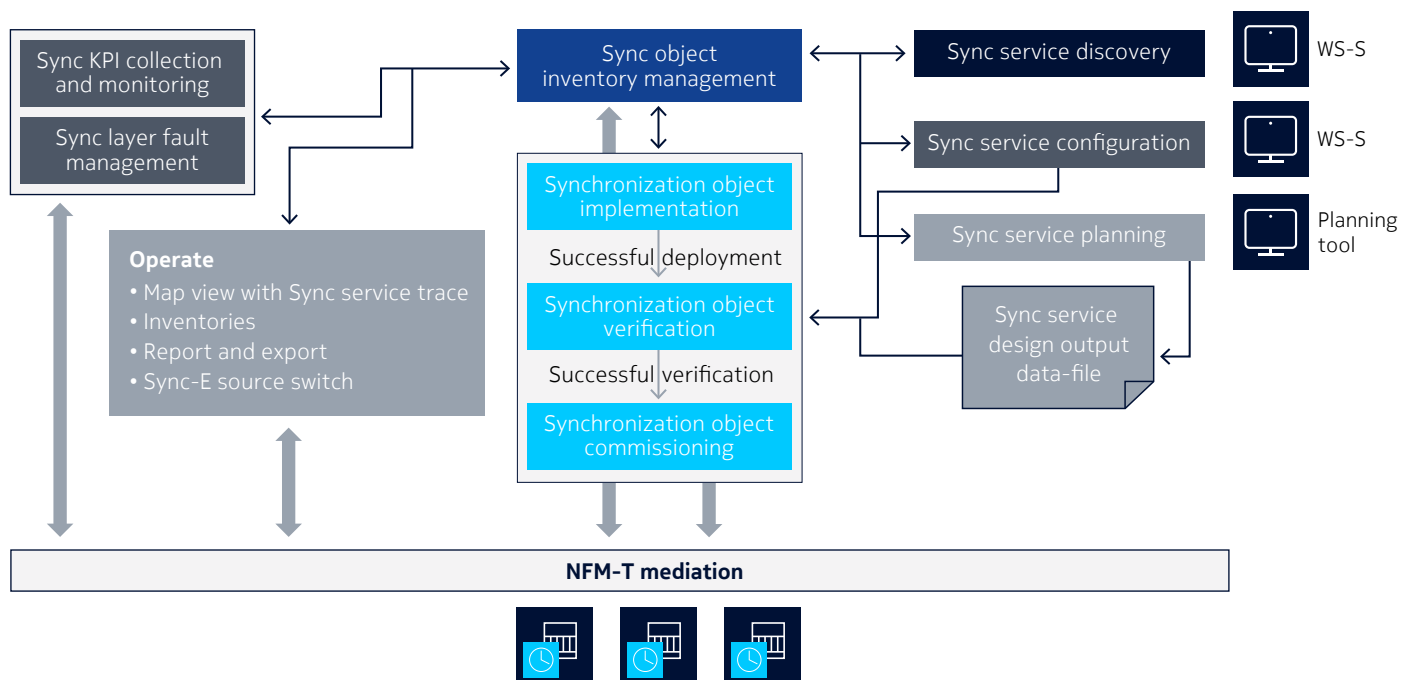
Synchronization service assurance is provided by the Nokia Network Services Platform’s fault management application and the synchronization NG-PM function of the WS-S. This function’s key responsibilities include synchronization KPI collection and monitoring, synchronization fault preemption, identification and recovery, and real-time presentation of synchronization time values (with nanosecond accuracy).

The WS-S is offered as an optional and licensed application of NFM-T with a base license that provides feature right-to-use (RTU) entitlement and asset protection, and standard license points to scale the solution. WS-S addresses three primary use cases:

- **Sync service discovery** – The WS-S supports discovery of sync-capable 1830 PSS nodes. Upon instantiation, it will either add the discovered node(s) to a service or create a new service. This feature provides a quick and easy means for the operator to manage all its sync-configured network nodes with a single tool.
- **Sync service deploy** – The WS-S enables the user to create a PTP/SyncE (time/frequency distribution) service, which consists of nodes synchronized from a common timing source. While today's network operators are often forced to manually log in to every node and configure the synchronization parameters, the WS-S enables the user to apply a common template to the nodes and customize the sync parameters for each node.
- **Sync service planning** (future) – The WS-S will support the importing of synchronization service designs (via design data file), working in conjunction with Nokia planning tools. The user will be able to use these tools to plan the synchronization topology and services and perform 'what-if' analysis before provisioning the network with the WS-S.

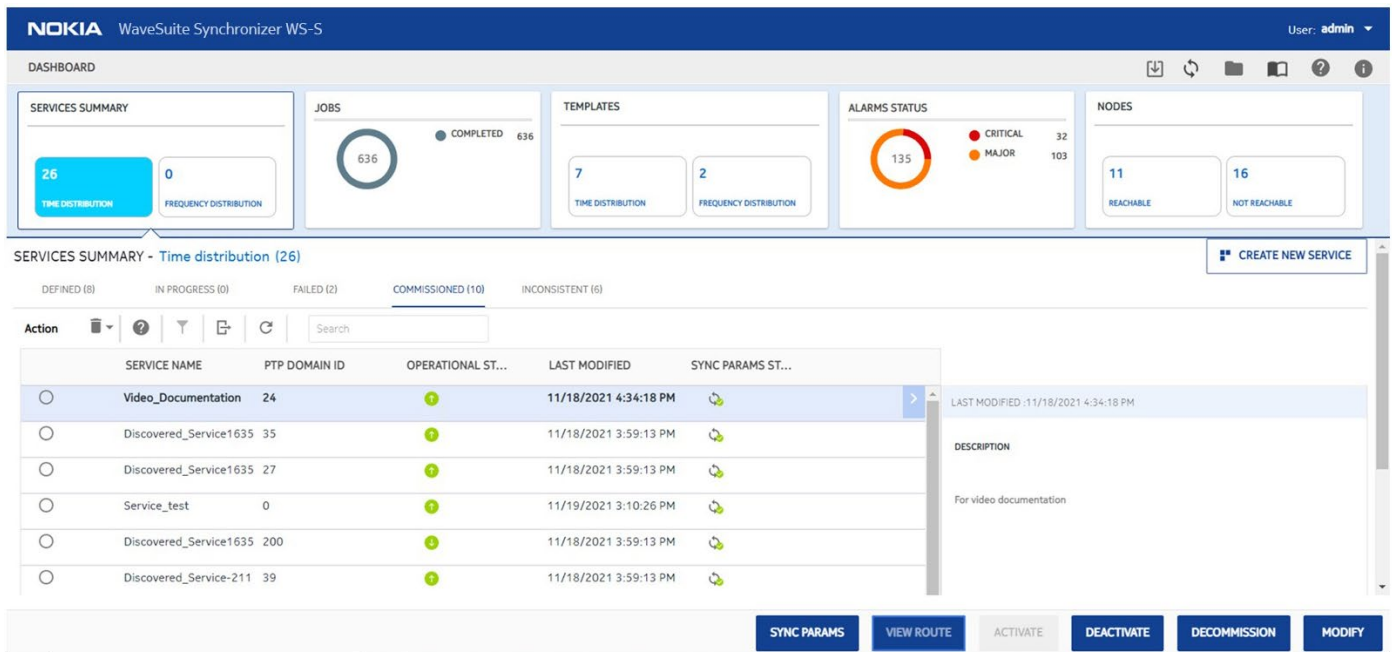
Figure 5 shows how the three sync service functions fit into the overall lifecycle of a synchronization service.

Figure 5. Synchronization service lifecycle



The WS-S dashboard, shown in Figure 6 below, can be launched and accessed from the NFM-T. This dashboard is a one-stop shop for all information about the sync service status, jobs, sync templates and alarm status.

Figure 6. WS-S dashboard



The sync services are classified as:

- Defined: services that have been defined in WS-S but not yet deployed
- In progress: services for which deployment is in progress
- Failed: services for which deployment has failed
- Commissioned: services that have been successfully deployed
- Inconsistent: services that have been partially deployed or that are not consistent with the network synchronization element

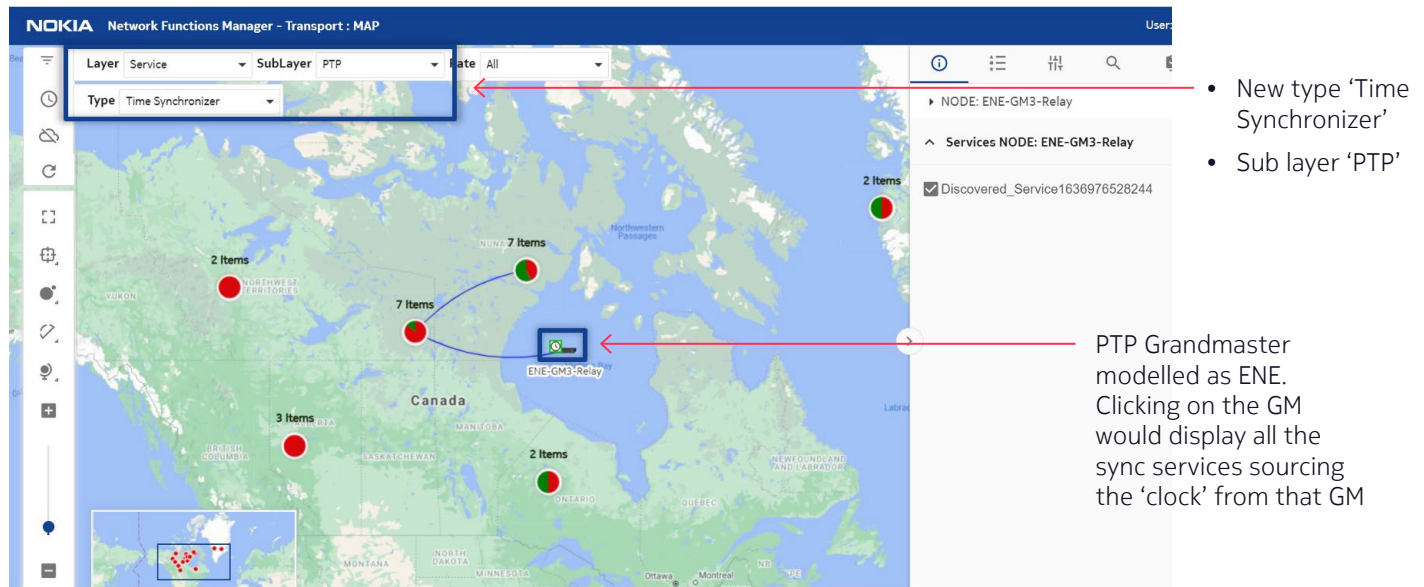
The WS-S supports templates for PTP service deployment. The operator can create, save, publish, unpublish and delete the templates for sync service provisioning. By default, system-defined best-practice templates based on the ITU-T and IEEE standards are available for the operator.

For service assurance, synchronization alarms are raised when there is a fault in the PTP clock, PTP port or ToD port. The alarms status provides a summary view based on alarm severity. For a detailed view, the alarm tab provides a navigable link to the Network Services Platform's Fault Management application (FM-App), which allows the operator to view and manage these alarms. The operator can use the FM-App to filter the root cause of the alarm and fix the fault condition.

The WS-S dashboard also provides the user with various options to manage the sync services (e.g., modify, deactivate, sync with the network element), along with links to help content and user documentation.

To present the operator with a graphical user interface (GUI) view of the synchronization topology, the NFM-T map now supports a synchronization layer on top of the existing map layers, as shown in Figure 7. This new feature enables the operator to view the synchronization layer in the same network context and look and feel as any other layer in the network. The user can view the PTP/SyncE service in the NFM-T map by choosing the appropriate filters. This makes it possible to view the PTP/SyncE tree from the T-GM/PRTC down to the last T-BC in the chain.

Figure 7. NFM-T map synchronization layer



WS-S supports Event Messages for Clock State Change, Port State Change, GM Change, and Path Change. Upon receiving any of these notifications from the nodes, WS-S looks for associated data for this change, i.e., new Clock Admin State, new Port Admin State, GM ID, Locked Port Number and Parent Port Number.

WaveSuite Synchronizer evolution

Hierarchical representation of the synchronization service:

A typical L0/1/2 service is made up of an A-end and a Z-end, along with associated transmission parameters. This information could be depicted on a network map or in a table. A synchronization service, on the other hand, would start from a timing source and span across the network in a tree-like pattern. While such a service could be represented on a map or in a tabular view, a better representation would be a hierarchical view that represents the synchronization service as the synchronization signals flow through the network. This view would not conform to the actual geographical locations of the various synchronization elements but rather provide a logical view to the operator.

End-to-end management of the synchronization service:

The management of synchronization will not be complete until the timing source can also be managed as part of the synchronization service to provide the operator with true end-to-end visibility. The WS-S will integrate management support for third-party timing sources from Nokia partners. This will include device configuration and management, as well as fault and KPI monitoring.

Conclusion

Synchronization is critically important to 5G mobile networks where disaggregation of RAN functions leads to varying architectures that have different synchronization performance requirements for fronthaul and midhaul/backhaul. The challenge for service providers and network operators goes beyond meeting stringent synchronization performance requirements. They must also address the planning, end-to-end provisioning, and operations and maintenance required for robust and resilient synchronization distribution networks. This requires new tools that can optimize the manually intensive synchronization chain configuration for network provisioning and monitoring, as well as provide powerful network-layer synchronization management to enable the simplification and automation of tasks.

Nokia optical transport networks based on the 1830 PSS portfolio lead the market by fully implementing and complying with the latest versions of existing ITU-T standards. They provide new capabilities that aid network operators in the OAM tasks required to manage synchronization distribution networks. These include Recommendation ITU-T G.8275.1 PTP telecom profile (Edition 2.1) features of path traceability, synchronization uncertain indication, and limiting the maximum number of steps in the synchronization chain. The 1830 PSS also enables improved traceability of the eEEC chain in accordance with Recommendation ITU-T G.8264/G.781 and includes ITU-T Synchronization OAM tools (ITU-T G Suppl. 68) that greatly facilitate the monitoring and operation of synchronization layer networks while also enabling homogeneity across different vendor implementations.

The Nokia solution offering goes beyond the standards by providing enhanced management, monitoring and supervision capabilities. It now includes powerful network-layer synchronization management through the WS-S application, which enables the management of time and frequency synchronization distribution in 1830 PSS-based networks while helping to deliver Synchronization as a Service, or SyncaaS. The creation of PTP and/or SyncE services has now become an efficient process, using custom templates to reduce provisioning effort and time.

The advanced Network Element functionalities defined in the new standards, or newer editions thereof, coupled with the addition of the WS-S application to the NFM-T optical network management, greatly simplify the tedious procedures once used to configure and manage synchronization networks node by node. With an efficient and intuitive GUI representation of the synchronization layer, the WS-S offers service providers and network operators a holistic view of synchronization services and topology and has the same look and feel as any other layer in the network.

Abbreviations

APTS	assisted partial timing support
CLI	command line interface
C-RAN	centralized RAN
DWDM	dense wavelength division multiplexing
EEC	synchronous Ethernet Equipment Clock
eEEC	enhanced synchronous Ethernet Equipment Clock
EMS	Element Management System
eOEC	enhanced synchronous OTN Equipment Clock
ePRC	enhanced primary reference clock
ePRTC	enhanced primary reference time clock
ESMC	Ethernet Synchronization Message Channel
eSyncE	enhanced SyncE
FM	fault management
FTS	Full Timing Support
FTTH	Fiber to the Home
GE	Gigabit Ethernet
GM	Grandmaster
GUI	graphical user interface
HRM	hypothetical reference model
IP	Internet Protocol
ITU-T	ITU Telecommunication Standardization Sector
LAG	link aggregation
MAC	media access control
MNO	mobile network operator
MPLS	Multiprotocol Label Switching
NFM-T	Network Functions Manager - Transport
NMS	Network Management System
NOC	network operations center
OAM	operations, administration and maintenance
OTC	optical timing channel
PDU	protocol data unit
PM	performance management

PTP	Precision Time Protocol
PRC	primary reference clock
PRTC	primary reference time clock
PRS	Positioning Reference Signal
PSN	Packet Switched Network
PTN	Packet Transport Network
PTS	Partial Timing Support
PTSF	packet timing signal fail
QL	quality level
RAN	radio access network
SDH	synchronous digital hierarchy
SDO	standards definition organization
SLS	service level specification
SONET	synchronous optical networking
SyncaaS	Synchronization as a Service
SyncE	Synchronous Ethernet
T-BC	telecom boundary clock
ToD	time of day
T-TSC	telecom time slave clock
TLV	type-length-value
WebUI	web user interface
WS-S	WaveSuite Synchronizer

References

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