

Timing and Synchronization Configuration Guide for Cisco 8000 Series Routers, Cisco IOS XR Releases

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Preface

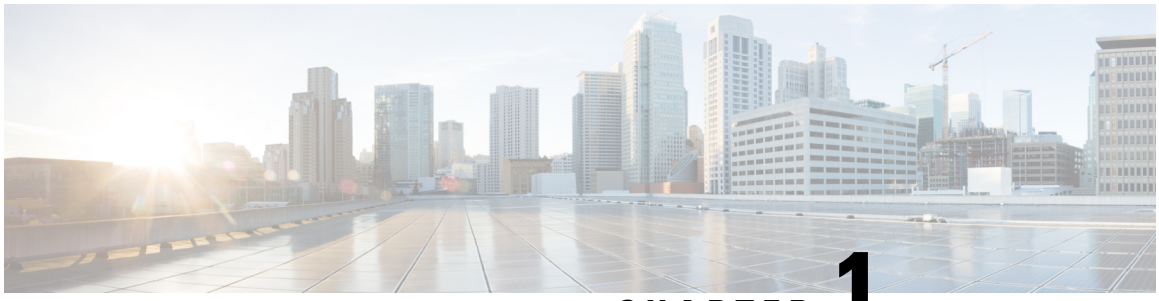
This cumulative guide provides a single, continuously updated version that includes all the latest IOS XR features and release updates. It simplifies your experience by letting you bookmark one link and access the complete guide, instead of navigating through multiple release-specific versions.

Specific changes or updates tied to individual releases are clearly called out within the relevant sections. For a list of features introduced in a specific release, refer to the Release Notes or the IOS XR Feature Finder.

The table lists the release numbers for which this document has been updated since its initial publication.

Table 1: Changes to this document

Date	Summary
October 2025	First published for Release 25.3.1



CHAPTER 1

Using YANG Data Models

• Using YANG Data Models, on page 1

Using YANG Data Models

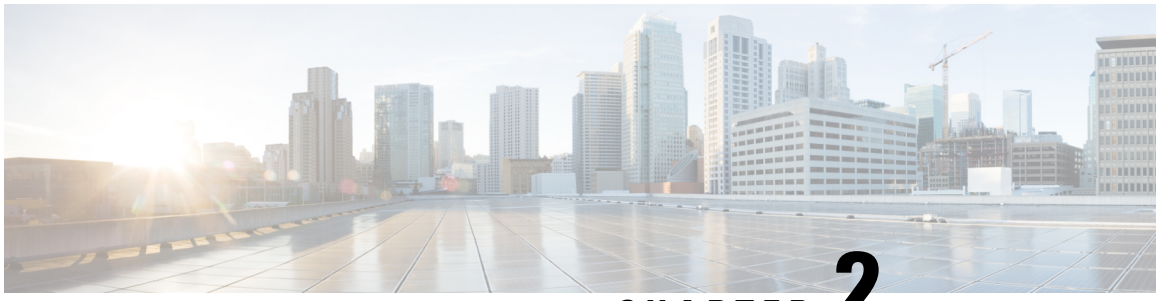
Cisco IOS XR supports a programmatic way of configuring and collecting operational data of a network device using YANG data models. Although configurations using CLIs are easier and human-readable, automating the configuration using model-driven programmability results in scalability.

The data models are available in the release image, and are also published in the Github repository. Navigate to the release folder of interest to view the list of supported data models and their definitions. Each data model defines a complete and cohesive model, or augments an existing data model with additional XPaths. To view a comprehensive list of the data models supported in a release, navigate to the *Available-Content.md* file in the repository.

You can also view the data model definitions using the YANG Data Models Navigator tool. This GUI-based and easy-to-use tool helps you explore the nuances of the data model and view the dependencies between various containers in the model. You can view the list of models supported across Cisco IOS XR releases and platforms, locate a specific model, view the containers and their respective lists, leaves, and leaf lists presented visually in a tree structure. This visual tree form helps you get insights into nodes that can help you automate your network.

To get started with using the data models, see the *Programmability Configuration Guide*.

Using YANG Data Models



CHAPTER 2

Timing and synchronization

A timing and synchronization system is a network infrastructure component that

- ensures precise alignment of time across network devices,
- supports the security and efficiency of time-dependent network services, and
- enables accurate logging, data correlation, and coordinated operations.

Accurate timing and synchronization help you manage network security, availability, and efficiency by ensuring that all devices share the same time base. Configure and synchronize clocks on routers and switches to ensure the network displays accurate time. Accurate time is critical for troubleshooting, auditing, and maintaining network integrity.

- Network Time Protocol (NTP) is commonly used to synchronize router clocks.
- Time-sensitive applications, such as financial trading or telecommunication services, rely on precise network synchronization.

- Synchronization, on page 3
- Synchronous Ethernet (SyncE), on page 4
- GPS, an external clock interface, on page 5
- BITS, an external clock interface, on page 5
- Precision Time Protocol (PTP), on page 6
- Network Time Protocol (NTP), on page 6

Synchronization

A synchronization is a network timing mechanism that

- aligns the clocks of network elements to the same time, phase, and frequency,
- prevents data loss, corruption, or misinterpretation caused by desynchronized devices, and
- supports accurate operation of applications that require precise timing.

Frequency synchronization ensures all networking equipment (NEs) operate at the same clock rate or frequency, preventing issues like data loss or call quality degradation.

There are four types of sources for frequency synchronization:

- **Line interfaces** include Synchronous Ethernet (SyncE) interfaces.
- **Clock interfaces** are external connectors for connecting other timing signals, such as BITS and GPS.
- **PTP clock** If IEEE 1588 version 2 is configured on the router, a Precision Time Protocol (PTP) clock may be available to frequency synchronization.
- **Internal oscillator** This is a free-running internal oscillator chip.

Phase synchronization ensures the phase of signals is consistent across the network, so devices agree on the timing of data bits, critical for functions like seamless mobile handover. Phase synchronization is achieved mainly using PTP.

Time synchronization also called Time of Day (ToD), ensures network elements agree on the current time for applications requiring precise timing, such as financial transactions. Time synchronization is achieved using NTP (millisecond accuracy) and PTP (nanosecond accuracy).

Synchronous Ethernet (SyncE)

A Synchronous Ethernet (SyncE) is a network synchronization technology that

- uses the Ethernet physical layer to deliver precise frequency synchronization,
- integrates synchronization directly into existing Ethernet infrastructure, and
- eliminates the need for separate synchronization equipment or cabling.

SyncE is defined by the ITU-T and relies on Ethernet interfaces for transport. Because it operates at the physical layer, SyncE is robust against packet-based issues such as delay and jitter, making it especially reliable in high-traffic environments.

However, SyncE only provides frequency synchronization; applications requiring time or phase synchronization need additional protocols such as the Precision Time Protocol (PTP). Every network element between the source and destination must support SyncE to extend frequency synchronization to network edges.

ESMC

A Ethernet Synchronization Messaging Channel (ESMC) is a SyncE protocol that

- communicates Synchronization Status Messages (SSM) as defined in ITU-T G.8264,
- allows SyncE network nodes to exchange information about the quality level of their synchronization source, and
- enables nodes to optimize network performance by selecting and switching to the best available synchronization source.

ESMC helps you maintain network resilience. If your current synchronization source fails, your nodes can switch to another source. This process minimizes the impact on network performance.

Enhanced ESMC

An Enhanced Ethernet Synchronization Messaging Channel (ESMC) channel is an Ethernet synchronization messaging mechanism that

- extends the standard ESMC protocol with additional features,
- provides extra synchronization quality level indicators for improved accuracy, and
- enables faster and more precise network switching to alternative synchronization sources during failures or changes.

Enhanced ESMC channels improve network responsiveness and allow for better management of frequency synchronization within Ethernet networks by providing more detailed data about the synchronization source quality.

GPS, an external clock interface

A global positioning system (GPS) is a satellite-based timing and navigation technology that

- transmits highly accurate time and frequency signals from atomic clocks in orbit,
- enables precise synchronization for geographically dispersed devices, and
- functions independently of terrestrial network infrastructure.

Use GPS for frequency synchronization to obtain precise timing and frequency references from atomic clocks on satellites. A GPS receiver uses these references to synchronize network devices. Most locations with a clear view of the sky can receive a GPS signal. This capability makes GPS ideal for institutions with distributed equipment.

Configure GPS settings for the grandmaster clock, on page 22 section details the configuration steps involved for frequency synchronization using GPS.

BITS, an external clock interface

A Building Integrated Timing Supply (BITS) system is a timing distribution system that

- uses a centralized clock to generate timing signals distributed to network equipment,
- relies on high-quality oscillators to ensure a stable and accurate reference frequency, and
- operates independently from external systems such as GPS.

Use BITS systems for single buildings, campuses, or data centers, not for wide-area or geographically distributed networks. BITS systems synchronize many network elements (NEs) within a confined area. Use dedicated infrastructure and perform regular maintenance to maintain accuracy and reliability. If the centralized clock fails, synchronization across the entire network will be disrupted.

For configuration steps, see the Configure BITS, an external Clock Interface for Frequency Synchronization section.

Precision Time Protocol (PTP)

A Precision Time Protocol (PTP) is a time synchronization protocol that

- delivers precise time and frequency synchronization over packet-based networks,
- operates independent of specific hardware or physical layer protocols, and
- scales efficiently across large industrial, scientific, and telecommunications networks.

PTP can synchronize the clocks of network elements (NE) with accuracy of 1 nanosecond (0.000000001 seconds), making it suitable for high-precision environments. It is flexible and widely applicable across many network architectures.

PTP traffic affects network performance, especially in large or high-traffic networks. Latency, jitter, and packet loss reduce synchronization accuracy. PTP includes mechanisms that mitigate these problems.

PTP profiles allow adaptation for specific use cases. For example:

- The G.8265.1 profile fulfills frequency synchronization requirements for telecom networks.
- The G.8275.1 profile meets time of day (ToD) and phase synchronization needs.

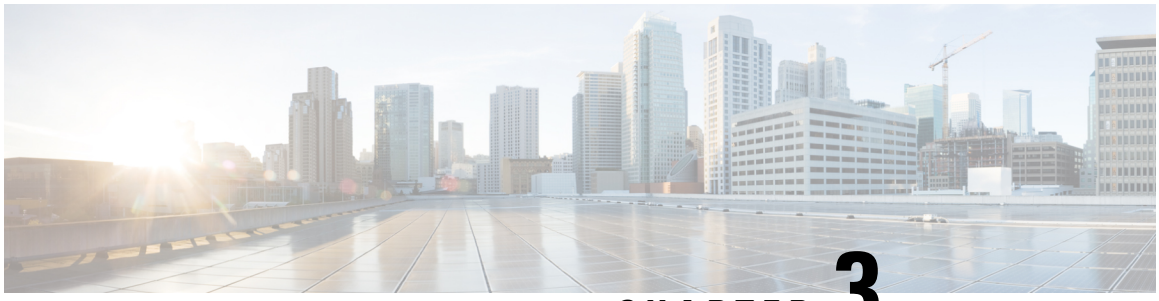
Network Time Protocol (NTP)

A Network Time Protocol (NTP) is a time synchronization method that

- synchronizes clocks among devices on a network using primary reference clocks,
- operates independently of hardware and network architecture, and
- provides accuracy of 1 millisecond (0.001 seconds) in time coordination.

NTP servers obtain time from reference clocks, such as Global Positioning System (GPS) receivers or telephone modem services. Then they distribute synchronized time to network devices. You can use NTP in small local networks or in large environments spread across different locations.

Use PTP instead of NTP for applications where extremely high precision is required. Because it is an older protocol, NTP can be targeted by various types of attacks. To manage NTP security, you must take extra precautions.



CHAPTER 3

Frequency synchronization

A frequency synchronization is a timing method that

- distributes precision frequency across a network
- enables circuit emulation by maintaining precise timing between endpoints, and
- supports compliance with standards such as International Telecommunication Union Telecommunication Standardization Sector (ITU-T) G.8262.

Frequency synchronization provides precise frequency—rather than time of day—enabling next-generation network services. The feature is crucial for applications like circuit emulation, where each circuit endpoint requires synchronization with a known, common precision frequency reference.

Table 2: Feature History Table

Feature name	Release Information	Feature Description
Frequency Synchronization	Release 7.3.1	Based on the ITU-T G.8262 recommendations, timing devices provide precision frequency to support frequency synchronization for bandwidth, frequency accuracy, holdover, and noise generation measurement. These actions ensure correct network operations when synchronous equipment receives timing from another synchronous equipment clock or a higher-quality clock.

- Source and Selection Points, on page 8
- Synchronous Ethernet (SyncE), on page 9
- Configure frequency synchronization, on page 15
- Verify the frequency synchronization configuration, on page 27
- SyncE preference for PTP receiver interfaces, on page 30

Source and Selection Points

Source and selection points are frequency synchronization elements that

- identify the input timing source for a network device
- serve as the decision points for selecting among multiple synchronization signals, and
- ensure devices maintain accurate timing by choosing the most reliable source.

Frequency synchronization in telecommunications networks depends on obtaining timing information from a high-quality source. Selection points evaluate potential sources such as Global Navigation Satellite System (GNSS), master clocks, or peer devices, and determine which to use based on reliability, signal quality, and predefined priority.

Source

A source is a frequency signal input/output interface that

- provides timing or frequency signals to a system or receives them from it
- maintains an associated Quality Level (QL) to indicate clock accuracy, and
- accepts assigned priority values to define synchronization preference and prevent timing loops.

Four types of sources exist:

1. Line interfaces—these include interfaces such as SyncE, used for synchronizing network equipment.
2. Clock interfaces—external connectors for timing signals, such as BITS and GPS sources.
3. PTP clock—these are IEEE 1588 v2-based clocks that supply time-of-day and frequency information.
4. Internal oscillator—a free running oscillator chip for independent timekeeping.

Each source has a Quality Level (QL) that shows clock accuracy. The Quality Level helps you determine which source devices in the system to synchronize with. Assign priority values to each router's source. These priorities define the network synchronization flow and help prevent timing loops. QL information and the priority levels you assign allow each router to select a source for SyncE interface synchronization according to ITU standard G.781.

Selection points

A selection point is a timing signal node in a network device that

- enables choices to be made between multiple incoming frequency signals
- forms interconnected graphs representing the flow of timing across different cards in a router, and
- may select one or many signals as outputs for further distribution within the system.

Inputs to selection points include:

- signals received directly from timing sources

- outputs from other selection points on the same card, or
- outputs from selection points on other cards.

Outputs of selection points may:

- drive signals sent out of a set of interfaces
- serve as input to another selection point on the same card, or
- serve as input to a selection point on another card.

Use the `show frequency synchronization selection` command to view selection point details in the system.

Synchronous Ethernet (SyncE)

A Synchronous Ethernet (SyncE) technology is an ITU-T standard for computer networking that

- distributes frequency synchronization across Ethernet networks using the physical layer
- enables accurate transfer of clock signals from a primary reference clock (PRC) to downstream devices, and
- supports hop-by-hop frequency synchronization to maintain consistent timing across devices.

SyncE is designed to address the need for precise frequency synchronization in modern Ethernet networks. This is especially important as Synchronous Digital Hierarchy (SDH) equipment is replaced by Ethernet devices. Unlike traditional Ethernet, which does not inherently provide frequency synchronization, SyncE leverages existing Ethernet interfaces. This enables the propagation of a common, high-precision clock signal across the network. Devices connected via Ethernet ports operate with synchronized timing. Synchronized timing is essential for many applications in telecommunications and data communications.

To operate SyncE links reliably, networks use operational messages. These messages determine the most reliable timing source for each node and communicate timing source quality information. In SDH environments, these are called Synchronization Status Messages (SSMs). SyncE uses the Ethernet Synchronization Message Channel (ESMC) to transport Synchronization Status Messages (SSMs), maintaining high-quality timing information throughout the network.

How syncE works

Summary

Use SyncE (Synchronous Ethernet) to synchronize clocks across your network. It extracts, distributes, and recovers clock frequency through Ethernet data signals.

The key components in this process are:

- **Primary reference clock (PRC):** Generates traceable network timing for synchronization across all nodes.
- **Network element (NE):** Includes Primary and Client Clock NEs, which distribute and recover clock signals.

- **Synchronous Ethernet equipment clock (EEC):** Adopted in every NE to maintain synchronization within the chain.
- **Clock data recovery (CDR):** Recovers clock signal at the transceiver or via an external module.
- **Transmit and receive (Tx and Rx) ports:** These ports transmit and receive data signals containing clock frequency information.

Workflow

Figure 1: Clock Frequency Extraction for SyncE

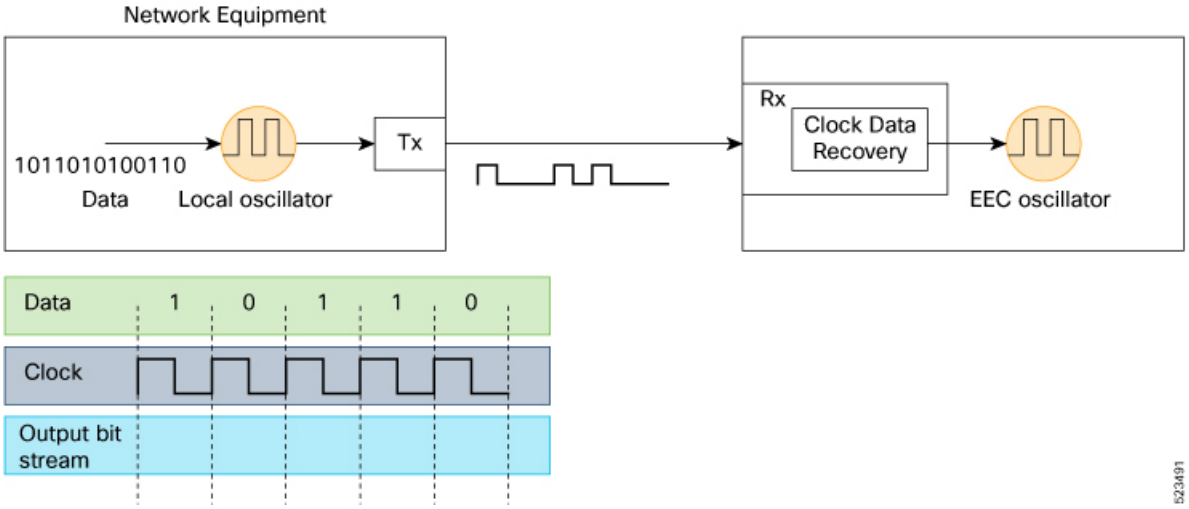
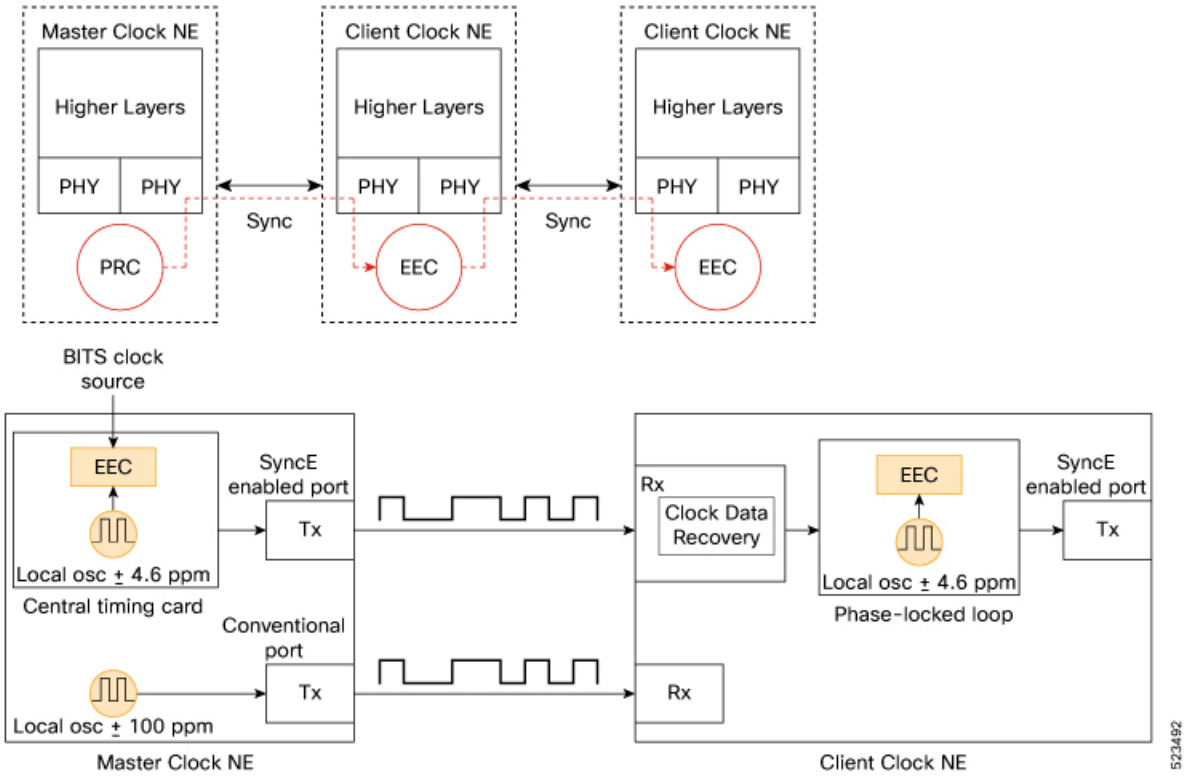


Figure 2: Clock Deployment for SyncE



The process involves these stages:

1. The PRC distributes the master clock across network elements in the chain.
2. Each NE uses an EEC to adopt the synchronized clock, ensuring the timing is traceable to the PRC.
3. The Tx port transmits data signals embedded with clock frequency.
4. The Rx port at the receiving NE extracts and recovers the clock frequency from the incoming signal using CDR (either integrated or external).
5. The recovered clock is sent to the central timing card of the NE, which provides reference timing for further distribution.
6. The Client Clock NE becomes the Primary Clock NE for the next downstream NE, perpetuating node-to-node clock synchronization.

Result

With SyncE, you achieve robust network-wide synchronization of timing signals, even when network load varies or specific packet traffic changes. Use SyncE when you need precise timing and reliable data transfer for your applications.

SyncE profiles support matrix

Use this matrix to quickly identify which SyncE profiles are available for each Cisco 8000 series hardware module or router and under which Cisco IOS XR release.

Table 3: SyncE profiles support matrix

Hardware Module	Supported SyncE profiles	Cisco IOS XR Release
8711-28H8F-M	G.8262 G.8264	Release 26.3.1
8711-48Z-M	G.8262 G.8264	Release 25.4.1
8404-SYS-D	G.8262 G.8264	Release 25.4.1
8404-RSP1-2FH/4H	G.8262 G.8264	Release 25.4.1
84-MPA-2H12Z-M	G.8262 G.8264	Release 25.4.1
84-MPA-2FH/6H-M	G.8262 G.8264	Release 25.4.1
8011-12G12X4Y-A/D	G.8262 G.8264	Release 25.4.1
8011-32Y8L2H2FH	G.8262 G.8264	Release 25.4.1
8011-4G24Y4H-I	G.8262 G.8264	Release 25.1.1
Cisco 8712 Router	G.8262 G.8264	Release 24.4.1
8711-32FH-M router	G.8262 G.8262.1	Release 24.3.1
86-MPA-14H2FH-M	G.8262 G.8264	Release 24.1.1
86-MPA-24Z-M	G.8262 G.8264	Release 24.1.1
86-MPA-4FH-M	G.8262 G.8264	Release 24.1.1

Hardware Module	Supported SyncE profiles	Cisco IOS XR Release
Cisco 8608 Router	G.8262 G.8264	Release 24.1.1
8608-RP Route Processor 1588 Port (1G/10G)	G.8262 G.8264	Release 24.1.1
8000-RP2 Route Processor	G8275.1 G8273.2	Release 7.11.1
88-LC0-36FH-M	G8275.1 G8273.2	Release 7.11.1
8800-LC-36FH	G8275.1 G8273.2	Release 7.11.1
8800-RP2 Route Processor 1588 Port(1G/10G)	G.8262 G.8264	Release 7.10.1
• 88-LC0-36FH-M line card • 8202-32FH-M router	G.8262 G.8264	Release 7.5.2
• 8201-32FH router • 88-LC-34H14FH line card • 88-LC0-36FH line card	G.8262 G.8264	Release 7.3.3
• 8201 router • 8202 router • 8800-LC-36FH line card • 8800-LC-48FH line card	G.8262 G.8264	Release 7.3.1

SyncE restrictions

- SyncE is not supported on 8800-RP 1588 ports.
- Enable Frequency Synchronization selection input on two interfaces on each line card.
- Enable Frequency Synchronization selection input on only one bundle member for link aggregation.

Enhanced ESMC and Enhanced SyncE

An enhanced Ethernet Synchronization Message Channel (ESMC) protocol is a network synchronization protocol that

- enables frequency synchronization across Ethernet networks by using enhanced quality levels
- distributes synchronization status messages with improved precision using updated Type Length Value (TLV) fields, and
- supports clock synchronization across modern Ethernet devices with greater accuracy and reliability.

Enhanced SyncE (eSyncE) is an updated implementation of Synchronous Ethernet that uses the enhanced Quality Level (QL) TLV defined in ITU-T G.8264 to support a greater range of quality levels and more accurate synchronization.

- As part of the ESMC protocol, Synchronization Status Messages (SSMs) distribute the quality level (QL) of timing signals.
- The enhanced QL in TLV format enables networks to select and communicate improved clock quality standards, contributing to higher bandwidth, frequency accuracy, and reduced noise.
- Configure the router to send or receive enhanced TLV for precise synchronization. Set a local clock identifier, usually based on the device MAC address, to enable this feature.

Table 4: Feature History Table

Feature name	Release information	Feature description
Ethernet Synchronization Message Channel (ESMC)	Release 25.4.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100])(select variants only*) *This feature is supported on: • 8011-32Y8L2H2FH • 8011-12G12X4Y-A/D
Ethernet Synchronization Message Channel (ESMC)	Release 25.1.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100])(select variants only*) *This feature is now supported on Cisco 8011-4G24Y4H-I routers.

Feature name	Release information	Feature description
Ethernet Synchronization Message Channel (ESMC)	Release 7.3.1	The ITU-T G.8264 performance compliance standard defines the ESMC protocol. Use this standard to synchronize clock frequency across a network using an Ethernet port and select the desired quality level. The G.8264 standard includes an extended Quality Level (QL) represented as a Type Length Value (TLV). If you use Ethernet equipment instead of SONET or SDH devices, you achieve high-quality clock synchronization over Ethernet ports through improved frequency synchronization.



Note The default clock ID is based on the MAC address of the chassis.

Restriction for ESMC

Enable enhanced ESMC only on routers that support eSyncE. Routers without eSyncE support ignore enhanced TLVs, do not provide accurate clock quality, and drop QL TLVs at ingress nodes. Devices with enhanced ESMC support use extended QL TLVs.

Configure frequency synchronization

Configure frequency synchronization on the router using your preferred source (Synchronous Ethernet [SyncE], GPS, BITS, or Precision Time Protocol [PTP]).

Use this procedure to set up frequency synchronization, which is essential for accurate timing across your network devices.

Before you begin

To begin, ensure you have administrator access to the router.

Procedure

Step 1 Enable frequency synchronization on the router.

For detailed steps, see the *Enable Frequency Synchronization on the Router* section.

Step 2 Choose the frequency source for your configuration, and select from the options listed.

- If you use SyncE as the source, refer to the configuration steps in the *Configure Frequency Synchronization on an Interface* section.
- If you use an external clock interface (GPS or BITS) on Cisco 8000 hardware,
  - To configure frequency synchronization using GPS, refer to *Configure GPS, an external Clock Interface for Frequency Synchronization*.
  - For BITS, refer to *Configure BITS, an external Clock Interface for Frequency Synchronization*.
- If you use PTP, refer to G.8265.1 in the Precision Time Protocol (PTP) chapter.

Use your chosen source to configure frequency synchronization on the router.

Enable frequency synchronization on the router

Configure the router to use frequency synchronization for accurate timing across interfaces.

Perform this task when you need to synchronize frequency across router interfaces using specified timing sources.

Before you begin

Access the router CLI with appropriate administrative privileges.

To enable frequency synchronization on the router, complete these steps:

Procedure

Step 1 Configure the timing sources to drive the output from a clock interface:

Enter configuration mode and enable frequency synchronization:

```
Router# config
Router(config)# frequency synchronization
Router(config-freqsync)# clock-interface timing-mode system
```

Note If you do not configure timing mode system, the router raises the major alarm `T4 PLL is in FREERUN mode.` This alarm has no functional impact.

Step 2 (Optional) Configure the ITU-T quality level (QL) options if needed:

```
Router(config-freqsync)# quality itu-t option 2 generation 1
```

Note The quality option here must match the option that is specified in the quality receive and quality transmit commands in the interface frequency synchronization configuration mode.

Step 3 Enable logging of changes and errors:

```
Router(config-freqsync)# log selection changes
Router(config-freqsync)# commit
```

Your router now uses frequency synchronization, and the system logs any relevant changes or errors.

What to do next

Configure frequency synchronization on all interfaces that must participate.

Configure frequency synchronization on the route processor

Enable frequency synchronization for the 1588 port on the route processor.

Use this task to configure frequency synchronization at the route processor for supported routers. This task ensures accurate time and frequency distribution.

Before you begin

Verify that your router and line card support the 1588 port for frequency synchronization. To view supported models, see the SyncE profiles support matrix, on page 11.

Complete the steps to configure frequency synchronization on your route processor:

Procedure

Step 1 Access the router CLI and enter configuration mode.

Step 2 Configure the 1588 port for frequency synchronization.

Enter the following commands:

```
Router# config
Router(config)# int PTP0/RP0/CPU0/0
Router(config-if)# frequency synchronization
Router(config-if-freqsync)#selection input
Router(config-if-freqsync)#wait-to-restore 0
Router(config-if-freqsync)#no shutdown
Router(config-if)# commit
Router(config-if)# end
```

Step 3 Verify the 1588 port configuration details by using the **show run interface** command.

```
Router# show running-config interface PTP0/RP0/CPU0/0
interface PTP0/RP0/CPU0/0
frequency synchronization
  selection input
  wait-to-restore 0
!
!
```

Review the output to confirm frequency synchronization settings are applied.

You have configured frequency synchronization on the 1588 port of your route processor.

What to do next

Configure frequency synchronization on interfaces that need to participate.

Configure frequency synchronization on an interface

Configure SyncE on an interface

Enable frequency synchronization on your router interface to maintain stable network timing.

After you configure the parameters, your interface participates in frequency synchronization.

Before you begin

Enable frequency synchronization globally on your router to ensure accurate timing for all interfaces.

To configure SyncE on your interface, follow each step in order.

Procedure

Step 1 Enter configuration mode on the router.

```
Router# config
```

Step 2 Select the interface you want to enable for frequency synchronization.

```
Router(config)# interface HundredGigE 0/1/1/0
```

Step 3 Enable frequency synchronization mode on the selected interface.

```
Router(config-if)# frequency synchronization
Router(config-if-freqsync)#
```

Step 4 (Optional) Define parameters for frequency synchronization. Specify selection input, priority, wait-to-restore value, and time-of-day priority.

```
Router(config-if-freqsync)# selection input
Router(config-if-freqsync)# priority 100
Router(config-if-freqsync)# wait-to-restore 10

Router(config-if-freqsync)# time-of-day-priority 50
```

Step 5 (Optional) Configure the Synchronization Status Message (SSM) quality levels for the frequency source on the receiving interface.

```
Router(config-if-freqsync)# quality receive highest itu-t option 1 prc
```

Step 6 Commit your configuration.

```
Router(config-if-freqsync)# commit
```

Note For interfaces that do not support SSM, only the lowest QL can be specified. In these cases, the output signal is squelched, and no signal is sent.

The quality option specified must match the globally configured quality option.

Based on the configured parameters, the interface participates in frequency synchronization.

Configure enhanced Synchronous Ethernet (eSyncE)

Configure eSyncE to enable enhanced Synchronous Ethernet (eSyncE) timing distribution using the device clock.

Use this task when you must enable eSyncE on a device to allow enhanced-quality-level signaling across the network.

Before you begin

- Ensure you have administrator access to the device.
- Confirm the device runs a compatible OS version.

Follow these steps to configure eSyncE:

Procedure

Step 1 Set the MAC address for your device clock to transmit the Quality Level (QL) Type-Length-Value (TLV) in the network.

```
Router# configure
Router(config)# frequency synchronization
Router(config-freqsync)# clock-id mac-address aaaa.bbbb.cccc
Router(config-freqsync)# commit
Router(config-freqsync)# exit
```

Step 2 Specify which quality level options your device clock will transmit.

For example, use the following configuration:

```
Router(config)# interface HundredGigE 0/1/0/0
Router(config-if)# frequency synchronization
Router(config-if-freqsync)# quality transmit exact itu-t option 1 ePRTC
Router(config-if-freqsync)# end
```

Step 3 Verify the eSyncE configuration.

```
Router# show frequency synchronization interfaces
Interface HundredGigE 0/11/0/1 (up)
  Assigned as input for selection
  Wait-to-restore time 0 minutes
  SSM Enabled
    Peer Up for 00:00:54, last SSM received 0.741s ago
    Peer has come up 1 times and timed out 0 times
    ESMC SSMs        Total  Information     Event    DNU/DUS
      Sent:             55           53         2         45
```

```
    Received:         55           55         0          0
Input:
  Up
  Last received QL: Opt-I/ePRTC
  Effective QL: Opt-I/ePRTC, Priority: 30, Time-of-day Priority 100
  Originator clock ID: aaaabbfffebbcccc
  SyncE steps: 1, eSyncE steps: 1
  All steps run eSyncE; Chain of extended ESMC data is complete
  Supports frequency
Output:
  Selected source: HundredGigE 0/11/0/1
  Selected source QL: Opt-I/ePRTC
  Effective QL: DNU
  Originator clock ID: aaaabbfffebbcccc
  SyncE steps: 2, eSyncE steps: 2
  All steps run eSyncE; Chain of extended ESMC data is complete
Next selection points: ETH_RXMUX
```

Review the output to confirm that eSyncE steps and QL values are correct.

You have configured eSyncE for the chosen interface and synchronization quality. Your device now broadcasts the correct QL level. If verification output matches, eSyncE is operational.

What to do next

Monitor the synchronization status when needed, and adjust the configuration to meet your network needs.

Configure GPS, an external clock interface for frequency synchronization

Setting GPS

Use the router's GPS interface to receive external timing signals for synchronization and operational monitoring. This section explains which inputs are supported and how to interpret the indicator states.

Supported GPS interface inputs

The router GPS Sync-2 interface receives three main types of external synchronization signals. All three inputs must be present (up) for GPS input to start.

- **1PPS**: The interface receives a pulse per second signal and accepts an RS422 or DIN connector as input.
- **10MHz**: The interface receives a reference frequency signal and accepts a DIN connector as input.
- **ToD**: Time-of-Day signal. Accepts RS422 format as input.

Note Unlike the Ethernet interface, the Sync-2 interface cannot receive or transmit QL. Assign a QL value manually to the Sync-2 interface.

By default, 1PPS and 10MHz operate in output mode. You cannot configure ToD output mode.

On the 8800-RP variant, 10MHz and 1PPS operate in output mode only when you configure PTP Slave or boundary clock (BC) mode.

LED Indicators and behaviors

The GPS module provides multiple indicators for different operational statuses.

Timing GPS LED states

- **Off**: No GPS is configured or the GPS port is down.
- **Green**: GPS port is up. When lit, GPS is configured and 1PPS, ToD, and 10M inputs are valid.

Sync LED states

- **Green**: The time core is synchronized to an external source such as SyncE or 1588.
- **Amber**: The system is in the holdover state or the acquiring state.
- **Off**: Synchronization is disabled or in a free run state.

This table describes the meaning of GPS, BITS port, and SYNC LED states:

Table 5: LED Light States

LED Type	LED State	Description
GPS	Green	The GPS interface is provisioned, and frequency, time of day, and phase input are operating accurately.
	Off	The system has not provisioned the GPS interface, or the GPS input is not operating accurately.
BITS port	Green	The BITS interface is provisioned and the frequency is operating accurately.
	Off	The BITS interface isn't provisioned or the BITS input isn't operating accurately.

LED Type	LED State	Description
SYNC	Green	The frequency, time, and phase are synchronized to an external interface, which can be the building integrated timing supply (BITS), GPS, or a recovered RX clock.
	Amber	The router operates in holdover or free-run mode. Based on user configuration, the router does not synchronize to an external interface.
	Off	The system has not enabled centralized frequency, time, and phase distribution. As a result, the router uses the local oscillator on the RSP for all clocking.

Configure GPS settings for the grandmaster clock

Set up the grandmaster clock to synchronize time with GPS for precise frequency and timing.

Perform this task on a router to configure the clock interface for GPS synchronization. Define synchronization parameters and verify that the GPS input is active.

Before you begin

- Ensure you have administrative access to the device CLI.
- Confirm that the grandmaster-clock hardware is installed and GPS connectivity is established.

To configure GPS settings for the grandmaster clock, perform the steps in this section.

Procedure

Step 1 Configure the clock interface to synchronize with a GPS.

Example:

```
Router# config
Router(config)# clock-interface sync 2 location 0/RP0/CPU0
Router(config-clock-if)# port-parameters
Router(config-clk-parms)# gps-input tod-format cisco pps-input ttl
Router(config-clk-parms)# exit
```

Step 2 Define the frequency synchronization parameters.

Example:

```
Router(config-clock-if)# frequency synchronization
Router(config-clk-freqsync)# selection input
Router(config-clk-freqsync)# wait-to-restore 0
```

```
Router(config-clk-freqsync)# quality receive exact itu-t option 1 PRC
Router(config-clk-freqsync)# exit
```

Step 3 Configure timing sources to drive the output from your clock interface.

Example:

```
Router(config-clock-if)# frequency synchronization
Router(config-clk-freqsync)# quality itu-t option 1
Router(config-clk-freqsync)# clock-interface timing-mode system
Router(config-clk-freqsync)# end
```

Step 4 Verify that GPS input is valid to confirm your configuration.

Example:

```
Router# show controllers timing controller clock

SYNCC Clock-Setting: -1 -1 6 -1
             Port 0    Port 1    Port 2    Port 3
Config :     No        No        Yes       No
Mode :       -         -         GPS       -
Submode1 :   -         -         CISCO     -
Submode2 :   -         -         UTC       -
Submode3 :   0         0         0         0
Shutdown :   0         0         0         0
Direction :  RX/TX     RX/TX     RX        RX/TX
Baud-Rate :  -         -         9600      -
QL Option :  O1        O1        -         -
RX_ssm(raw): -         -         -         -
TX_ssm :     -         -         -         -
If_state :   DOWN      DOWN      UP        DOWN  << Port 2 is UP when GPS input is valid.
```

When synchronization is complete, the grandmaster clock uses the GPS source and Port 2 displays `UP` to indicate valid GPS input.

What to do next

Monitor synchronization status regularly to keep the system operating. If Port 2 does not show `UP`, troubleshoot your GPS connection.

Configure a BITS external clock interface for frequency synchronization

Enable frequency synchronization on your router using the Building-Integrated Timing Supply (BITS) interface.

Perform this configuration if your network requires external frequency synchronization via a BITS source.

Before you begin

Complete these requirements before you configure the device.

- Verify that your device supports BITS interfaces.
- Confirm that the BITS cable is connected to the appropriate port.

Begin configuring BITS for frequency synchronization with these steps:

Procedure

Step 1 Access the router CLI.

Step 2 Enter global configuration mode.

Step 3 Configure the clock interface for BITS:

- Enter `clock-interface bits 0` to select the first BITS port.
- Set the mode to receive or transmit, as needed.
  - For receive mode, enter `mode rx`.
  - For transmit mode, enter `mode tx`.

Step 4 Assign BITS as the synchronization source using the `synchronization` command.

Step 5 Save the configuration.

The router uses the external BITS signal for frequency synchronization.

What to do next

Monitor router synchronization status. Confirm that the router operates correctly.

Configure BITS interfaces

Set up and verify BITS-IN and BITS-OUT interfaces to help you meet phase transient response standards and maintain proper frequency synchronization.

Use this task to configure BITS interfaces on both RP0 and RP1. This configuration helps ensure frequency synchronization and maintain quality standards during redundancy or failover.

Before you begin

- Frequency synchronization must be configured with the required quality level option at the global level.
- Make sure RP0 and RP1 have identical configurations and connect both to the same external reference for sync 0 and sync 2, so the system meets phase transient response compliance standards during RP failover.
- BITS-IN and BITS-OUT on the peer nodes must be configured with the same mode and format.
- Depending on the quality level you choose in the global configuration, change E1 or T1 modes as needed. Make sure TX and RX modes and submodes are identical.
- If SSM is not present in BITS for non-CRC-4 or D4 modes, configure the manual receive quality level.

To configure and verify BITS interfaces, perform these actions:

Procedure

Step 1 Configure BITS-IN.

Example:

```
Router# config
Router(config)# clock-interface sync 0 location 0/RP0/CPU0
Router(config-clock-if)# port-parameters
Router(config-clk-parms)# bits-input e1 crc-4 sa4 ami
Router(config-clk-parms)# exit
Router(config-clock-if)# frequency synchronization
Router(config-clk-freqsync)# selection input
Router(config-clk-freqsync)# wait-to-restore 0
Router(config-clk-freqsync)# priority 1
Router(config-clk-freqsync)# end
```

Step 2 Verify the BITS-IN configuration.

Example:

```
Router# show running-config clock-interface sync 0 location 0/RP0/CPU0
Wed Aug 21 12:31:43.350 UTC
clock-interface sync 0 location 0/RP0/CPU0
 port-parameters
  bits-input e1 crc-4 sa4 ami
 !
 frequency synchronization
  selection input
  priority 1
  wait-to-restore 0
 !
!
Router# show controllers timing controller clock
Wed Aug 21 12:38:20.394 UTC

SYNCC Clock-Setting: 1 -1 -1 -1

          Port 0          Port 1          Port 2          Port 3
Config     : Yes            No              No              No
Mode       : E1             -               -               -
Submode1   : CRC-4          -               -               -
Submode2   : AMI            -               -               -
Submode3   : 0              0               0               0
Shutdown   : 0              0               0               0
Direction  : RX             RX/TX           RX/TX           RX/TX
Baud-Rate  : -              -               -               -
QL Option  : O1             O1              -               -
RX_ssm(raw): 99             -               -               -
TX_ssm     : -              -               -               -
If_state   : UP           DOWN            DOWN            DOWN
```

Step 3 Configure BITS-OUT.

Example:

```
Router# config
Router(config)# clock-interface sync 0 location 0/RP0/CPU0
Router(config-clock-if)# port-parameters
Router(config-clk-parms)# bits-output e1 crc-4 sa4 ami
Router(config-clk-parms)# end
```

Step 4 Verify the BITS-OUT configuration.

Example:

```
Router# show running-config clock-interface sync 0 location 0/RP0/CPU0
Wed Aug 21 12:54:02.853 UTC
clock-interface sync 0 location 0/RP0/CPU0
 port-parameters
  bits-output e1 crc-4 sa4 ami
 !
!
Router# show controllers timing controller clock
Wed Aug 21 12:49:32.923 UTC
SYNCC Clock-Setting: 1 -1 -1 -1

          Port 0          Port 1          Port 2          Port 3
Config     : Yes            No              No             No
Mode       : E1             -               -              -
Submode1   : CRC-4           -               -              -
Submode2   : AMI             -               -              -
Submode3   : 0               0               0              0
Shutdown   : 0               0               0              0
Direction  : TX              RX/TX           RX/TX          RX/TX
Baud-Rate  : -               -               -              -
QL Option  : O1              O1              -              -
RX_ssm(raw): -               -               -              -
TX_ssm     : 22              -               -              -
If_state   : UP              DOWN            DOWN           DOWN
```

Step 5 Verify quality level received and clock interfaces.

Example:

```
Router# show frequency synchronization clock-interfaces brief
Tue Feb 23 23:42:22.654 UTC
Flags: > - Up               D - Down                         S - Assigned for selection
d - SSM Disabled            s - Output squelched             L - Looped back
Node 0/RP0/CPU0:
==============
Fl      Clock Interface       QLrcv    QLuse    Pri   QLsnd    Output driven by
=====   ===================   ======   ======   ===   ======   ========================
D       Sync0                 n/a      n/a      n/a   n/a      n/a
D       Sync1                 n/a      n/a      n/a   n/a      n/a
>S      Sync2                 None     PRC      100   n/a      n/a
>S      Internal0             n/a      SEC      255   n/a      n/a
Node 0/RP1/CPU0:
==============
Fl      Clock Interface       QLrcv    QLuse    Pri   QLsnd     Output driven by
=====   ===================   ======   ======   ===   ======    ========================
D       Sync0                 n/a      n/a      n/a   n/a       n/a
D       Sync1                 n/a      n/a      n/a   n/a       n/a
D       Sync2                 n/a      n/a      n/a   n/a       n/a
>S      Internal0             n/a      SEC      255   n/a       n/a
```

When you finish these steps, the system is prepared for frequency synchronization and quality level compliance across BITS interfaces.

What to do next

- Confirm system sync status and stability after configuration.

- If any interface does not meet the expected standards, repeat the configuration steps.

Verify the frequency synchronization configuration

Verify that your frequency synchronization settings are accurate and intact after configuration.

Use this task after you perform frequency synchronization configuration to detect and resolve common configuration errors.

Before you begin

- Complete all frequency synchronization configuration steps.
- Access the router CLI.

Follow these steps to verify the frequency synchronization configuration:

Procedure

Step 1 Use the **show frequency synchronization configuration-errors** command to display any configuration errors related to frequency synchronization.

```
Router# show frequency synchronization configuration-errors

Node 0/2/CPU0:
==============
  interface HundredGigE 0/2/0/0 frequency synchronization
    * Frequency synchronization is enabled on this interface, but isn't enabled globally.

  interface HundredGigE 0/2/0/0 frequency synchronization quality transmit exact itu-t option 2
generation 1 PRS
    * The QL that is configured is from a different QL option set than is configured globally.
```

Displays any errors that are caused by inconsistencies between shared-plane (global) and local-plane (interface) configurations. There are two possible errors that can be displayed:

- Frequency Synchronization is configured on an interface (line interface or clock-interface), but is not configured globally. See Enable frequency synchronization on the router, on page 16.
- The QL option configured on some interfaces does not match the global QL option. Under an interface (line interface or clock interface), the QL option is specified using the **quality transmit** and **quality receive** commands. The value you specify must match the value in the global **quality itu-t option** command. If the global **quality itu-t option** command is not configured, use the default (option 1).

After you resolve all errors and the command produces no output, proceed to the next step.

Step 2 Check the configuration using both the **show frequency synchronization interfaces brief** command and the **show frequency synchronization clock-interfaces brief** command.

```
Router# show frequency synchronization interfaces brief

Flags:  > - Up               D - Down             S - Assigned for selection
        d - SSM Disabled     x - Peer timed out   i - Init state

Fl  Interface               QLrcv QLuse Pri QLsnt Source
```

```
=== ======================== ===== ===== === ===== ========================
>Sx HundredGigE 0/2/0/0   Fail  Fail  100 DNU   None
Dd  HundredGigE 0/2/0/1   n/a   Fail  100 n/a   None

Router# show frequency synchronization clock-interfaces brief

Flags:  > - Up                D - Down              S - Assigned for selection
        d - SSM Disabled      s - Output squelched  L - Looped back

Node 0/0/CPU0:
==============
  Fl    Clock Interface     QLrcv  QLuse  Pri QLsnd  Source
  ===== =================== ====== ====== === ====== ========================
  >S    Sync0               PRC    Fail   100 SSU-B  Internal0 [0/0/CPU0]

  >S    Internal0           n/a    SSU-B  255 n/a    None

Node 0/1/CPU0:
==============
  Fl    Clock Interface     QLrcv  QLuse  Pri QLsnd  Source
  ===== =================== ====== ====== === ====== ========================
  D     Sync0               None   Fail   100 SSU-B  Internal0 [0/1/CPU0]

  >S    Internal0           n/a    SSU-B  255 n/a    None
```

Note these points:

- All line interfaces that have frequency synchronization configured are displayed.
- All clock interfaces and internal oscillators are displayed.
- Sources configured as inputs (those using **selection input** display ‘S’ in the Flags column. Sources not configured as inputs do not display ‘S’

Note Internal oscillators can always serve as input sources.

- ‘>’ or ‘D’ is displayed in the flags field as appropriate.

If any of these items are not true, continue to the next step.

Step 3 Investigate issues within individual interfaces using **show frequency synchronization interfaces** and **show frequency synchronization clock-interfaces** commands.

```
Router# show frequency synchronization interfaces HundredGigE 0/2/0/2

Interface HundredGigE 0/2/0/2 (shutdown)
  Assigned as input for selection
  SSM Enabled
  Input:
    Down
    Last received QL: Failed
    Effective QL:     Failed, Priority: 100
  Output:
    Selected source:    Sync0 [0/0/CPU0]
    Selected source QL: Opt-I/PRC
    Effective QL:       Opt-I/PRC
  Next selection points: LC_INGRESS

Router# show frequency synchronization clock-interfaces location 0/1/CPU0
```

```
Node 0/1/CPU0:
==============
  Clock interface Sync0 (Down: mode not configured)
    SSM supported and enabled
    Input:
      Down
      Last received QL: Opt-I/PRC
      Effective QL:     Failed, Priority: 100
    Output:
      Selected source:    Internal0 [0/1/CPU0]
      Selected source QL: Opt-I/SSU-B
      Effective QL:       Opt-I/SSU-B
  Next selection points: RP_SYSTEM



  Clock interface Internal0 (Up)
    Assigned as input for selection
    Input:
      Default QL:   Opt-I/SSU-B
      Effective QL: Opt-I/SSU-B, Priority: 255
  Next selection points: RP_SYSTEM RP_CLOCK_INTF
```

If the clock interface is down, a reason is displayed. This may occur because the clock interface configuration is missing or conflicting.

Step 4 Verify that the fsyncmgr process is running on the appropriate nodes using **show processes fsyncmgr location** command.

```
Router# show processes fsyncmgr location 0/0/CPU0

                  Job Id: 134
                     PID: 30202
        Executable path: /pkg/bin/fsyncmgr
             Instance #: 1
             Version ID: 00.00.0000
                Respawn: ON
          Respawn count: 1
  Max. spawns per minute: 12
           Last started: Mon Mar  9 16:30:43 2009
          Process state: Run
          Package state: Normal
      Started on config: cfg/gl/freqsync/g/a/enable
                   core: MAINMEM
              Max. core: 0
              Placement: None
           startup_path: /pkg/startup/fsyncmgr.startup
                  Ready: 0.133s
       Process cpu time: 1730768.741 user, -133848.-361 kernel, 1596920.380 total
  ---------------------------------------------------------------------------------
```

You resolve all configuration errors, and all frequency synchronization interfaces and processes work as intended.

What to do next

After making configuration changes, monitor the interfaces periodically for synchronization issues, and then verify the interfaces again.

SyncE preference for PTP receiver interfaces

A SyncE preference for PTP receiver interfaces is a synchronization configuration feature that

- prioritizes the SyncE source on the same interface as the selected PTP receiver
- enables automatic SyncE source selection when sources have equal Quality Levels (QL) and user priority, and
- provides seamless switching of SyncE sources when the PTP receiver interface changes, maintaining synchronization integrity.

In network deployments using redundant clock sources for synchronization, issues may arise when SyncE and PTP sources come from different origins. This may lead to synchronization failures. The **synchronous-ethernet prefer-interface ptp-receiver** command mitigates this by aligning SyncE selection with the PTP receiver interface.

Table 6: Feature History Table

Feature Name	Release Information	Feature Description
SyncE preference for PTP receiver interface	Release 25.4.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100])(select variants only*) *This feature is supported on: • 8011-32Y8L2H2FH • 8011-12G12X4Y-A/D
SyncE preference for PTP receiver interface	Release 25.1.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100])(select variants only*) *This feature is now supported on Cisco 8011-4G24Y4H-I routers.

Feature Name	Release Information	Feature Description
SyncE preference for PTP receiver interface	Release 24.4.1	You can now mitigate synchronization issues when SyncE and PTP sources come from different, non-traceable origins. This feature ensures that SyncE selection among sources with equal Quality Levels (QL) and user priority prefers the interface on which the PTP receiver is selected. If the PTP source fails or its quality degrades, causing the system to switch to another PTP source, SyncE switches to the new PTP source, provided the new interface has the same SyncE QL and priority as the previously selected interface. This feature introduces the **synchronous-ethernet prefer-interface ptp-receiver** command.

Benefits of SyncE preference for PTP receiver interface

These are the benefits of SyncE preference for the PTP receiver interface.

- **Enhanced synchronization**: Ensures synchronous Ethernet (SyncE) and Precision Time Protocol (PTP) traceability to the same clock source.
- **Improved reliability**: Reduces risks of synchronization failures due to rapid clock drifts.
- **Simplified configuration**: Performs synchronous Ethernet (SyncE) source selection to match the PTP receiver, which simplifies network management.

Requirement: Configure SyncE preference correctly for PTP receiver interface

Synchronous Ethernet (SyncE) auto-selection occurs only when the Precision Time Protocol (PTP) receiver interface is included in the interface selection list.

If more than two Synchronous Ethernet (SyncE) interfaces are configured, automatic switching might not occur because the Precision Time Protocol (PTP) receiver interface may not be auto-selected.

Configure SyncE to prefer the PTP receiver interface

Set the Synchronous Ethernet (SyncE) preference to prioritize the PTP receiver interface for frequency synchronization.

This task explains how to configure a router so that it uses the PTP receiver interface as the preferred source for SyncE frequency synchronization.

Before you begin

- Verify that your device supports the features that are for Synchronous Ethernet (SyncE) and Precision Time Protocol (PTP).
- Make sure you have configuration permissions.

To configure SyncE to prefer the PTP receiver interface, perform these steps:

Procedure

Step 1 Use the CLI to enter frequency synchronization configuration mode.

Example:

```
Router#configure
Router(config)#frequency synchronization
```

Step 2 Set the SyncE preference so the router uses the PTP receiver interface.

Example:

```
Router(config-freqsync)#synchronous-ethernet prefer-interface ptp-receiver
Router(config-freqsync)#commit
```

Step 3 Check that SyncE prefers the PTP receiver interface.

Example:

```
Router#show ptp interfaces brief
Intf              Port         Port                 Line
Name              Number       State        Encap   State         Mechanism
-------------------------------------------------------------------------------
Te0/0/0/18        2            Passive      Ethernet up           -
Te0/0/0/19        1            Slave        Ethernet up           -
```

The **show ptp interfaces breif** command provides information about the ptp interfaces. You can then verify that the PTP receiver (Slave) interface is selected for frequency synchronization by using the **show frequency synchronization interfaces brief** command.

```
Router#show frequency synchronization interfaces brief

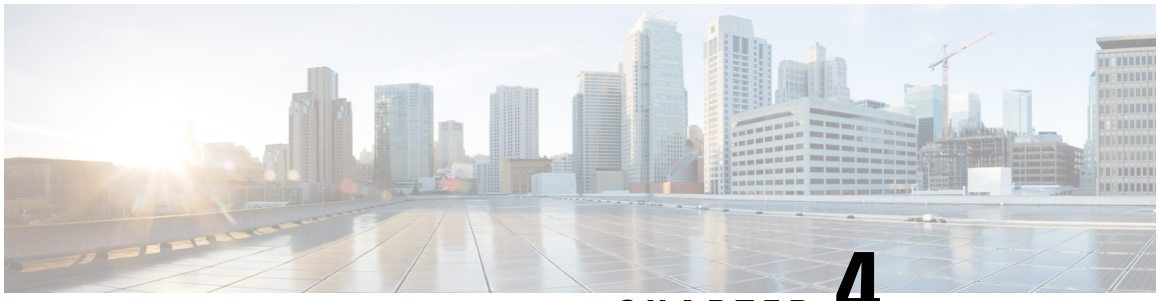
Flags:  > - Up               D - Down             S - Assigned for selection
        d - SSM Disabled     x - Peer timed out   i - Init state
        s - Output squelched
Fl   Interface                QLrcv QLuse Pri QLsnd Output driven by
==== ======================== ===== ===== === ===== ========================
>S   TenGigE0/0/0/18          PRC   PRC   100 DNU   TenGigE0/0/0/19
>S   TenGigE0/0/0/19          PRC   PRC   100 PRC   TenGigE0/0/0/19
```

Make sure the PTP receiver (Slave) interface is selected for frequency synchronization.

SyncE now uses the PTP receiver interface for frequency synchronization.

What to do next

- Monitor synchronization status to confirm that clocking remains stable.
- If necessary, repeat the configuration for each additional interface.



CHAPTER 4

Precision Time Protocol

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Precision Time Protocol

A Precision Time Protocol (PTP) is a time synchronization protocol that

- achieves nanosecond-level synchronization of real-time clocks across networked devices
- uses a master-client hierarchy to organize clock relationships, and

- enables all devices in the network to continually synchronize to the most accurate clock through ongoing exchanges of timing messages.

PTP is defined in the IEEE 1588 standard. The network selects the best available clock, known as the grandmaster clock, as the authoritative time source. All other network clocks, known as members, synchronize with this grandmaster clock. The protocol identifies the port connected to the most accurate device (the master clock), then synchronizes all other devices to it and maintains synchronization throughout the network.

Restrictions for PTP

Consider these restrictions when enabling PTP on Cisco 8000 series routers.

- Do not configure PTP over IP on tagged interfaces of the 88-LC1-52Y8H-EM and 88-LC1-12TH24FH-E line cards.
- The Sync2 interface is supported only when the 10 megahertz (MHz), one pulse per second (PPS), and time-of-day (ToD) ports are configured.
- Configure PTP only on interfaces without global MACSec or MACSec enabled.
- Enable PTP only when global MACSec-FIPS-Post is not configured, since MACSec-FIPS-Post is unavailable for individual interfaces.
- Do not configure transparent Clock. Use one-step clock mode.
- Configure the device to receive follow-up PTP packets to support a two-step peer primary. The device does not send follow-up PTP packets.
- Avoid configuring PTP on bundle ethernet interfaces, bundle ethernet subinterfaces, loopback interfaces, and LAG ethernet subinterfaces.
- Configure PTP only on individual bundle member links; do not configure it on bundle-ether interfaces.

Benefits of PTP

Use PTP to achieve accurate and stable timing in smart grid power automation applications, such as peak-hour billing, virtual power generators, and outage management. Accurate timing helps you monitor networks and troubleshoot issues more effectively. You can implement PTP, a message-based protocol, on packet-based networks such as ethernet.

PTP offers these benefits for your Ethernet network:

- It has low cost and is easy to set up in existing Ethernet networks.
- It requires minimal bandwidth for PTP data packets.
- It is compatible with routers and different types of network delays.

Guidelines for PTP

The guidelines for PTP on Cisco 8000 Series routers are:

- PTP is supported on Gigabit Ethernet interfaces (1G, 10G, 40G, and 100G).

- If you use encapsulation default or untag on a subinterface, configure PTP on the subinterface—not on the main interface.

Router delays in time synchronization

A router delay is a network timing phenomenon that

- introduces latency in the transmission of PTP packets
- causes packet buffering and processing delays, and
- can be mitigated through optimized PTP configurations.

PTP clock types and roles

The Precision Time Protocol (PTP) network synchronizes clocks across devices by assigning specialized roles to each participating device. The main PTP clock types and their functions are:

- Grandmaster (GM)—The network device connected to the primary time source. All other clocks synchronize to the grandmaster clock.
- Ordinary Clock (OC)— A clock with one PTP port that operates in either:
  - Master mode: Distributes timing information to client clocks
  - Slave mode: Synchronizes its clock to a master clock. Slave mode can be enabled on up to two interfaces to connect to different masters
- Boundary Clock (BC)—Selects the best master clock to synchronize with. Acts as master if no better clock is found. Starts PTP sessions with downstream client clocks, reducing network hops and packet delay between the grandmaster and clients.
- Transparent Clock (TC)—A switch or device that measures and adds the time it takes PTP packets to transit the device to the time correction field, ensuring accurate synchronization by compensating for switch forwarding delays.



Note

- A PTP network may include both PTP-enabled and non-PTP devices. Only devices supporting PTP can act in the roles described above.
- Accurate placement of boundary and transparent clocks in the network improves timing precision and minimizes synchronization errors.

Port state machine

This method identifies the state of each network port. A port can be passive (neither master nor client), operate as a master that provides time to other clocks, or function as a secondary that receives time from other clocks in the network.

Best master clock algorithm

A best master clock algorithm (BMCA) is a protocol mechanism that

- operates automatically in IEEE 1588-based PTP networks
- compares properties of all participating clocks to decide which one will be the Grandmaster Clock, and
- ensures a single clock distributes time to all other clocks in the network.

Frequency and time selection

The selection of the source to synchronize the device clock frequency is made by frequency synchronization which is described in the Source and Selection Points section of the Frequency Synchronization module in this document. The Announce, Sync, and Delay-request frequencies must be the same on the master and client.

Delay request-response mechanism

A Delay Request-Response mechanism is a time synchronization method defined in IEEE Std 1588-2008 that

- enables a client port to estimate the difference between its clock and the master clock
- supports one-step and two-step message timestamping options, and
- is configurable for use in network devices operating in a client role.

This mechanism is a foundational element in PTP operations, helping to achieve network-wide time alignment.

Supported delay request-response options

The supported options for the delay request-response mechanism include:

- One-step mechanism: The Sync message contains the timestamp within the Sync message itself.
- Two-step mechanism: The timestamp for a Sync message is sent separately in a Follow-up message after the initial Sync message.

Supported client port operations in delay request-response mechanism

A router port operating in Client state with delay request-response enabled supports these operations:

- Sending Delay-request messages to request timing information from the master,

- Handling incoming Sync, Follow-up, and Delay-response messages for time synchronization.

Supported message timeout configuration in delay request-response mechanism

The timeout periods for both Sync and Delay-response messages in the delay request-response mechanism are independently configurable, enabling administrators to tune synchronization behavior according to network requirements.

Role of transparent clocks in PTP

Transparent clocks are network devices that

- measure and record the time it takes for PTP timing packets to pass through themselves,
- insert this delay into a special time-interval field in the packets, and
- forward all timing messages between network nodes without altering their content.

In PTP, transparent clocks make routers invisible to the master and client nodes regarding timing accuracy. By accounting for the delays they introduce, transparent clocks enable the end devices to better calculate the exact communication path delay. An end-to-end transparent clock handles all messages as a router would, with the added benefit of precise delay measurement.

Comparison of transparent clocks and regular routers

This table highlights the differences between transparent clocks and regular routers in the context of PTP:

Table 7: Difference between transparent clocks and regular routers

Attribute	Transparent clock	Regular router
Delay measurement	Measures and inserts its own delay into packets	Does not measure or account for delay
Handling of PTP messages	Forwards messages, records transit times	Simply forwards, no timestamping
Effect on synchronization	Improves time accuracy across the network	Can introduce timing inaccuracies
Network transparency in PTP	Makes itself transparent to timing calculation	Opaque; contributes unmeasured delay

To read a detailed description of synchronization messages, see the PTP Event Message Sequences section.

- Boundary clock synchronization
- Local clock synchronization

Hybrid mode in frequency and time-of-day synchronization

Hybrid mode is an operational synchronization mode for routers that

- enables the selection of separate sources for frequency and time-of-day (ToD) synchronization
- uses a physical frequency source such as BITS or SyncE to provide frequency synchronization, and
- leverages PTP or GPS to provide ToD synchronization.

Hybrid mode allows network devices to combine the stability of traditional physical frequency sources with the precision of protocol-based ToD sources for improved synchronization performance.

Sources for frequency and time-of-day synchronization

The sources available for router synchronization are:

- Frequency sources:
  - BITS (Building Integrated Timing Supply)
  - GPS
  - SyncE
  - IEEE 1588 PTP
- Time-of-day (ToD) sources:
  - The selected frequency source
  - PTP (if available), typically GPS or PTP

The router may select different sources independently for frequency and ToD, providing operational flexibility.

Frequency selection algorithm

Frequency selection on the router uses the algorithm specified in ITU-T recommendation G.781.

The algorithm described in ITU-T G.781 defines criteria and methods for automatic frequency source selection to ensure synchronization resilience within the network.

Refer to the official ITU-T G.781 documentation for more technical details.

Time-of-day source selection configuration

- Configuration location:

  Time-of-day priority configuration is set under the clock interface frequency synchronization configuration mode and under the global PTP configuration mode.

- Priority values:

  The configuration controls the order in which sources are selected for ToD. Allowable numeric values range from 1 to 254, with lower numbers having higher priority.

Assigning the correct priority ensures the router selects the most preferred and reliable ToD source first.

Time of the day support

The router receives GPS ToD messages in serial ASCII stream through the RS422 interface in one of these configurable formats:

- NTP Type 4
- Cisco

Port states for PTP

State machine indicates the behavior of each port.

Table 8: Port states for PTP

State	Description
INIT	Port isn't ready to participate in PTP.
LISTENING	First state when a port becomes ready to participate in PTP: In this state, the port listens to PTP masters for a (configurable) period of time.
PRE-MASTER	Port is ready to enter the MASTER state.
MASTER	Port provides timestamps for any Client or boundary clocks that are listening.
UNCALIBRATED	Port receives timestamps from a Master clock but, the router's clock isn't yet synchronized to the Master clock.
SLAVE	Port receives timestamps from a Master clock and the router's clock is synchronized to the Master clock.
PASSIVE	Port is aware of a better clock than the one it would advertise if it was in MASTER state and isn't a Client clock to that Master clock.

Boundary clock synchronization

The ordinary and boundary clocks configured for the delay request-response mechanism use these event messages to generate and communicate timing information.

- Sync
- Follow_Up
- Delay_Req
- Delay_Resp

These messages are sent in this sequence.

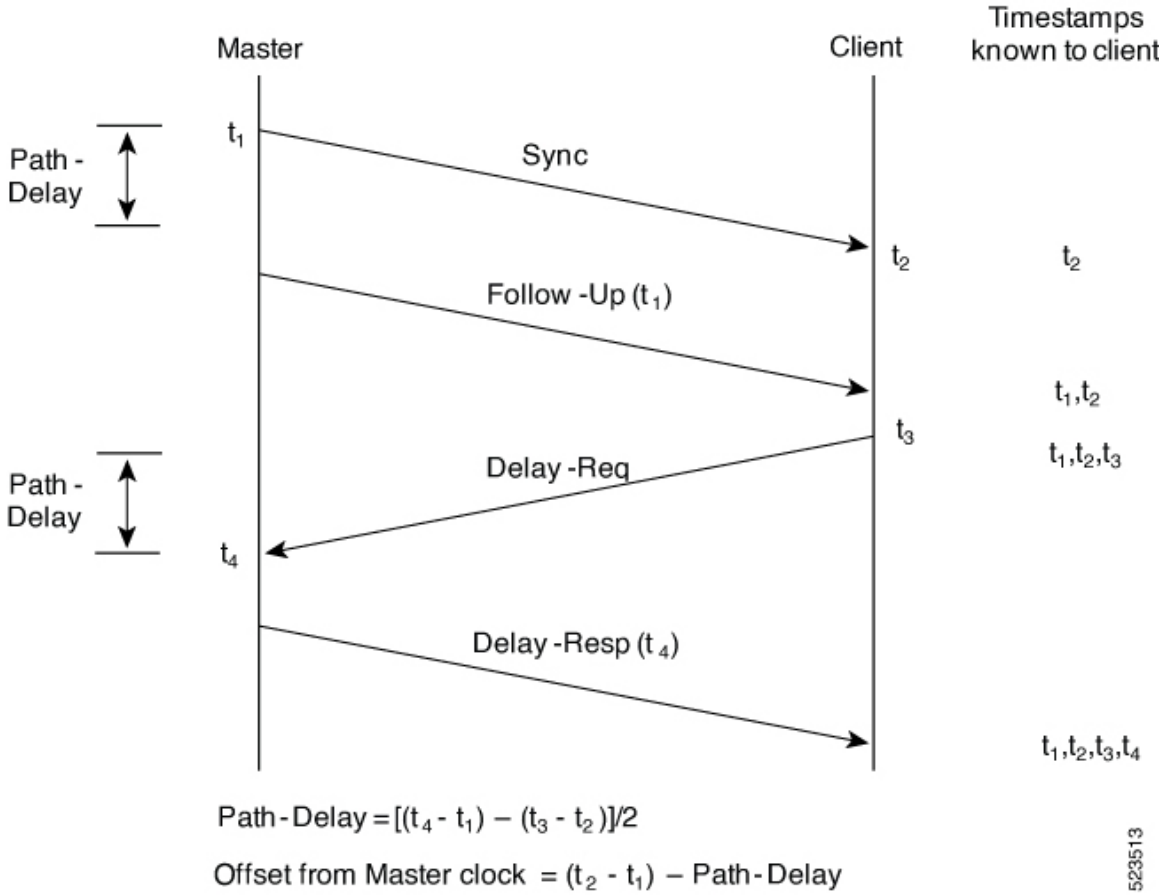
1. The master sends a Sync message to the client and notes the time (t1) at which it was sent.

2. The client receives the Sync message and notes the time of reception (t2).
3. The master conveys to the client the timestamp t1 by embedding the timestamp t1 in a Follow_Up message.
4. The client sends a Delay_Req message to the master and notes the time (t3) at which it was sent.
5. The master receives the Delay_Req message and notes the time of reception (t4).
6. The master conveys to the client the timestamp t4 by embedding it in a Delay_Resp message.

After this sequence, the client possesses all four timestamps. These timestamps can be used to compute the offset of the client clock relative to the master, and the mean propagation time of messages between the two clocks.

The offset calculation is based on the assumption that the time for the message to propagate from master to client is the same as the time required from client to master. This assumption isn't always valid on an Ethernet/IP network due to asymmetrical packet delay times.

Figure 3: Detailed Steps—Boundary Clock Synchronization



Local clock synchronization

In an ideal PTP network, the master and client clocks operate at the same frequency. However, drift can occur on the network. Drift is the frequency difference between the master and client clock. You can compensate for drift by using the time stamp information in the device hardware and follow-up messages (intercepted by the router) to adjust the frequency of the local clock to match the frequency of the master clock.

PTP transport media, messages, and transport mode

This table summarizes the different types of support information related to the Precision Time Protocol (PTP). It covers available transport media, the types of messages used, and the supported transport modes for each media type.

Table 9: PTP transport options

Category	Details
Transport Media	• UDP over IPv4 • UDP over IPv6 • Ethernet
Messages	• Signaling • Announce • Sync • Follow-up • Delay-request • Delay-response • Management
Transport Modes	• Unicast: This is the default mode. All packets are sent as unicast messages. Unicast is applicable only for PTP over IP profiles. • Multicast: All packets are sent as multicast messages. Multicast is the only mode for PTP over ethernet profiles.

Best practice: Avoid timing loops in PTP and SyncE networks

To maintain reliable network synchronization and prevent instability in environments that use both PTP and SyncE, follow these best practices:

- Ensure both PTP and SyncE are traceable back to the same primary clock source. This consistency prevents discrepancies between synchronization protocols and reduces the risk of timing loops.
- Use PTP local priority settings that correspond to the priority of SyncE inputs. This alignment maintains a unified synchronization hierarchy and ensures the preferred clock source is consistent across both protocols.

Timing loops can arise when configuring multiple redundant paths—especially in ring topologies—or when a node receives synchronization from SyncE and then provides PTP synchronization back into the network. These loops cause erratic behavior (such as state flapping between PHASE-ALIGNED and FREQUENCY-LOCKED states) and can compromise network performance and reliability.

Delay measurement in network time synchronization

A delay measurement principle is a method in network time synchronization that

- determines the path delay between devices using the transmit and receive times of messages
- adjusts local clocks to compensate for the measured delay, and
- assumes a symmetrical communication path unless otherwise specified.

PTP averages the round-trip delay time of messages sent between the master and client to compute the one-way delay. This measurement is critical for adjusting the current time information in network data for accurate synchronization. However, in routed networks, communication paths are often asymmetrical, which can introduce errors if not accounted for.

PTP profile and class support matrix

This table provides information about the PTP timing profiles and class that are supported on the Cisco 8000 series routers and line cards.



Note

- 10G ports from 4 to 11 support Class B on 8011-32Y8L2H2FH.
- 10G Ports of 8K-MPA-16Z2D MPA support Class B.
- PTP is not supported (PTP Performance will not meet Class-B Specification) on 1G ports of 8K-MPA-16Z2D MPA.
- PTP will not work properly with scenarios such as MPA Shut, No-Shut, or MPA reload.

Table 10: Timing Profile and Class Support Matrix

Hardware Module	Supported Profile	Cisco IOS XR Release
8711-28H8F-M	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 26.3.1
8711-48Z-M	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 25.4.1
8404-SYS-D	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 25.4.1
8404-RSP1-2FH/4H	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 25.4.1
84-MPA-2H12Z-M	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 25.4.1
84-MPA-2FH/6H-M	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 25.4.1
8011-12G12X4Y-A/D	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 25.4.1

Hardware Module	Supported Profile	Cisco IOS XR Release
8011-32Y8L2H2FH	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 25.4.1
8K-MPA-18Z1D	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 25.1.1
8011-4G24Y4H-I	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 25.1.1
Cisco 8212-48FH-M router	G.8262 G.8264 G.8275.1 G.8273.2	Release 24.4.1
Cisco 8712 Router	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 24.4.1
8K-MPA-4D	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 24.4.1
8K-MPA-16H	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 24.4.1

Hardware Module	Supported Profile	Cisco IOS XR Release
8K-MPA-16Z2D	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 24.4.1
8212-48FH-M	G.8265.1 G.8275.2 G.8263	Release 24.4.1
8711-32FH-M router	G.8265.1 G.8273.2 Class C G.8275.1 G.8275.2	Release 24.3.1
88-LC1-52Y8H-EM	G.8265.1	Release 24.4.1
	G.8273.2 Class C G.8275.1	Release 24.3.1
	G.8275.2	Release 24.4.1
88-LC1-12TH24FH-E	G.8265.1	Release 24.4.1
	G.8273.2 Class C G.8275.1	Release 24.3.1
	G.8275.2	Release 24.4.1
86-MPA-14H2FH-M	G.8265.1	Release 24.3.1
	G.8273.2 Class C G.8275.1	Release 24.1.1
	G.8275.2	Release 24.3.1
86-MPA-24Z-M	G.8265.1	Release 24.3.1
	G.8273.2 Class C	Release 24.1.1
	G.8275.1	
	G.8275.2	Release 24.3.1

Hardware Module	Supported Profile	Cisco IOS XR Release
86-MPA-4FH-M	G.8265.1	Release 24.3.1
	G.8273.2 Class C G.8275.1	Release 24.1.1
	G.8275.2	Release 24.3.1
Cisco 8608 Router	G.8265.1	Release 24.3.1
	G.8273.2 Class C G.8275.1	Release 24.1.1
	G.8275.2	Release 24.3.1
8608-RP 1588 Port(1G/10G)	G.8275.1 G.8273.2 Class C	Release 24.1.1
8800-RP2 1588 Port(1G/10G)	G.8275.1 G.8273.2 Class B	Release 7.10.1
• 8000-RP2 Route Processor • 88-LC0-36FH-M and 8800-LC-36FH line cards	G.8275.1 G.8273.2 Class C	Release 7.11.1
• 88-LC0-36FH-M line card • 8202-32FH-M router	G.8273.2 Class C G.8275.1	Release 7.5.2
• 88-LC0-36FH line card • 88-LC0-34H14FH line card • 8201-32FH router	G.8273.2 Class C G.8275.1	Release 7.3.3
• 8201 router • 8202 router • 8800-LC-48H line card • 8800-LC-36FH line card	G.8273.2 Class C G.8275.1 G.8265.1 G.8263	Release 7.3.1

ITU-T telecom profiles for PTP

An ITU-T telecom profile is a configuration set for the Precision Time Protocol (PTP) that:

- is defined by the ITU-T recommendations for telecommunication networks

- provides targeted configuration to meet the requirements of specific telecom applications, and
- differs from generic PTP profiles defined by IEEE 1588-2008.

Supported ITU-T telecom profiles

Cisco IOS-XR supports several ITU-T telecom profiles.

- G.8265.1: Time/phase synchronization for packet networks.
- G.8273.2: PTP packet profiles for telecom boundary clocks and telecom time slave clocks.
- G.8275.1: Precision time distribution in packet networks (full timing support).
- G.8275.2: Precision time distribution in packet networks (partial timing support).

Differences between telecom profiles and IEEE 1588-2008

Key differences between ITU-T telecom profiles for PTP and the default IEEE 1588-2008 standard include:

- Tailored configuration options to meet telecom network requirements, whereas IEEE 1588 profiles are more general-purpose.
- Specific adaptation for deployment scenarios in packet-based telecom networks.
- Enhanced mechanisms for synchronization accuracy and reliability in telecom applications.

G.8265.1

A G.8265.1 profile is a synchronization profile used in telecom networks that

- fulfills frequency-distribution requirements for packet-based timing,
- defines message formats and procedures for distributing precise time, and
- specifies network behaviors to ensure high-quality synchronization.

G.8265.1 is widely implemented in packet-based mobile backhaul and telecommunications environments where traditional TDM timing is replaced by packet-based precision.

G.8265.1 profile features

The G.8265.1 profile has several notable features:

- Clock advertisement: Specifies changes to values in announce messages; uses clock class value to advertise clock quality, with other values unused.
- Clock selection: Includes an alternate BMCA to select port states and clocks; requires receipt of Sync messages and optionally Delay-Response messages to qualify a clock for selection.
- Transport mechanism: Only supports the IPv4 PTP transport mechanism.
- Mode: Only supports transport of data packets in unicast mode.
- Clock type: Only supports ordinary clock type (one PTP port).
- G.8261 class-specification standard: Supported within the profile.

- Port Numbers: All PTP port numbers can only be one (1) because all clocks in this profile network are ordinary clocks.
- G.8261 class-specification standard is supported.

Packet rates supported by G.8265.1

G.8265.1 specifies packet rates higher than those in the IEEE 1588-2008 standard for various message types:

Table 11: Packet rates supported by G.8265.1

Packet Type	Supported Rates
Sync / Follow-Up	128 packets per second to 1 every 16s
Delay-Request / Delay-Response	128 packets per second to 1 every 16s
Announce	8 packets per second to 64 packets per second

These rates allow for fine-tuned adjustment of synchronization messaging frequency.

Master clock selection in G-8265.1

G.8265.1 uses an alternate algorithm to select between master clocks based on local priority and clock quality, ensuring the most suitable master clock is always chosen.

Packet Timing Signal Fail (PTSF) conditions in G.8265.1

The G.8265.1 profile defines several Packet Timing Signal Fail (PTSF) conditions that prevent certain master clocks from being selected:

- PTSF-lossSync condition: Raised when a master clock does not receive a reliable stream of Sync and Delay-Response messages. Cisco IOS XR requests Sync and Delay-Response grants for each configured master to monitor this condition.
- PTSF-lossAnnounce condition: Raised when a master clock does not receive a reliable stream of Announce messages.
- PTSF-unusable condition: Raised when a master receives a reliable stream of Announce, Sync, and Delay-Response messages, but the stream is unusable by client clocks. Cisco IOS XR does not use this condition.

PTSF conditions assist in identifying and excluding unreliable masters from being selected as the network's reference clock.

Configure global G.8265.1 client profile

Create a global configuration profile for a PTP interface that can then be assigned to any interface as required. It uses the G.8265.1 profile as an example:

Procedure

Step 1 Configure a global G.8265.1 client profile.

Example:

```
Router# config
Router(config)# ptp
Router(config-ptp)# clock
Router(config-ptp-clock)# domain 4
Router(config-ptp-clock)# profile g.8265.1 clock-type slave
Router(config-ptp-clock)# exit
```

Step 2 Configure the specifics of the G.8265.1 client profile.

Example:

```
Router(config-ptp)# profile slave
Router(config-ptp-profile)# transport ipv4
Router(config-ptp-profile)# sync frequency 32
Router(config-ptp-profile)# announce frequency 1
Router(config-ptp-profile)# delay-request frequency 32
Router(config-ptp-profile)# end
```

Step 3 Verify the configured PTP profile details using the **show run ptp** command.

Example:

```
Router# show run ptp
ptp
clock domain 4
profile g.8265.1 clock-type slave
!
profile slave
transport ipv4
sync frequency 32
announce frequency 1
delay-request frequency 32
!
```

Configure global G.8265.1 master profile

This procedure describes the steps involved creating a global configuration profile for a PTP interface that can then be assigned to any interface as required. It uses the G.8265.1 profile as an example:

Procedure

Step 1 Configure G.8265.1 master profile.

Example:

```
Router# config
Router(config)# ptp
Router(config-ptp)# clock
Router(config-ptp-clock)# domain 4
```

```
Router(config-ptp-clock)# profile g.8265.1 clock-type master
Router(config-ptp-clock)# exit
```

Step 2 Configure the specifics of the G.8265.1 master profile.

Example:

```
Router(config-ptp)# profile master
Router(config-ptp-profile)# transport ipv4
Router(config-ptp-profile)# sync frequency 32
Router(config-ptp-profile)# announce frequency 1
Router(config-ptp-profile)# delay-request frequency 32
Router(config-ptp-profile)# end
```

Step 3 Verify the configured PTP profile details using the **show run ptp** command.

Example:

```
Router# show run ptp
ptp
clock domain 4
profile g.8265.1 clock-type master
!
profile master
transport ipv4
sync frequency 32
announce frequency 1
delay-request frequency 32
```

G.8263 Standard

A G.8263 standard for client clocks is a performance compliance standard that

- applies to client clocks configured with the ITU-T G.8265.1 profile
- enables these clocks to drive frequency synchronization based on PTP packets received from traceable primary devices at secondary devices, and
- includes provisions for handling excess packet delay variation (PDV) by enabling a special servo mode using the **network-type high-pdv** command.

The G.8263 standard helps achieve precise and reliable frequency synchronization in packet-based networks, particularly under variable network conditions. By using a specialized servo mode for high PDV situations, the standard ensures client clock performance compliance even when network quality fluctuates.

Table 12: Feature History Table

Feature Name	Release Information	Feature Description
ITU-T G.8263 standard for client clock with ITU-T G.8265.1 profile	Release 7.3.1	ITU-T G.8263 is a performance compliance standard for client clocks configured with ITU-T G.8265.1 profiles. These clocks drive frequency synchronization based on the PTP packets received at the secondary devices, from traceable primary devices.

Configure high PDV mode on the client clock

Procedure

Step 1 Configure telecom profile G.8265.1 and clock-type as client using the **profile** command.

Example:

```
Router# config
Router(config)# ptp
Router(config-ptp)# clock
Router(config-ptp-clock)# domain 4
Router(config-ptp-clock)# profile g.8265.1 clock-type slave
Router(config-ptp-clock)# commit
Router(config-ptp-clock)# exit
```

Step 2 Configure the network type as high PDV using the **network-type high-pdv** command.

Example:

```
Router(config-ptp)# network-type high-pdv
Router(config-ptp)# end
```

Step 3 Verify the configured PTP profile details using the **show run ptp** command.

Example:

```
ptp
 clock
  domain 4
  profile g.8265.1 clock-type slave
 !
 network-type high-pdv
 !
```

G.8273.2

A G.8273.2 profile is a time synchronization specification that

- enables distribution of time and phase synchronization across packet-based networks
- supports enhanced Class C timing mode for highly accurate clock synchronization, and
- ensures both PTP and Frequency Synchronization are available to meet demanding telecom network requirements.

Cisco's implementation of G.8273.2 supports the enhanced Class C timing mode. Class C mode is essential for telecom infrastructures—including 5G networks—with stringent timing requirements. This mode significantly reduces the Maximum Absolute Time Error (Max|TE|) and improves synchronization for Telecom Boundary Clocks (T-BC) and Telecom Time Secondary Clocks (T-TSC).

Class C timing support is available for both Precision Time Protocol (PTP) and Frequency Synchronization, providing comprehensive synchronization capabilities throughout the network.

For details on configuration and supported platforms:

- See Configure PTP on Route Processor for PTP setup instructions.
- See Timing Profile and Class Support Matrix for a list of supported platforms.

For example, a mobile operator deploying 5G infrastructure can implement G.8273.2 Class C profiles to ensure base stations maintain precise time synchronization, which is critical for seamless handovers and reliable service delivery.

G.8275.1

A G.8275.1 profile is a PTP synchronization profile for telecom networks that

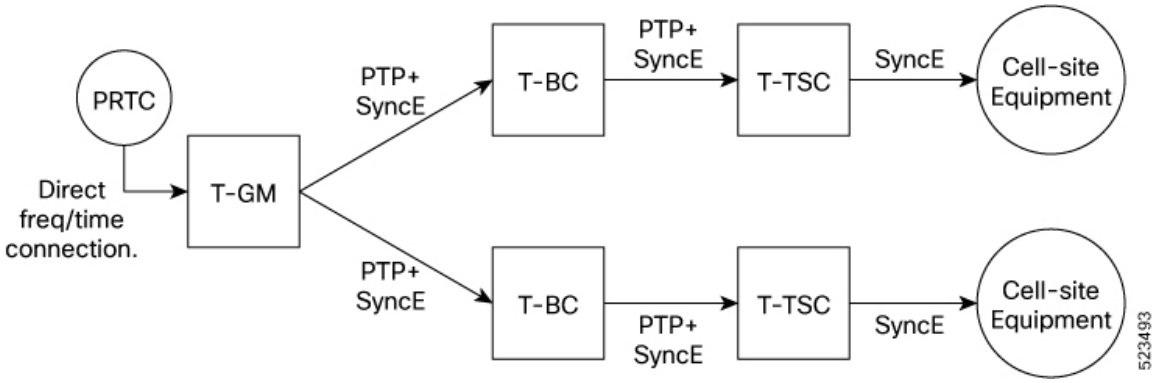
- fulfills time-of-day and phase synchronization requirements for all participating network devices
- ensures every network node takes part in the PTP protocol for optimal synchronization, and
- provides improved frequency stability and phase accuracy for time distribution.

The G.8275.1 profile addresses telecom network needs for precise timing by ensuring all devices synchronize using standard PTP mechanisms.

Table 13: Feature History Table

Feature Name	Release Information	Feature Description
ITU-T G.8275.1 profile	Release 7.3.1	This feature supports the architecture defined in ITU-T G.8275 for systems requiring accurate phase and time synchronization, phase or time-of-day synchronization is required, and where each network device participates in the PTP protocol. Support of this capability is extended on the Cisco 8000 Series router in this release.

Figure 4: Sample G.8275.1 Topology



Multicast mode forwarding in the G.8275.1 profile

Data packet transport in the G.8275.1 profile is restricted to multicast mode. Forwarding decisions depend on whether packets use forwardable or nonforwardable multicast MAC addresses. Only packets meeting the multicast mode criteria are transmitted between devices.

Features of the G.8275.1 profile

The G.8275.1 profile introduces a set of technical features designed to optimize synchronization in telecom environments:

- Synchronization model: Utilizes a hop-by-hop synchronization approach. Each network device synchronizes its local clock to the upstream device and provides synchronization to its downstream neighbor.
- Clock selection: Implements an alternate Best Master Clock Algorithm (BMCA) to determine the synchronization source.
  - The BMCA considers these parameters:
    - Clock class
    - Clock accuracy
    - Offset scaled log variance
    - Priority 2
    - Clock identity
    - Steps removed
    - Port identity
    - notSlave flag
    - Local priority
- Port state decision: Each port's state is selected based on the alternate BMCA algorithm. Ports may be configured to master-only for multicast transport mode.

Packet rates in the G.8275.1 profile

The G.8275.1 profile defines standard packet rates for each message type:

- Announce packets: 8 packets per second
- Sync/Follow-Up packets: 16 packets per second
- Delay-Request/Delay-Response packets: 16 packets per second

Port state selection in the G.8275.1 profile

Port states in the G.8275.1 profile are determined using the alternate BMCA algorithm. A port can be set to master-only mode, enforcing master status when multicast transport is used. This configuration ensures correct synchronization hierarchy throughout the network.

Transport mechanism in the G.8275.1 profile

The G.8275.1 profile exclusively supports Ethernet as the PTP transport mechanism, ensuring compatibility and standardization across network devices implementing this profile.

Types of clocks supported in the G.8275.1 profile

The types of clocks in the G.8275.1 profile and their characteristics are:

- Telecom Grandmaster (T-GM):

  Provides timing to all other network devices; it does not synchronize its local clock to other network elements except the Primary Reference Time Clock (PRTC).

- Telecom Boundary Clock (T-BC):

  Synchronizes to either a T-GM or upstream T-BC and distributes timing to downstream T-BCs or T-TSCs. If higher-quality clocks are unavailable, the T-BC may act as a grandmaster.

- Telecom Time Slave Clock (T-TSC):

  Synchronizes its local clock to another PTP clock (typically the T-BC); it does not provide synchronization to other devices.

Domain numbers in the G.8275.1 profile

G.8275.1 profile networks support domain numbers ranging from 24 to 43, with 24 configured as the default domain number for synchronization and interoperability.

Configure global G.8275.1 profile

Procedure

Step 1 Configure the G.8275.1 clock type.

Example:

```
Router# config
Router(config)# ptp
Router(config-ptp)# clock
Router(config-ptp-clock)# domain 24
Router(config-ptp-clock)# profile g.8275.1 clock-type T-BC
Router(config-ptp-clock)# exit
```

Step 2 Configure the G.8275.1 client profile.

Example:

```
Router(config-ptp)# profile slave
Router(config-ptp-profile)# multicast target-address ethernet 01-1B-19-00-00-00
Router(config-ptp-profile)# transport ethernet
Router(config-ptp-profile)# sync frequency 16
Router(config-ptp-profile)# announce frequency 8
Router(config-ptp-profile)# delay-request frequency 16
Router(config-ptp-profile)# exit
```

Step 3 Configure the G.8275.1 master profile.

Example:

```
Router(config-ptp)# profile master
Router(config-ptp-profile)# multicast target-address ethernet 01-1B-19-00-00-00
Router(config-ptp-profile)# transport ethernet
Router(config-ptp-profile)# sync frequency 16
Router(config-ptp-profile)# announce frequency 8
Router(config-ptp-profile)# delay-request frequency 16
Router(config-ptp-profile)# exit
```

Step 4 Enable the logging of servo events.

Example:

```
Router(config-ptp)# physical-layer-frequency
Router(config-ptp)# log
Router(config-ptp-log)# servo events
Router(config-ptp-log)# end
```

Step 5 Verify the configured PTP profile details using the **show run ptp** command.

Example:

```
Router# show run ptp
ptp
 clock
  domain 24
  profile g.8275.1 clock-type T-BC
 !
 profile slave
  multicast target-address ethernet 01-1B-19-00-00-00
  transport ethernet
  sync frequency 16
  announce frequency 8
  delay-request frequency 16
 !
 profile master
  multicast target-address ethernet 01-1B-19-00-00-00
  transport ethernet
  sync frequency 16
  announce frequency 8
  delay-request frequency 16
 !
 physical-layer-frequency
 log
  serv
```

Configure PTP hybrid mode

This procedure describes the steps involved in configuring the router in a hybrid mode. You can configure a hybrid mode by selecting PTP for phase and time-of-day (ToD) and another source for the frequency.

Note

- G.8275.1 PTP profile supports only the hybrid mode. It's mandatory to have a hybrid mode for the G8275.1 profile for T-BC and T-TSC clock types. By default, the hybrid mode is used, regardless of the physical-layer-frequency configuration.
- Configure appropriate clock priorities when using synchronous ethernet for frequency synchronization. This ensures the system selects the frequency source from the same interface as the PTP source. Aligning both frequency and time synchronization to the same interface helps maintain consistency and reduces configuration complexity.

Procedure

Step 1 Configure frequency synchronization for an interface. The time-of-day-priority setting specifies that syncE to be used as a ToD source if there's no source available with a lower priority.

Example:

```
Router# config
Router(config)# frequency synchronization
Router(config)# commit
Router(config)# interface HundredGigE 0/0/0/0
Router(config-if)# frequency synchronization
Router(config-if-freqsync)# selection input
Router(config-if-freqsync)# time-of-day-priority 100
Router(config-if-freqsync)# end
```

Step 2 Verify PTP hybrid Mode.

Example:

```
Router# show frequency synchronization selection location 0/RP0/CP$

Node 0/RP0/CPU0:
==============
Selection point: T0-SEL-B (3 inputs, 1 selected)
Last programmed 00:01:04 ago, and selection made 00:00:24 ago
Next selection points
SPA scoped : None
Node scoped : CHASSIS-TOD-SEL
Chassis scoped: LC_TX_SELECT
Router scoped : None
Uses frequency selection
Used for local line interface output
S Input Last Selection Point QL Pri Status
== ======================== ======================== ===== === ===========
1 HundredGigE 0/0/0/0 0/2/CPU0 ETH_RXMUX 1 ePRTC 1 Locked
PTP [0/RP0/CPU0] n/a PRS 254 Available
Internal0 [0/RP0/CPU0] n/a ST3E 255 Available

Selection point: T4-SEL (3 inputs, 1 selected)
Last programmed 00:01:04 ago, and selection made 00:00:24 ago
Next selection points
SPA scoped : None
Node scoped : None
Chassis scoped: None
Router scoped : None
Uses frequency selection
```

```
Used for local clock interface output
S Input Last Selection Point QL Pri Status
== ======================== ======================== ===== === ===========
1 HundredGigE 0/0/0/0 0/2/CPU0 ETH_RXMUX 1 ePRTC 1 Locked
PTP [0/RP0/CPU0] n/a PRS 254 Available
Internal0 [0/RP0/CPU0] n/a ST3E 255 Available

Selection point: 1588-SEL (2 inputs, 1 selected)
Last programmed 00:01:04 ago, and selection made 00:00:24 ago
Next selection points
SPA scoped : None
Node scoped : None
Chassis scoped: None
Router scoped : None
Uses frequency selection
S Input Last Selection Point QL Pri Status
== ======================== ======================== ===== === ===========
1 HundredGigE 0/0/0/0 0/2/CPU0 ETH_RXMUX 1 ePRTC 1 Locked
Internal0 [0/RP0/CPU0] n/a ST3E 255 Available

Selection point: CHASSIS-TOD-SEL (2 inputs, 1 selected)
Last programmed 00:00:53 ago, and selection made 00:00:51 ago
Next selection points
SPA scoped : None
Node scoped : None
Chassis scoped: None
Router scoped : None
Uses time-of-day selection
S Input Last Selection Point Pri Time Status
== ======================== ======================== === ==== ===========
1 PTP [0/RP0/CPU0] n/a 100 Yes Available
HundredGigE 0/0/0/0 0/RP0/CPU0 T0-SEL-B 1 100 No Available

RP/0/RP0/CPU0:SF-D#show frequency synchronization selection location 0/RP0/CP$

Node 0/RP0/CPU0:
==============
Selection point: T0-SEL-B (3 inputs, 1 selected)
Last programmed 00:01:09 ago, and selection made 00:00:29 ago
Next selection points
SPA scoped : None
Node scoped : CHASSIS-TOD-SEL
Chassis scoped: LC_TX_SELECT
Router scoped : None
Uses frequency selection
Used for local line interface output
S Input Last Selection Point QL Pri Status
== ======================== ======================== ===== === ===========
1 HundredGigE 0/0/0/0 0/2/CPU0 ETH_RXMUX 1 ePRTC 1 Locked
PTP [0/RP0/CPU0] n/a PRS 254 Available
Internal0 [0/RP0/CPU0] n/a ST3E 255 Available

Selection point: T4-SEL (3 inputs, 1 selected)
Last programmed 00:01:09 ago, and selection made 00:00:29 ago
Next selection points
SPA scoped : None
Node scoped : None
Chassis scoped: None
Router scoped : None
Uses frequency selection
Used for local clock interface output
S Input Last Selection Point QL Pri Status
== ======================== ======================== ===== === ===========
1 HundredGigE 0/0/0/0 0/2/CPU0 ETH_RXMUX 1 ePRTC 1 Locked
```

```
PTP [0/RP0/CPU0] n/a PRS 254 Available
Internal0 [0/RP0/CPU0] n/a ST3E 255 Available

Selection point: 1588-SEL (2 inputs, 1 selected)
Last programmed 00:01:09 ago, and selection made 00:00:29 ago
Next selection points
SPA scoped : None
Node scoped : None
Chassis scoped: None
Router scoped : None
Uses frequency selection
S Input Last Selection Point QL Pri Status
== ======================== ======================== ===== === ===========
1 HundredGigE 0/0/0/0 0/2/CPU0 ETH_RXMUX 1 ePRTC 1 Locked
Internal0 [0/RP0/CPU0] n/a ST3E 255 Available

Selection point: CHASSIS-TOD-SEL (2 inputs, 1 selected)
Last programmed 00:00:57 ago, and selection made 00:00:56 ago
Next selection points
SPA scoped : None
Node scoped : None
Chassis scoped: None
Router scoped : None
Uses time-of-day selection
S Input Last Selection Point Pri Time Status
== ======================== ======================== === ==== ===========
1 PTP [0/RP0/CPU0] n/a 100 Yes Available
HundredGigE 0/0/0/0 0/RP0/CPU0 T0-SEL-B 1 100 No Available
```

Configure the PTP client interface

This procedure describes the steps involved in configuring a PTP interface to be a client.

Procedure

Step 1 Configure the PTP interface to be a Client.

Example:

```
Router# config
Router(config)# interface HundredGigE 0/0/0/1
Router(config-if)# ptp
Router(config-if-ptp)# profile slave
Router(config-if-ptp)# port state slave-only
outer(config-if-ptp)# end
```

Step 2 Verify the port state details using the **show run interface** command.

Example:

```
Router# show run interface HundredGigE 0/0/0/1
interface HundredGigE0/0/0/1
 ptp
  profile slave
  port state slave-only
 !
```

Configure the PTP master interface

This procedure describes the steps involved in configuring a PTP interface to be a master.

Procedure

Step 1 Configure the PTP interface to be a master.

Example:

```
Router# config
Router(config)# interface HundredGigE 0/0/0/0
Router(config-if)# ipv4 address 18.1.1.1/24
Router(config-if)# ptp
Router(config-if-ptp)# profile master
Router(config-if-ptp)# port state master-only
Router(config-if-ptp)# end
```

Step 2 Verify the port state details using the **show run interface** command.

Example:

```
Router# show run interface HundredGigE 0/0/0/0
interface HundredGigE0/0/0/0
ptp
 profile master
 port state master-only
!
```

Configure PTP on route processor

This procedure describes the steps to configure the 1588 port on the Router Processor (RP) to be a slave.

Procedure

Step 1 Configure the PTP interface to be a slave.

Example:

```
Router# config
Router(config)# interface PTP0/RP0/CPU0/0
Router(config-if)# ptp
Router(config-if-ptp)# profile slave
Router(config-if-ptp)# port state slave-only
outer(config-if-ptp)# end
```

Step 2 Verify the port state details using the **show run interface** command.

Example:

```
Router# show run interface PTP0/RP0/CPU0/0
interface PTP0/RP0/CPU0/0
 ptp
  profile slave
  port state slave-only
 !
```

Note 1588 port on an RP is supported on specific platforms. For more information on the supported platform for 1588 port, see PTP profile and class support matrix.

G.8275.2

A G.8275.2 profile is a PTP telecom network synchronization profile that

- enables phase and time-of-day synchronization without requiring every device in the network to participate in the PTP protocol,
- operates over IPv4 using unicast mode, and
- relies on partial timing support from the network, allowing nodes that are not directly connected.

In 4G mobile networks, G.8275.2 ensures base stations remain synchronized for consistent service quality.

Phase and Time-of-Day Synchronization

Synchronizing devices in a network using G.8275.2 is like coordinating watches among teammates: not everyone needs to set their watch with the master, but as long as key team leaders pass along the correct time, the group remains coordinated.

Features of G.8275.2 profile

The G.8275.2 profile provides these key features:

- clock selection using an alternate BMCA algorithm, with dedicated parameters for synchronization and port state selection.
- decision logic for port state configuration (server-only, client-only, or any).
- defined packet rates for Synchronization, Announce, and Delay-Request/Response packet types.
- support for IPv4 PTP transport mechanism exclusively, using unicast mode.
- multiple supported clock types for flexible role assignment in network devices.
- domain number specification, with valid range 44–63 and default 44.

Clock selection algorithm in G.8275.2 profile

G.8275.2 uses an alternate Best Master Clock Algorithm (BMCA) to:

- select the clock for network synchronization,
- determine the port state for all local ports.

The BMCA bases its decision on these parameters:

- Clock class
- Clock accuracy
- Offset scaled log variance
- Priority 2
- Clock identity
- Steps removed
- Port identity
- notSlave flag
- Local priority

Note See the ITU-T G.8275.2 documentation for valid clock class values.

Clock types supported by G.8275.2 profile

Devices using G.8275.2 may be configured as one of these PTP clock types:

- Telecom Grandmaster (T-GM): Provides timing to other network devices, does not synchronize its clock to others, but may use GPS/GNSS for improved accuracy.
- Telecom Time Subordinate/Client Clock (T-TSC) and Partial-Support T-TSC (T-TSC-P): Synchronizes local clock to another PTP clock, but does not serve as a synchronization source for other devices.
- Telecom Boundary Clock (T-BC) and Partial-Support T-BC (T-BC-P): Synchronizes its clock to a T-GM or upstream T-BC and then provides timing to downstream T-BC or T-TSC clocks.

Port State Decision in G.8275.2 Profile

The alternate BMCA algorithm determines port states within G.8275.2 networks. Each port can be configured as:

- server-only
- client-only
- any (either server or client mode)

Port state decisions are made according to the network synchronization hierarchy and BMCA results.

Transport Mechanism and Mode in G.8275.2 Profile

G.8275.2 profile supports only:

- IPv4 transport mechanism for Precision Time Protocol (PTP) packets.
- Unicast mode for PTP packet transmission; multicast is not supported.

Domain Numbers in G.8275.2 Profile

The valid domain numbers for G.8275.2 networks are:

- Range: 44 to 63
- Default: 44

Domain numbers help separate synchronization domains within the same physical network.

Packet rates supported by G.8275.2 profile

G.8275.2 defines these packet rates for PTP operations:

- Synchronization/Follow-Up packets: 1–128 packets per second (minimum and maximum)
- Announce packets: 1–8 packets per second (minimum and maximum)
- Delay-Request/Delay-Response packets: 1–128 packets per second (minimum and maximum)

Configure G.8275.2 profile in hybrid mode

This procedure provides the G.8275.2 profile configuration in hybrid mode.

Procedure

Step 1 Configure the T-GM with GNSS as source. If GNSS is the source, perform step a. If the server clock receives front panel inputs, skip to step b.

a) Enable GNSS.

Example:

```
gnss-receiver 0 location 0/RP1/CPU0
no shut
constellation auto
frequency synchronization
selection input
wait-to-restore 0
quality receive exact itu-t option 1 PRC
```

b) Enable GPS for phase and frequency input.

Example:

```
clock-interface sync 2 location 0/RP0/CPU0
         port-parameters
         gps-input tod-format ntp4 pps-input ttl baud-rate 9600
         !
         frequency synchronization
         selection input
         priority 1
         wait-to-restore 0
         quality receive exact itu-t option 1 PRC
         !
         !
```

c) Configure global frequency.

Example:

```
frequency synchronization
        quality itu-t option 1
        clock-interface timing-mode system
        !
```

d) Configure global PTP.

Example:

```
ptp
          clock
          domain 44
          profile g.8275.2 clock-type T-GM
         !
         profile 8275.2
        transport ipv4
        port state any
        sync frequency 64
        announce frequency 8
        delay-request frequency 64
         !
         physical-layer-frequency
        !
```

e) Configure PTP and SyncE output on port for T-GM.

Example:

```
interface HundredGigE0/0/0/1
    ptp
    profile 8275.2
    !
    frequency synchronization
    !
```

Step 2 Configure G.8275.2 on T-BC.

a) Configure global SyncE.

Example:

```
frequency synchronization
     quality itu-t option 1
     clock-interface timing-mode system
     !
```

b) Configure global PTP.

Example:

```
ptp
clock
domain 44
profile g.8275.2 clock-type T-BC
!
profile 8275.2
  transport ipv4
  port state any
  sync frequency 64
  announce frequency 8
  delay-request frequency 64
!
physical-layer-frequency  <-- This is a mandatory command -->
!
```

c) Configure client port on Hybrid BC.

Example:

```
interface HundredGigE0/0/0/0
ptp
profile 8275.2
!
frequency synchronization
selection input
priority 1
wait-to-restore 0
!
!
```

d) Configure server port on Hybrid BC.

Example:

```
interface HundredGigE0/0/0/1
ptp
profile 8275.2
!
frequency synchronization
!
!
```

Step 3 Configure G8275.2 on T-TSC.

a) Configure global SyncE.

Example:

```
frequency synchronization
     quality itu-t option 1
     clock-interface timing-mode system
     !
```

b) Configure global PTP.

Example:

```
ptp
clock
domain 44
profile g.8275.2 clock-type T-TSC
!
profile 8275.2
  transport ipv4
  port state any
  sync frequency 64
  announce frequency 8
  delay-request frequency 64
!
physical-layer-frequency  <-- This is a mandatory command -->
!
```

c) Configure client port on Hybrid BC.

Example:

```
interface HundredGigE0/0/0/0
ptp
profile 8275.2
!
frequency synchronization
selection input
priority 1
wait-to-restore 0
```

```
!
!
```

Configure G.8275.2 profile in non-hybrid mode

This procedure provides the G.8275.2 profile configuration in non-hybrid mode.

Before you begin

Procedure

Step 1 Configure the T-GM with GNSS as source. If GNSS is the source, perform step a. If the server clock receives front panel inputs, skip to step b.

a) Enable GNSS.

Example:

```
gnss-receiver 0 location 0/RP1/CPU0
frequency synchronization
selection input
wait-to-restore 0
quality receive exact itu-t option 1 PRC
```

b) Enable GPS for phase and frequency input.

Example:

```
clock-interface sync 2 location 0/RP0/CPU0
         port-parameters
         gps-input tod-format ntp4 pps-input ttl baud-rate 9600
         !

         selection input
         priority 1
         wait-to-restore 0
         quality receive exact itu-t option 1 PRC
         !
         !
```

c) Configure global PTP.

Example:

```
ptp
          clock
          domain 44
          profile g.8275.2 clock-type T-GM
         !
         profile 8275.2
        transport ipv4
        port state any
        sync frequency 64
        announce frequency 8
        delay-request frequency 64
         !
        !
```

d) Configure PTP and SyncE output on port for T-GM.

Example:

```
interface HundredGigE0/0/0/1
    ptp
    profile 8275.2
    !
    !
```

Step 2 Configure G.8275.2 on T-BC.

a) Configure global PTP.

Example:

```
ptp
clock
domain 44
profile g.8275.2 clock-type T-BC
!
profile 8275.2
  transport ipv4
  port state any
  sync frequency 64
  announce frequency 8
  delay-request frequency 64
!
```

b) Configure client port on Hybrid BC.

Example:

```
interface HundredGigE0/0/0/0
ptp
profile 8275.2
!
selection input
priority 1
wait-to-restore 0
!
!
```

c) Configure server port on Hybrid BC.

Example:

```
interface HundredGigE0/0/0/1
ptp
profile 8275.2
!
!
```

Step 3 Configure G8275.2 on T-TSC.

a) Configure global PTP.

Example:

```
ptp
clock
domain 44
profile g.8275.2 clock-type T-TSC
!
profile 8275.2
  transport ipv4
  port state any
  sync frequency 64
  announce frequency 8
```

```
  delay-request frequency 64
!
```

b) Configure client port on Hybrid BC.

Example:

```
interface HundredGigE0/0/0/0
ptp
profile 8275.2
!
selection input
priority 1
wait-to-restore 0
!
!
```

Guidelines for configuring PTP for syncE and PTP traceability

The router follows specific logic when selecting a SyncE source.

- A SyncE source among equal sources [1] is selected on the same interface on which PTP is selected by the router.
- If the SyncE source on the PTP receiver interface is inferior (in terms of QL and user configured priority) than any other available SyncE source, then the SyncE source is selected using the default criteria (based on the ITU-T G.781 requirements).
- In the event that the selected PTP source goes down or if the PTP source's quality degrades, the system may switch to another PTP source. In such case, use the **synchronous-ethernet prefer-interface ptp-receiver** command so that the SyncE source selection would also switch to the new PTP receiver interface. Here, the preferred switching of SyncE source to the new PTP receiver interface shall happen only if the new interface uses the same SyncE QL and the user configured priority as the previously selected interface.

Configure PTP for SyncE-PTP traceability

Configure SyncE and PTP clocks to be traceable using Cisco IOS XR features, ensuring robust synchronization in hybrid operation scenarios.

In hybrid mode, when SyncE and PTP clocks originate from separate nodes, lack of traceability and excessive offset may prevent the PTP-receiver from synchronizing with the PTP-transmitter. Cisco IOS XR Release 24.4.1 introduces the**synchronous-ethernet prefer-interface ptp-receiver** command to improve traceability.

Before you begin

- Ensure you are running Cisco IOS XR Release 24.4.1 or later.
- Identify the interface where PTP is selected by the router.

Procedure

Step 1 Configure the router to prefer the syncE source from the interface chosen for PTP receiver.

Example:

```
Router# configure terminal
Router(config)# frequency synchronization synchronous-ethernet prefer-interface ptp-receiver
Router(config)# commit
```

Step 2 Verify that the configuration is successful.

```
Router(config)# show running-config frequency synchronization
frequency-synchronization
 synchronous-ethernet prefer-interface ptp-receiver
!
```

Configure G.8275.2 profile

This section describes the global configuration of the telecom profile for the server clock.

Procedure

Step 1 Configure the global telecom profile for the server clock.

Example:

```
ptp
 clock
  domain 44
  profile g.8275.2 clock-type T-GM
 !
 profile master
  transport ipv4
  sync frequency 64
  announce frequency 8
  unicast-grant invalid-request deny
  delay-request frequency 64
 !
!

interface GigabitEthernet0/0/0/11
 ptp
  profile master
 !
 ipv4 address 11.11.11.1 255.255.255.0
!
```

Step 2 Configure the global telecom profile for the client clock.

Example:

```
ptp
 clock
  domain 44
  profile g.8275.2 clock-type T-TSC
 !
 profile slave
  transport ipv4
  port state slave-only
  sync frequency 64
  announce frequency 8
  delay-request frequency 64
```

```
 !
 log
  servo events
  best-master-clock changes
 !
!
interface GigabitEthernet0/0/0/12
 ptp
  profile slave
  master ipv4 10.10.10.1
   !
 !
 ipv4 address 10.10.10.2 255.255.255.0
!
```

Step 3 Configure the global telecom profile with the clock type set to T-Boundary Clock (T-BC).

Example:

```
ptp
 clock
  domain 44
  profile g.8275.2 clock-type T-BC
 !
 profile slave
  transport ipv4
  port state slave-only
  sync frequency 64
  announce frequency 8
  unicast-grant invalid-request deny
  delay-request frequency 64
 !
 profile master
  transport ipv4
  sync frequency 64
  announce frequency 8
  unicast-grant invalid-request deny
  delay-request frequency 64
 !
 log
  servo events
  best-master-clock changes
 !
!


interface GigabitEthernet0/0/0/11
 ptp
  profile master
 !
 ipv4 address 10.10.10.2 255.255.255.0
!

interface GigabitEthernet0/0/0/12
 ptp
  profile slave
  master ipv4 10.10.10.1
   !
 !
 ipv4 address 10.10.10.3 255.255.255.0
!
```

PTP delay asymmetry

A PTP delay asymmetry is a network timing feature that

- enables offsetting static delays that occur due to different routing paths or differences in ingress and egress behavior,
- improves Precision Time Protocol (PTP) accuracy by compensating for path asymmetry, and
- synchronizes real-time clocks more effectively across devices in a network.

When configuring PTP delay asymmetry, you can set static delay values for each client clock relative to every server clock. The delay can be defined in microseconds or nanoseconds. Configured values are also synchronized with the servo algorithm to further enhance PTP server performance and overall clock synchronization accuracy on the network.

Table 14: Feature History Table

Feature Name	Release Information	Description
PTP Delay Asymmetry	Release 25.4.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100])(select variants only*) *This feature is supported on: • 8011-32Y8L2H2FH • 8011-12G12X4Y-A/D
PTP Delay Asymmetry	Release 25.1.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100])(select variants only*) *This feature is now supported on Cisco 8011-4G24Y4H-I routers.
PTP Delay Asymmetry	Release 7.3.2	Any delays on Precision Time Protocol (PTP) paths can impact PTP accuracy and in turn impact clock settings for all devices in a network. This feature allows you to configure the static asymmetry such that the delay is accounted for and the PTP synchronization remains accurate. The **delay-symmetry** command is introduced for this feature.

A positive value indicates that the server-to-client propagation time is longer than the client-to-server propagation time, and conversely for negative values.

Note

- If you configure multiple PTP delay asymmetries for the same PTP profile, the latest PTP delay asymmetry that you configure is applied to the PTP profile.
- For G8275.1 and G8275.2 PTP profiles, PTP delay asymmetry is supported for both, client port and dynamic port that act as a client.
- Fixed delay can be measured by using any test and measurement tool. Fixed delay can be compensated by using the positive or negative values. For example, if the fixed delay is +10 nanoseconds, configure -10 nanoseconds to compensate the fixed delay.

Restrictions: PTP delay asymmetry

These restrictions apply while configuring PTP delay asymmetry:

- You can configure PTP delay asymmetry only on the PTP port of the grandmaster clock. The grandmaster clock can be a boundary clock or an ordinary clock.
- Use PTP delay asymmetry for compensating delays in fixed cables, not for variable delays in the network.
- You can configure PTP delay asymmetry within the range of -3 to 3 microseconds (or -3000 to 3000 nanoseconds).

Supported PTP profiles for delay asymmetry

These PTP profiles support the configuration of PTP delay asymmetry.

- PTP over IP (G8275.2 or default profile)
- PTP over L2 (G8275.1)

Configure PTP delay asymmetry

Procedure

Step 1 Configure PTP delay asymmetry on the client side.

Example:

```
Router# configure
Router(config)# interface HundredGigE 0/1/0/0
Router(config-if)# ptp
Router(config-if-ptp)# delay-asymmetry 3 microseconds
Router(config-if-ptp)# end
```

Step 2 Verify if PTP delay asymmetry is applied.

Example:

```
Router# show ptp foreign-masters
Interface HundredGigE0/1/0/0 (PTP port number 1)
IPv4, Address 209.165.200.225, Unicast
Configured priority: 1
Configured clock class: None
Configured delay asymmetry: 3 microseconds <- configured variable delay asymmetry value
Announce granted: every 2 seconds, 300 seconds
Sync granted: 16 per-second, 300 seconds
Delay-resp granted: 16 per-second, 300 seconds
Qualified for 2 minutes, 45 seconds
Clock ID: 80e01dfffe8ab73f
Received clock properties:
Domain: 0, Priority1: 128, Priority2: 128, Class: 6
Accuracy: 0x22, Offset scaled log variance: 0xcd70
Steps-removed: 1, Time source: GPS, Timescale: PTP
Frequency-traceable, Time-traceable
Current UTC offset: 37 seconds (valid)
Parent properties:
Clock ID: 80e01dfffe8ab73f
Port number: 1
```

Step 3 Validate the approximate compensated delay value.

Example:

```
Router# show ptp platform servo
Servo status: Running
Servo stat_index: 2
Device status: PHASE_LOCKED
Servo Mode: Hybrid
Servo log level: 0
Phase Alignment Accuracy: -2 ns
Sync timestamp updated: 18838
Sync timestamp discarded: 0
Delay timestamp updated: 18837
Delay timestamp discarded: 0
Previous Received Timestamp T1: 1657002314.031435081  T2: 1657002314.031436686  T3: 1657002314.026815770
  T4: 1657002314.026814372
Last Received Timestamp T1: 1657002314.031435081  T2: 1657002314.031436686  T3: 1657002314.088857790
  T4: 1657002314.088856392
Offset from master:  0 secs, 1502 nsecs    <<--compensated value shows 1.5 microseconds because the
 asymmetry configured under the interface is
3 microseconds.->>
Mean path delay   :  0 secs, 103 nsecs
setTime():0  stepTime():0 adjustFreq():2
Last setTime: 0.000000000 flag:0  Last stepTime:0 Last adjustFreq:-5093
```

PTP virtual port

A PTP virtual port is a timing interface that

- enables routers and network devices to select and advertise the best available clock source among a PTP server and local timing sources,
- allows external frequency, phase, and time inputs to participate in the Precision Time Protocol (PTP) source selection process, and
- supports standardized deployment by associating PTP protocol operations with external clock inputs as specified in ITU-T G.8275.1.

Table 15: Feature History Table

Feature Name	Release Information	Feature Description
Use PTP Virtual Port to Select Timing Source	Release 25.4.1	Introduced in this release on: Fixed Systems (8700 [ASIC: K100], 8010 [ASIC: A100])(select variants only*) *This feature is supported on: • 8011-32Y8L2H2FH • 8011-12G12X4Y-A/D • 8711-48Z-M
Use PTP Virtual Port to Select Timing Source	Release 25.3.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100]) (select variants only*) You can now select the best available timing source for your routers by using the PTP Virtual Port (VP) feature. This feature allows you to compare, select, and advertise the best clock source between a PTP server and other local timing sources connected to the routers. VP is an external frequency, phase, and time input interface on a Telecom Boundary Clock (T-BC), and thus participates in the timing source selection. For some useful information, see ITU-T Telecom Profiles for PTP. *This feature is now supported on Cisco 8011-4G24Y4H-I routers.

Additional reference information

- PTP virtual ports, often deployed on Telecom Boundary Clocks (T-BCs), provide external timing interfaces that participate in the device's selection of a clock source.
- With the continued diversification of backhaul networks, operators use PTP virtual ports to compare, select, and advertise the optimal timing source for network synchronization.
- ITU-T G.8275.1 introduces and defines the operation of the PTP virtual port within the context of highly accurate time distribution.

Limitations for PTP virtual port

These are the limitations for PTP virtual port:

- Only configure PTP virtual ports for G8275.1 and G8275.2 profiles in hybrid or non-hybrid modes.
- Do not configure virtual ports under ordinary clocks.

Configure PTP virtual port

Configure a PTP virtual port to distribute time from GNSS or SyncE sources using G8275.1 and G8275.2 profiles.

Use this task to set up PTP virtual port parameters in hybrid and non-hybrid modes to ensure accurate time distribution in your network.

Before you begin

- Verify you have Global Navigation Satellite System (GNSS) or Synchronous Ethernet (SyncE) sources available.
- Ensure you have access to a router supporting PTP configuration in the required profiles.

Procedure

Step 1 Configure a PTP virtual port to distribute time derived from a Global Navigation Satellite System (GNSS) or Synchronous Ethernet (SyncE) source.

Example:

```
Router#config
Router(config)#ptp
Router(config-ptp)#virtual-port
Router(config-ptp-vp)#offset-scaled-log-variance 20061
Router(config-ptp-vp)#priority2 128
Router(config-ptp-vp)#clock-class 6
Router(config-ptp-vp)#clock-accuracy 33
Router(config-ptp-vp)#local-priority 128
Router(config-ptp-vp)#exit
Router(config-ptp)#time-of-day priority 90
Router(config-ptp)#commit
```

Step 2 Verify the virtual port details with the **show ptp platform servo** command in global PTP configuration mode.

Example:

```
Router#show ptp platform servo
Servo status: Running
Servo stat_index: 2
Device status: PHASE_LOCKED
Servo Mode: Electrical
Servo log level: 0
Phase Alignment Accuracy: 11 ns
Sync timestamp updated: 10092
Sync timestamp discarded: 0
Delay timestamp updated: 10091
Delay timestamp discarded: 0
```

```
Previous Received Timestamp T1: 1642091334.238048486  T2: 1642091334.238048504  T3:
1642091334.217949799  T4: 1642091334.217949839
Last Received Timestamp T1: 1642091334.238048486  T2: 1642091334.238048504  T3: 1642091334.281936816
 T4: 1642091334.281936855
Offset from master:  0 secs, 0 nsecs
Mean path delay   :  0 secs, 0 nsecs
setTime():0  stepTime():0 adjustFreq():0
Last setTime: 0.000000000 flag:0  Last stepTime:0 Last adjustFreq:0
```

Assisted Partial Timing Support (APTS)

Assisted partial timing support (APTS) is a synchronization architecture that

- uses a local high-quality time reference (such as a GNSS-based PRTC clock) as the primary source of timing,
- relies on the Precision Time Protocol (PTP) as a backup timing source, and
- ensures accurate delivery of phase and time synchronization across mobile backhaul networks, even when the primary source is unavailable.

Table 16: Feature History Table

Feature Name	Release Information	Feature Description
Use APTS to Select Timing Source	Release 25.4.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100]) (select variants only*) *This feature is now supported on: • 8011-32Y8L2H2FH • 8011-12G12X4Y-A/D
Use APTS to Select Timing Source	Release 25.3.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100]) (select variants only*) Assisted Partial Timing Support (APTS) enables you to select timing and synchronization for mobile backhaul networks. APTS allows for proper distribution of phase and time synchronization in the network. For some useful information, see ITU-T Telecom Profiles for PTP. *This feature is now supported on Cisco 8011-4G24Y4H-I routers.

Limitations for APTS

These are the limitations for PTP virtual port.

- Cisco IOS XR software supports APTS only for G8275.2 non-hybrid profiles.

Configure APTS

Configure Adaptive PTP Slave (APTS) functionality for the G8275.2 profile in non-hybrid mode.

Complete this task to enable APTS operation according to G8275.2 profile requirements.

Before you begin

- Verify the G8275.2 profile is supported on your device.

Procedure

Step 1 Configure APTS on the G8275.2 profile in non-hybrid mode.

Example:

```
Router#config
Router(config)#ptp
Router(config-ptp)#apts
Router(config-ptp-apts)#clock
Router(config-ptp-apts-clock)#domain 24
Router(config-ptp-apts-clock)#profile g.8275.2 clock-type T-BC
Router(config-ptp-apts-clock)#exit
Router(config-ptp-apts)#profile profile1
Router(config-ptp-apts-profile)#transport ipv4
Router(config-ptp-apts-profile)#sync frequency 16
Router(config-ptp-apts-profile)#clock operation one-step
Router(config-ptp-apts-profile)#announce frequency 16
Router(config-ptp-apts-profile)#delay-request frequency 16
Router(config-ptp-apts-profile)#exit
Router(config-ptp-apts)#virtual-port
Router(config-ptp-apts-vp)#offset-scaled-log-variance 20061
Router(config-ptp-apts-vp)#priority2 128
Router(config-ptp-apts-vp)#clock-class 6
Router(config-ptp-apts-vp)#clock-accuracy 33
Router(config-ptp-apts-vp)#local-priority 128
Router(config-ptp-apts-vp)#exit
Router(config-ptp-apts)#frequency priority 254
Router(config-ptp-apts)#time-of-day priority 90
Router(config-ptp-apts)#log
Router(config-ptp-apts)#exit
Router(config-ptp)#commit
```

Step 2 Verify the APTS details with the **show ptp local-clock** command.

Example:

```
Router#sh ptp local-clock
Clock ID: 94aef0fffe0b8700
Clock properties:
  Domain: 44, Priority1: 128, Priority2: 128, Class: 165
  Accuracy: 0xfe, Offset scaled log variance: 0xffff
```

```
  Time Source: GPS
  Timescale: PTP
  Frequency-traceable, Time-traceable
  Current UTC offset: 37 seconds (valid)
Virtual Port:
  Configured: True, Connected: True
  Clock-class: 6
  Priority1: 128, Priority2: 128, Local Priority: 125
  Accuracy: 0x21, Offset scaled log variance: 0x4e5d
Local clock is grandmaster
APTS: Enabled
```

PTP performance monitoring features

A PTP performance monitoring feature is a network management capability that

- tracks and analyzes critical performance metrics in Precision Time Protocol (PTP) networks,
- monitors clock accuracy, synchronization status, and network delays to ensure precise time distribution, and
- enables detection and resolution of issues that could impact the reliability of time synchronization across devices.

PTP performance monitoring features support time-stamp analysis and detailed monitoring capabilities as defined in Annex J of IEEE 1588-2019, and offer enhanced granularity for time synchronization in telecommunication networks as specified in Annex F of ITU-T G.8275

Table 17: Feature History Table

Feature Name	Release Information	Feature Description
Performance monitoring for PTP networks	Release 26.1.1	Introduced in this release on: Fixed Systems (8400 [ASIC: K100], 8700 [ASIC: K100])(select variants only*) *This feature is supported on: • 8404-SYS-D • 8712-MOD-M

Feature Name	Release Information	Feature Description
Performance monitoring for PTP networks	Release 25.4.1	Introduced in this release on: Fixed Systems (8700 [ASIC: K100], 8010 [ASIC:A100])(select variants only*) *This feature is supported on: • 8711-48Z-M • 8011-32Y8L2H2FH • 8011-12G12X4Y-A/D • 8011-4G24Y4H-I
Performance monitoring for PTP networks	Release 25.3.1	Introduced in this release on: Fixed Systems (8200 [ASIC: Q100, Q200, P100], 8700 [ASIC: P100, K100], 8010 [ASIC: A100]); Centralized Systems (8600 [ASIC: Q200]); Modular Systems (8800 [LC ASIC: Q100, Q200, P100]) You can now get statistical information with Performance Monitoring in PTP networks, such as clock accuracy, synchronization status, and network delays by defining Performance Monitoring Parameters and Port Specific Parameters. This feature empowers operators with comprehensive performance monitoring and precise time-stamp analysis, offering enhanced granularity for time synchronization in telecommunication networks. By providing detailed insights, it enables operators to make well-informed decisions and take proactive actions to ensure optimal network performance. This feature introduces these changes: CLI: • **performance-monitoring** • **show ptp platform performance-counters** • **show ptp dataset performance** YANG Data Models: • `Cisco-IOS-XR-ptp-cfg.yang` • `Cisco-IOS-XR-ptp-oper.yang` • `Cisco-IOS-XR-um-ptp-cfg.yang` (see GitHub , YANG Data Models Navigator)

You can use these parameters to define the performance monitoring in a PTP network.

Performance monitoring parameters

These parameters are calculated for performance monitoring using timestamps from the grandmaster and maintained by the platform:

Key parameters:

- TimeTransmitter – TimeReceiver delay: Corrected propagation time from TimeTransmitter to TimeReceiver.
- TimeReceiver – TimeTransmitter delay: Corrected propagation time from TimeReceiver to TimeTransmitter.
- Mean path delay: Mean propagation time over the PTP communication path.
- Offset from TimeTransmitter: Time difference between TimeTransmitter and TimeReceiver PTP instances as measured by the receiver.

For each of these parameters, you can measure the average, minimum, maximum, and standard deviation for each measurement. These values are calculated and maintained for the following time intervals over the specified time periods:

- 3-minute: maintained for the current 1-hour period.
- 15-minute: maintained for the current 24-hour period.
- 1-hour: maintained for the current 2-hour period.
- 24-hour: maintained for the current 48-hour period.

The platform actively calculates the end-to-end latency between the TimeTransmitter and TimeReceiver through the Delay-Request-Response-Mechanism (DRRM), allowing Precision Time Protocol (PTP) to seamlessly operate across networks equipped with Transparent clocks, non-PTP aware switches, or a mix of both. Upon a request, PTP dynamically extracts these calculated values from the servo using a platform specific API, allowing you to make proactive changes to the network to ensure precise time synchronization essential for applications that depend on accurate timing.

Measurement statistics for each parameter:

- Average
- Minimum
- Maximum
- Standard deviation

Time intervals for monitoring (for each measurement):

- 3-minute (maintained for current 1-hour period)
- 15-minute (maintained for current 24-hour period)
- 1-hour (maintained for current 2-hour period)
- 24-hour (maintained for current 48-hour period)

The platform calculates end-to-end latency between TimeTransmitter and TimeReceiver using the Delay-Request-Response-Mechanism (DRRM), enabling PTP to operate across networks with Transparent

clocks, non-PTP-aware switches, or both. Upon request, PTP extracts these values from the servo via a platform-specific API to support precise time synchronization for timing-sensitive applications.

Port specific parameters and counters

Port-specific Precision Time Protocol (PTP) parameters include counters for various packet types, which are critical for monitoring and maintaining accurate time synchronization. The main port-specific parameters are:

- Sync packets: Sent by the master clock to synchronize slave clocks.
- Delay request packets: Sent by the slave clock to measure delay; master responds with a Delay Response packet.
- Follow-up packets: Sent by the master to provide the exact time of Sync packet transmission.
- Announce packets: Used by the master to advertise its presence and capabilities, aiding master clock selection.
- Management packets: Used for configuration and management within the PTP network.

Each packet type has associated received (rx) and transmitted (tx) counters, which should be collected for performance monitoring.

It is important to collect and maintain these counters for performance monitoring purposes, which follows the same time intervals and periods as those used for monitoring clock performance.

PTP record format structure

The PTP record format defines the organization of data stored for Precision Time Protocol (PTP) time synchronization events and measurements. It specifies how statistical data—such as timestamps, event types, and performance metrics—is arranged within a data buffer to support monitoring and historical analysis.

PTP record format attributes:

- The data buffer contains separate sections for both clock and port performance monitoring parameters.
- All records are stored sequentially and indexed by buffer position.
- Data covers recent intervals (3 minutes, 15 minutes, 1 hour, 24 hours), enabling short-term and long-term analysis.

Table 18: Record allocation in the buffer:

Buffer Position	Statistics Interval	Number of Records	Description
0	Current 15-minute set	1	Latest statistics for the current 15-minute interval
1–96	15-minute (last 24 hours)	96	Historical statistics—each for one 15-minute segment of past 24 hours
97	Current 24-hour set	1	Statistics for the ongoing 24-hour period
98	Previous 24-hour set	1	Statistics for the previous 24-hour period

Buffer Position	Statistics Interval	Number of Records	Description
100	Current 3-minute set	1	Latest statistics for the current 3-minute interval
101–120	3-minute (last 1 hour)	20	Historical statistics—each for one 3-minute segment of past hour
121	Current 1-hour set	1	Statistics for the ongoing 1-hour period
122	Previous 1-hour set	1	Statistics for the previous 1-hour period

Configure PTP performance monitoring

Enable and verify Precision Time Protocol (PTP) performance monitoring on the router.

Use these steps to configure and check PTP performance monitoring statistics, allowing you to track PTP clock and port performance over specific time intervals.

Procedure

Step 1 Configure the **performance-monitoring** command to enable collection of performance monitoring statistics and for the users to make performance monitoring requests.

Example:

```
Router(config)#ptp
Router(config-ptp)#performance-monitoring
Router(config-ptp)# commit
```

Step 2 Run the **sh ptp platform performance-counters** command to display the details of all 123 records.

The existing **show ptp platform** command is extended to include the performance monitoring data for the local clock. The detail mode of the command displays all 123 records while the brief mode displays only the current windows for 15 minutes, 24 hours, 3minutes, and 1hour.

Example:

```
Router# sh ptp platform performance-counters detail
PTP Current record index 15 min: 96
PTP Current record index 3 min: 119
PTP performance monitoring statistics:
================================================================================================================
15 min stats
[0]     07:08:59 UTC 15 min statistics
----------------------------------------------------------------------------------------------------------------

 Stat    Min(sec.nsec)        Max(sec.nsec)       Mean(sec.nsec)     Std deviation           Samples


----------------------------------------------------------------------------------------------------------------

 Master-slave-delay -000000000.15937      000000000.333       -000000000.1780       000000000.71191
      154
 Slave-master-delay  000000000.319        000000000.16593      000000000.2437       000000000.74103
      154
 mean-path-delay  000000000.322        000000000.334        000000000.327        000000000.4057
```

```
  154
offset-from-master -000000000.16263      000000000.6         -000000000.2108       000000000.72546
     154

-------------------------------------------------------------------------------------------------------------

Complete      Valid      PmRef      ServoAtStart     ServoAtEnd          LastServoFlapTime

-------------------------------------------------------------------------------------------------------------

FALSE      FALSE       TRUE        PHASE_LOCKED   HOLDOVER              07:09:09 UTC
==============
           ….
```

Step 3 Run the **show ptp dataset performance clock** command to display the performance monitoring data-set details in 15 minutes intervals.

Example:

```
Router#show ptp dataset performance clock
performanceMonitoringDS for the current 15-minute window:
Clock ID ccccfffeccccc00, steps removed 1, receiving port 2:
Start of time window: Thursday, 14:18:59
Measurement is valid
Period is complete
Measurement has been taken with reference to system clock
Master slave delay:
Average: 50ns
Min: 50ns
Max: 70ns
Std: 1ns
Slave master delay:
Average: 51ns
Min: 51ns
Max: 71ns
Std: 2ns
Mean path delay:
Average: 52ns
Min: 52ns
Max: 72ns
Std: 3ns
Offset from master:
Average: 53ns
Min: 53ns
Max: 73ns
Std: 4ns
Clock ID aaaabbbecccc00, steps removed 1, receiving port 2:
Start of time window: Thursday, 14:18:59
Measurement is not valid
Period is not complete
Measurement has been taken with reference to system clock
Master slave delay:
Average: 50ns
Min: 50ns
Max: 70ns
Std: 1ns
Slave master delay:
Average: 51ns
Min: 51ns
Max: 71ns
Std: 2ns
Mean path delay:
Average: 52ns
Min: 52ns
```

```
Max: 72ns
Std: 3ns
Offset from master:
Average: 53ns
Min: 53ns
Max: 73ns
Std: 4ns
```

Step 4 Run the **show ptp dataset performance port** command to display the Performance Monitoring Port Data-set in 15 minutes intervals.

Example:

```
Router# show ptp dataset performance port GigabitEthernet 0/0/0/1
performanceMonitoringPortDS for the current 15-minute window:
Interface GigabitEthernet 0/0/0/1
Start of time window: Thursday, 14:18:59
Measurement is valid
Period is not complete
Measurement has been taken with reference to system clock
Packets                      Sent        Received         Dropped
-------------------------------------------------------------------
Announce                        3             83              11
Sync                            0             32               5
Follow-Up                       0             31               0
Delay-Req                      22              0               0
Delay-Resp                      0             21               7
Pdelay-Req                      0              7               0
Pdelay-Resp                     0              0               0
Pdelay-Resp-Follow-Up           0              0               0
Signaling                       2              1               0
Management                      0              0               0
Other                           0              3              12
-----           -----           -----
TOTAL                          27            178              35
```

Advance monitoring tools

A network monitoring tool is a network management utility that

- monitors alternative transmission paths within a network,
- enhances detection of network issues such as clock failures or asymmetries by providing comprehensive oversight, and
- analyzes network performance for proactive maintenance.

Table 19: Feature History Table

Feature Name	Release Information	Feature Description
Extending advance monitoring to Cisco 8404-SYS-D	Release 26.1.1	Introduced in this release on:Centralized Systems(8404 [ASIC:K100])(select variants only*) *This feature is supported on Cisco 8404-SYS-D.
Advance monitoring	Release 25.4.1	Introduced in this release on:Fixed Systems(8010 [ASIC:A100])(select variants only*) You can now enhance the detection of network issues, such as clock failures or asymmetries, by using advanced monitoring. This optional extension to the ITU-defined PTP G.8275.1 profile offers additional capabilities for monitoring alternative time transmitter information through the PTP port. *This feature is supported on: • 8011-12G12X4Y-A/D • 8011-32Y8L2H2FH • 8011-4G24Y4H-I This feature introduces these changes: CLI: • **monitor-receiver** • **monitor-sender**

Advanced monitoring tools expand on standard network monitoring by supporting features such as the monitor-receiver and monitor-sender configuration options. These options enable the exchange of PTP (Precision Time Protocol) packets beyond typical port states, allowing ports in the time-transmitter state to receive packets and time-receivers to send packets. When a port is configured with monitor-sender or monitor-receiver, announce messages are sent with the correct alternateTimeTransmitter flag state.

You can monitor packet exchanges in the PTP network by enabling monitor-receiver on the main port and monitor-sender on the passive port to understand time errors. Alternatively, enabling monitor-receiver on both the main and PTP ports allows the PTP probe to monitor the PTP clock when both ports initiate the DRRM process. In some scenarios, monitoring packet exchange may only require a single direction of exchange.

Example

Enabling the monitor-receiver flag on the main port and the monitor-sender flag on the passive port allows advanced monitoring tools to analyze time errors and support comprehensive troubleshooting in a PTP-enabled network.

Configure advance monitoring

Enable advanced monitoring on PTP ports by configuring monitor-receiver and monitor-sender roles using either the PTP profile or interface configuration mode.

Procedure

Step 1 Configure monitor-receiver or monitor-sender for advance monitoring.

- To configure monitor-receiver on the the main port through ptp profile:

```
Router#configure
Router(config)#ptp
Router(config-ptp)#profile demo
Router(config-ptp-profile)#monitor-receiver
Router(config-ptp-profile)#commit
```

- To configure monitor-sender on the the passive port through ptp profile:

```
Router# configure
Router(config)# ptp
Router(config-ptp)# profile demo
Router(config-ptp-profile)# monitor-sender
Router(config-ptp-profile)# commit
```

- To configure monitor-receiver on the the main port through interface ptp:

```
Router# configure
Router(config)# interface <name>
Router(config-if)# ptp
Router(config-if-ptp)# monitor-receiver
Router(config-if-ptp)# commit
```

- To configure monitor-sender on the the passive port through interface ptp:

```
Router# configure
Router(config)# interface <name>
Router(config-if)# ptp
Router(config-if-ptp)# monitor-sender
Router(config-if-ptp)# commit
```

Step 2 Execute the following command to verify the monitor-receiver and monitor-sender configuration.

- Execute the **show ptp interfaces** command to verify the monitor-receiver.

  In this example, the Time_transmitter is configured with monitor-receiver enabled, and the Monitor-Receiver is set to true.

```
Router# show ptp interfaces GigabitEthernet0/8/0/2
         GigabitEthernet0/8/0/2 is in Master state
         PTP port number: 1
         Transport: Ethernet Multicast
         Address: b4a8.b905.4892
         Linestate: Up
         Monitor-Sender: FalseMonitor-Receiver: True
          Local Priority: 128
          Mechanism: One-step delay-request-response
          Sync rate: 16 per-second
          Announce rate: 8 per-second, timeout 3 intervals
          Min Delay-Request rate: 16 per-second
          CoS: General 6, Event 6, DSCP: General 46, Event 46
          Profile interop: No
          Platform capabilities (as Master):
          Supported:     One-step, L2 Encapsulation, Ethernet, IPv4, IPv6, Unicast,
                          Multicast, Master, Slave
                          Not-supported: Two-step, Source IP
                          Max-Sync-rate: 128 per second
                          Master state only
                          0 Unicast peers
```

Step 3 Execute the **show ptp foreign-masters** command to verify the alternatemaster flag.

- In this example, the Time_transmitter is configured with monitor-receiverenabled and alternateMaster is set to true.

```
Router# show ptp foreign-masters GigabitEthernet0/8/0/2                                  Interface
GigabitEthernet0/8/0/2 (PTP port number 1)
        Ethernet, Address 7426.acf7.4d9c, Multicast
        Configured priority: None (128)
        Configured clock class: None
        Configured delay asymmetry: None
        Is alternateMaster: True
        Qualified for 5 minutes, 24 seconds
        Clock ID: 7426acfffef74e80
        Received clock properties:
        Domain: 24, Priority1: 128, Priority2: 128, Class: 248
        Accuracy: 0xfe, Offset scaled log variance: 0xffff
        Steps-removed: 1, Time source: Internal, Timescale: PTP
        Frequency-traceable
        Current UTC offset: 37 seconds (valid)
        Parent properties:
        Clock ID: 7426acfffef74e80
        Port number: 1
```

Advanced monitoring is enabled on the selected PTP ports, allowing a time-transmitter to receive and a time-receiver to send packets, as configured.

PTP phase difference threshold between passive and secondary ports

A PTP phase difference threshold is a timing synchronization measure that

- monitors the phase difference between passive and secondary ports,
- triggers alarms or logs when phase differences exceed a configured threshold, and
- helps detect timing anomalies such as fiber asymmetry or clock failure within a Precision Time Protocol (PTP) network.

Table 20: Feature History Table

Feature Name	Release Information	Feature Description
Extending PTP Phase Difference Threshold Between Passive and Secondary Ports to Cisco 8404-SYS-D	Release 26.1.1	Introduced in this release on:Centralized Systems(8404 [ASIC:K100])(select variants only*) *This feature is supported on Cisco 8404-SYS-D.

Feature Name	Release Information	Feature Description
PTP Phase Difference Threshold Between Passive and Secondary Ports	Release 25.4.1	Introduced in this release on:Fixed Systems(8010 [ASIC:A100])(select variants only*) Passive ports can now be included in the Delay Request-Response Mechanism (DRRM), which allows for the monitoring of PTP phase differences between a passive port and a secondary port. If these PTP phase differences surpass a predefined limit, system logs are triggered. This feature enables you to detect potential errors such as fiber asymmetry or a clock failure in the PTP network. *This feature is supported on: • 8011-12G12X4Y-A/D • 8011-32Y8L2H2FH • 8011-4G24Y4H-I This feature introduces these changes: CLI: • **phase-difference-threshold-breach** • The **show ptp foreign-masters** command output is enhanced to include phase difference values and servo status. YANG Data Models: The following data models are enhanced: • `Cisco-IOS-XR-ptp-cfg.yang` • `Cisco-IOS-XR-um-ptp-cfg.yang`

- You can configure the phase difference threshold using the **phase-difference-threshold-breach** command.
- When a threshold is crossed, system logs are triggered to alert you of network timing deviations.

```
Phase difference for clock ACDE48FFFE234567, steps removed 1, receiving-port 1, received
 on interface GigabitEthernet0/2/0/3 is 40ns, configured threshold is 30ns. Raising
phase difference alarm.
```

If the configured threshold is 30ns and a received phase difference is 40ns, the router raises a phase difference alarm and logs a syslog event.

Configure the PTP phase difference alarm threshold

Set the threshold value that triggers Precision Time Protocol (PTP) phase difference alarms, allowing timely detection and response to synchronization issues in the network.

Use this task when you need to monitor and control the maximum allowable phase difference between PTP clocks on your network device. Configuring an appropriate threshold helps ensure critical timing and synchronization for services that depend on precise clock alignment.

Before you begin

- Identify the threshold value in nanoseconds appropriate for your network environment.

Procedure

Step 1 Configure the threshold for triggering PTP phase difference alarms using the **phase-difference-threshold-breach** command.

Example:

```
Router#configure terminal
Router(config)#ptp
Router(config-ptp)#phase-difference-threshold-breach 300
Router(config-ptp)#commit
```

This sets the phase difference threshold to 300 nanoseconds.

Step 2 Verify that PTP phase difference threshold value is configured using the **show running configuration** command.

Example:

```
ptp
phase-difference-threshold-breach 300
!
```

Step 3 Display the current operational value using the **show ptp foreign-masters** command.

Example:

```
Router#show ptp foreign-masters
Ethernet, Address 0102.0304.050a, Multicast
Configured priority: 40
Configured clock class: None
Configured delay asymmetry: 3 microseconds
Announce granted:   4 per-second,      600 seconds
Sync granted:       4 per-second,      600 seconds
Delay-resp granted: 4 per-second,      600 seconds
Not qualified (PTSF lossSync)
Clock ID: abcdef1
Phase difference: 300ns
Servo status: PTSF-unusable
Received clock properties:
Domain: 0, Priority1: 1, Priority2: 100, Class: 52
Accuracy: 0x00, Offset scaled log variance: 0x0000
Steps-removed: 2, Time source: GPS, Timescale: PTP
Time-traceable
Current UTC offset: 0 seconds
Parent properties:
Clock ID: 0
Port number: 0
```

Look for "Phase difference" and confirm that the operational value matches the configured threshold.

The router is now configured to monitor phase difference according to the specified threshold. If PTP phase difference exceeds this value, the system will generate an alarm, allowing for prompt corrective action.

What to do next

- Monitor alarm notifications to ensure phase synchronization remains within acceptable limits.
- Periodically review and adjust the threshold value if network requirements change or if false alarms occur

.

Foreign masters causing packet timing signal fail

Foreign masters causing packet timing signal fail are PTP clock sources that

- have timestamps indicating unstable or unusable timing quality,
- are automatically excluded from time source selection by the Best Master Clock Algorithm (BMCA), and
- continue to be monitored for timing stability and possible reintegration if conditions improve.

Table 21: Feature History Table

Feature Name	Release Information	Feature Description
Isolate Foreign Masters Causing Packet Timing Signal Fail	Release 25.4.1	Introduced in this release on:Fixed Systems(8010 [ASIC:A100](select variants only*) This feature permits the flexible selection of timing sources by filtering out Foreign Master (FM) clocks that exhibit unstable timing. This filtering causes the secondary clocks to produce a signal deemed Packet Timing Signal Fail (PTSF)-unusable, from consideration within the Best Master Clock Algorithm (BMCA). The system continuously monitors these clocks for timing stabilization, and upon detecting enhanced stability, it may reevaluate and possibly reintegrate them as suitable time sources. *This feature is supported on: • 8011-12G12X4Y-A/D • 8011-32Y8L2H2FH • 8011-4G24Y4H-I This feature introduces these changes: CLI: • **detect-ptsf-unusable** • The **show ptp foreign-masters** command output is enhanced to include phase difference values and servo status. YANG Data Models: The following data models are enhanced: • `Cisco-IOS-XR-ptp-cfg.yang` • `Cisco-IOS-XR-um-ptp-cfg.yang`

Syslogs for foreign masters causing packet timing signal fail

When the master becomes PTSF-unusable, and if its the current Grandmaster, the following system log (syslogs) is displayed:

```
Foreign master with clock ID ACDE48FFFE234567, steps removed 1, receiving-port 1, received
 on interface GigabitEthernet0/2/0/4 is now PTSF-unusable and disqualified from selection.
```

Configure PTSF-unusable

Procedure

Step 1 Exclude the FM with unstable timing from selection in the BMCA and declare it as unusable using the **detect-ptsf-unusable** command.

Example:

```
Router#configure terminal
Router(config)#ptp
Router(config-ptp)#detect-ptsf-unusable
Router(config-ptp)#commit
```

Step 2 Check if the master clock is PTSF-unuable using the **show ptp foreign-masters** command.

Example:

```
Router#show-ptp-foreign-masters
Ethernet, Address 0102.0304.050a, Multicast
    Configured priority: 40
    Configured clock class: None
    Configured delay asymmetry: 3 microseconds
    Announce granted:   4 per-second,      600 seconds
    Sync granted:       4 per-second,      600 seconds
    Delay-resp granted: 4 per-second,      600 seconds
    Not qualified (PTSF lossSync)
    Clock ID: abcdef1
    Phase difference: -5000ns
    Servo status: PTSF-unusable
    Received clock properties:
      Domain: 0, Priority1: 1, Priority2: 100, Class: 52
      Accuracy: 0x00, Offset scaled log variance: 0x0000
      Steps-removed: 2, Time source: GPS, Timescale: PTP
      Time-traceable
      Current UTC offset: 0 seconds
    Parent properties:
      Clock ID: 0
      Port number: 0
```

PTP holdover traceability suppression

A PTP holdover traceability suppression is a network synchronization feature that

- allows boundary clock devices to maintain the downstream clock class and traceability status during primary clock loss,

- sets the time traceability flag to TRUE for a configured holdover duration, and
- ensures minimal impact to downstream nodes by deviating from standard ITU-T G.8275.1 behavior when necessary.

Table 22: Feature History Table

Feature Name	Release information	Feature Description
PTP frequency-assisted holdover	Release 26.3.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100]), 8700 [ASIC: K100]; Modular Systems (8800 [LC ASIC: K100)] The frequency-assisted holdover feature enhances network stability by allowing for an extended holdover duration within the network-limits specification, when a Primary Reference Clock (PRC) frequency source remains available. This ensures that even if the GNSS or PTP time source is lost, the system can advertise timing stability for a longer, user-defined period without significant degradation. This feature introduces these changes: CLI: holdover-spec-frequency-assisted-duration

Feature Name	Release information	Feature Description
PTP holdover traceability suppression	Release 25.4.1	Introduced in this release on: 8010 [ASIC: A100])(select variants only*) You can now extend PTP holdover traceability suppression to devices operating as Boundary Clocks (T-BC), Grandmaster Clocks (T-GM), and T-GM with VP/APTS modes. When a device loses synchronization with a quality primary clock, this feature ensures that downstream nodes continue to receive the configured clock class and maintain traceability for a specified duration, enhancing overall network timing reliability. *This feature is supported on: • 8011-12G12X4Y-A/D • 8011-32Y8L2H2FH • 8011-4G24Y4H-I This feature introduces these changes: CLI: • **holdover-spec-duration** • **holdover-spec-clock-class** • **uncalibrated-traceable-override**

Example of PTP holdover traceability supression

If a device configured as T-BC with PTP Profile G.8275.1 loses its primary reference, it continues advertising the configured clock class and traceability for the holdover period, after which it downgrades to default behavior.

Configure PTP holdover traceability suppression

Enable and customize the holdover traceability suppression feature for Precision Time Protocol (PTP) on your router.

PTP holdover traceability suppression controls how the router indicates clock traceability during holdover, allowing more accurate time synchronization status reporting after PTP master loss.

Table 23: Use-case for each command

If...	Then...
You want to specify a custom holdover duration	Use **holdover-spec-duration** *milliseconds.*
You need to set a custom clock class during holdover	Use **holdover-spec-clock-class** *class-value.*
You need to force traceable status during uncalibrated state	Enter **uncalibrated-traceable-override.**
You want to force traceable during holdover only for set duration	Enter **holdover-spec-traceable-override.**
You need to specify custom holdover duration during which a Primary Reference Clock (PRC) frequency source is available	Enter **holdover-spec-frequency-assisted-duration** *<seconds>*

Before you begin

- Verify you have configured basic PTP settings on the device.

Procedure

Step 1 Configure holdover specification duration in milliseconds.

Example:

```
Router#configure
Router(config)#ptp
Router(config-ptp)#holdover-spec-duration 1000
```

Step 2 Set the holdover specification clock class value.

Example:

```
Router(config-ptp)#holdover-spec-clock-class 135
```

Step 3 Overide the uncalibrated traceable flag.

Example:

```
Router(config-ptp)#uncalibrated-traceable-override
```

Step 4 Enable traceable override for the specified holdover duration.

Example:

```
Router(config-ptp)#holdover-spec-traceable-override
Router(config-ptp)#commit
```

Step 5 Configure PTP frequency-assisted holdover specification duration in seconds.

Example:

```
Router#configure
Router(config)#ptp
Router(config-ptp)#holdover-spec-frequency-assisted-duration 410000
```

Step 6 Verify if the configuration is succesful.

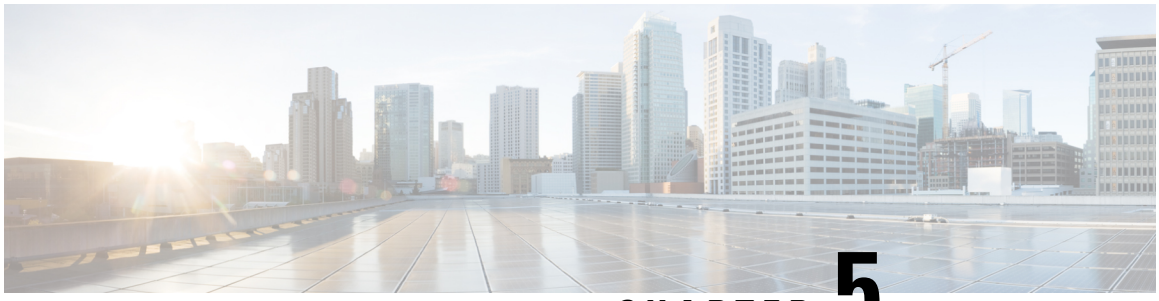
Example:

```
Router#show running-config ptp
ptp
 holdover-spec-duration 1000
 holdover-spec-clock-class 135
 uncalibrated-traceable-override
 holdover-spec-traceable-override
 holdover-spec-frequency-assisted-duration 410000
!
```

PTP holdover traceability suppression is enabled with your specified parameters. The router's behavior during PTP holdover reflects the options you selected, improving time synchronization status accuracy.

What to do next

Verify the PTP status and traceability using the appropriate show commands, such as **show ptp clock** or **show ptp status**, to confirm correct operation.



CHAPTER 5

Network Time Protocol

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- Obtain NTP time information, on page 99
- Configure NTP access groups , on page 102
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Network Time Protocol

A network time protocol is a time synchronization standard that

- synchronizes timekeeping among distributed devices by exchanging timestamped messages,
- uses a hierarchical stratum structure to ensure accurate and robust time propagation, and
- enables reliable event correlation and time-sensitive functions across networked system

A stratum is the level of a device in the NTP hierarchy, reflecting its distance from an authoritative time source such as an atomic or GPS clock.

NTP uses User Datagram Protocol (UDP) and operates in Coordinated Universal Time (UTC). It promotes efficiency by requiring minimal traffic (typically one packet per minute) to achieve synchronization within milliseconds. NTP enforces accuracy by refusing to synchronize with unsynchronized or significantly divergent devices, regardless of their stratum.

- Routers and switches in a data center use NTP to align their logs for troubleshooting and security audits.
- Computers on a corporate network synchronize with an NTP server to maintain consistent system clocks.

Using manual time settings on network devices, rather than NTP, can lead to clock drift and inconsistent logs.

Best practices: NTP configuration and WNRO issues mitigation

Best practices for configuring NTP

Follow these best practices when configuring NTP :

- Configure multiple redundant NTP time sources to avoid reliance on a single server and improve reliability.
- Use a loopback interface as the NTP source for consistency across device reboots and interface changes.
- Enable NTP authentication to secure communications and prevent malicious time alterations.
- Monitor NTP status and logs regularly; implement detection and alerting mechanisms using commands like **show ntp status** and **show ntp associations.**
- Use the **ntp panic-threshold-apply** command to check the configuration sanity checks, which reject large clock changes and prevent network instability.
- Address failure modes related to time-based authentication keychains by configuring overlapping key lifetimes to avoid routing disruptions.
- Regularly monitor and validate NTP synchronization status with monitoring tools and SNMP traps.
- Ensure operational practices include multiple NTP sources and configuration checks to prevent routing disruptions caused by time inaccuracies.

These practices help maintain accurate time synchronization, improve NTP security, and minimize the risk of network instability caused by incorrect time settings.

Mitigate GPS Week Number Rollover (WNRO) issues

To minimize the risk and impact of GPS Week Number Rollover (WNRO) issues in your network, apply these best practices:

- If your NTP source or server chain does not include any GPS sources, you do not need to take action—WNRO will not affect your network.
- GPS WNRO affects only the system clock; it does not disrupt user traffic.
- Contact your GPS hardware manufacturer for guidance and corrective actions if you suspect your GPS source may be susceptible to WNRO-related issues.
- If your GPS source is identified as a potential disruption point for WNRO (for example, on 2019-04-06 or later), configure the NTP master on the Cisco device connected to this source. Set the clock on the Stratum 1 device to isolate the affected source. With this setup, the device presents its own clock for synchronization to downstream NTP clients.
- Configure multiple NTP servers (ideally more than 3, preferably four servers) at the Stratum 2 level of your network. This enables NTP clients at Stratum 2 to synchronize with multiple Stratum 1 servers, which, if affected by WNRO, will be automatically marked as false ticker or outlier sources to prevent incorrect clock distribution.

Note The NTP master command is a temporary workaround. Use it only until the GPS source issue is resolved, to prevent incorrect time values from being propagated throughout your network

Obtain NTP time information

Procedure

Step 1 Configure poll-based associations.

Step 2 Configure broadcast based NTP association.

Configure poll-based associations

Establish a peer-to-peer NTP association between your router and one or more other devices to enable mutually redundant time synchronization.

Use this task when you need routers (or servers) to keep each other's time in sync, typically to improve redundancy and reliability for time sources in your network. You can configure NTP associations in either client mode or symmetric active mode, depending on the accuracy and reliability requirements.

The client and the symmetric active modes should be used when NTP is required to provide a high level of time accuracy and reliability.

When a networking device is operating in the client mode, it polls its assigned time serving hosts for the current time. The networking device then picks a host from all the polled time servers to synchronize with. Because the relationship that is established in this case is a client-host relationship, the host doesn't capture or use any time information sent by the local client device. This mode is most suited for file-server and workstation clients that aren't required to provide any form of time synchronization to other local clients. Use the **server** command to individually specify the time-serving hosts that you want your networking device to consider synchronizing with and to set your networking device to operate in the client mode.

When a networking device is operating in the symmetric active mode, it polls its assigned time-serving hosts for the current time and it responds to polls by its hosts. Because this is a peer-to-peer relationship, the host also retains time-related information about the local networking device that it's communicating with. This mode should be used when there are several mutually redundant servers that are interconnected via diverse network paths. Most stratum 1 and stratum 2 servers on the Internet today adopt this form of network setup. Use the **peer** command to individually specify the time-serving hosts that you want your networking device to consider synchronizing with and to set your networking device to operate in the symmetric active mode.

When the router polls several other devices for the time, the router selects one device with which to synchronize.

Note To configure a peer-to-peer association between the router and another device, you must also configure the router as a peer on the other device.

You can configure multiple peers and servers, but you can't configure a single IP address as both a peer and a server at the same time.

To change the configuration of a specific IP address from peer to server or from server to peer, use the **no** form of the **peer** or **server** command to remove the current configuration before you perform the new configuration. If you don't remove the old configuration before performing the new configuration, the new configuration doesn't overwrite the old configuration.

Before you begin

- Access the router's CLI with configuration privileges.
- Identify the IP addresses of peer devices.
- Ensure you have configuration access to the other device(s) for mutual setup.

Procedure

Step 1 Form a server association with another system.

Example:

```
Router# configure
Router(config)# ntp
Router(config-ntp)# server 172.19.69.1 minpoll 8 maxpoll 12
```

This step can be repeated as necessary to form associations with multiple devices.

Step 2 Form a peer association with another system.

Example:

```
Router(config-ntp)# peer 192.168.22.33 minpoll 8 maxpoll 12
source hundredGigE 0/0/0/1
Router(config-ntp)# end
```

This step can be repeated as necessary to form associations with multiple systems.

Note To complete the configuration of a peer-to-peer association between the router and the remote device, the router must also be configured as a peer on the remote device.

Step 3 Verify the configured NTP profile details.

Example:

```
Router# show running-config ntp
ntp
 server 172.19.69.1 minpoll 8 maxpoll 12
```

```
 peer 192.168.22.33 minpoll 8 maxpoll 12 source HundredGigE0/0/0/1
!
```

The router is associated with other devices in mutually redundant NTP associations, enhancing time synchronization resilience across your network.

Set-up broadcast-based NTP associations

Set up your device to use NTP broadcast packets for time synchronization in a localized network with many clients.

Use broadcast-based NTP associations if your network is localized, has more than 20 clients, and requires moderate time accuracy and reliability. Consider this method for networks with limited bandwidth, system memory, or CPU resources.

Note NTP is enabled when you issue the first NTP configuration command; there is no dedicated command to enable NTP.

Before you begin

- Ensure the NTP server and clients are on the same subnet.
- Determine which interfaces will send and receive broadcast packets.

Procedure

Step 1 Enable NTP on your device by entering any NTP configuration command.

Step 2 On the NTP server, configure the interface to send NTP broadcast packets.

Example:

```
Router# configure
Router(config)# ntp
Router(config-ntp)# broadcastdelay 2
Router(config-ntp)# interface HundredGigE 0/2/0/0
Router(config-ntp-int)# broadcast client
```

Step 3 On each client device, configure the interface to receive broadcast NTP.

Example:

```
Router(config-ntp-int)# broadcast destination 10.50.32.149
Router(config-ntp-int)# end
```

Step 4 (Optional) Set broadcast delay if needed.

Example:

```
Router(config-ntp-int)# broadcastdelay 2
```

Step 5 Verify the configured NTP profile details.

Example:

```
Router# show running-config ntp
ntp
 interface HundredGigE0/2/0/0
  broadcast client
  broadcast destination 10.50.32.149
 !
 broadcastdelay 2
!
```

Configure NTP access groups

Restrict or permit Network Time Protocol (NTP) access to your device by defining access groups based on access lists.

Access groups allow you to control which network devices, subnets, or hosts can synchronize with or query the device via NTP using basic IPv4 or IPv6 access lists.

NTP access group options are scanned in this order, from least to most restrictive.

- `peer` — Allows time requests and NTP control queries and allows the system to synchronize time with peers whose addresses match the access list.
- `serve` — Allows time requests and NTP control queries but does not permit the system to synchronize itself to peers.
- `serve-only` — Allows only time requests.
- `query-only` — Allows only NTP control queries.

If any access groups are specified, only those access types are granted. For details on NTP control queries, refer to RFC 1305 (NTP version 3).

For details on NTP control queries, see RFC 1305 (NTP version 3).

Procedure

Step 1 Create an access group and apply a basic IPv4 or IPv6 access list to it.

Example:

```
Router# configure
Router(config)# ntp
Router(config-ntp)# access-group peer peer-acl
Router(config-ntp)# end
```

Step 2 Verify the configured NTP profile details.

Example:

```
Router# show running-config ntp
ntp
 access-group ipv4 peer peer-acl
```

```
 broadcastdelay 2
!
```

Only the devices, subnets, or hosts specified in the access lists are allowed the configured NTP access type. All other access types are denied unless explicitly permitted by an access group.

Configure NTP authentication

Ensure your device authenticates and synchronizes time only with trusted peers using encrypted NTP authentication.

Use encrypted NTP authentication to ensure your device accepts time synchronization only from designated, trusted peers. This method leverages authentication keys and a message authentication code (MAC) to provide access control and data integrity, instead of relying on IP address-based restrictions.

Before you begin

- Confirm you have access to the device CLI.
- Gather the required MD5 authentication keys.

Procedure

Step 1 Define the authentication keys.

Example:

```
Router# configure
Router(config)# ntp
Router(config-ntp)# authenticate
Router(config-ntp)# authentication-key 3 md5 clear key1
```

Each key has a key number, a type, a value, and, optionally, a name. Currently the only key type supported is md5.

Step 2 Define trusted authentication keys.

Example:

```
Router(config-ntp)# trusted-key 3
Router(config-ntp)# commit
```

If a key is trusted, this router only synchronizes to a system that uses this key in its NTP packets.

Step 3 Verify the configured NTP profile details.

Example:

```
Router# show running-config ntp
ntp
 authentication-key 3 md5 encrypted 020D01425A
 authenticate
 trusted-key 3
 !
```

The device synchronizes time only with designated, trusted peers by validating NTP packets using authentication keys and an embedded MAC.

Configure the source IP address for NTP packets

Set a specific interface's IP address as the source for all NTP packets sent by the router, instead of the default interface-based source IP.

By default, a router uses the outgoing interface IP address as the source IP in NTP packets. In networks with multiple interfaces, you may need to control which interface's IP address is used as the NTP source for security, routing, or reachability purposes.

Before you begin

- Identify the interface you want to use as the NTP source.
- Confirm that NTP is enabled on your router.

Procedure

Step 1 Configure an interface from which the IP source address.

Example:

```
Router# configure
Router(config)# ntp
Router(config-ntp)# source HundredGigE 0/0/0/1
Router(config-ntp)# end
```



Note This interface will be used as the source IP address for all NTP packets. If you need to set a source address for a specific association, use the source keyword with the peer or server command instead. For more details, see Configuring Poll-Based Associations.

Step 2 Verify the configured NTP profile details.

Example:

```
Router# show running-config ntp
ntp
 authentication-key 3 md5 encrypted 020D01425A
 authenticate
 trusted-key 3
 source HundredGigE0/0/0/1
!
```

Configure the system as an authoritative NTP server

Enable your router to function as an authoritative NTP server within your network, providing time synchronization to other devices even if the system is not synchronized to an external time source.

Use this task when no reliable external NTP source is available, or when you want your router to act as the main time reference for other network devices. Setting the router as an authoritative NTP server helps maintain time consistency across the network.

Before you begin

- Understand that configuring multiple authoritative NTP servers with low stratum numbers on the same network may cause time inconsistencies.

Procedure

Step 1 Make the router an authoritative NTP server.

Example:

```
Router# configure
Router(config)# ntp
Router(config-ntp)# master 9
Router(config-ntp)# end
```



Note Use the **master** command with caution. It's easy to override valid time sources using this command, especially if a low stratum number is configured. Configuring multiple machines in the same network with the **master** command can cause instability in time keeping if the machines don't agree on the time.

Step 2 Verify the configured NTP profile details.

Example:

```
Router# show running-config ntp
ntp
 master 9
```

Update the hardware clock

Ensure the hardware clock (system calendar) on your device synchronizes periodically with the more accurate software clock, especially when using NTP.

Devices with hardware clocks may experience slight time drift over periods. Synchronizing the hardware clock to the NTP-synchronized software clock maintains time accuracy, which is important for logging, authentication, and other timed operations.

Before you begin

- Confirm that Network Time Protocol (NTP) is correctly configured on your device.
- Verify that your device supports a hardware clock and the update-calendar feature.

Procedure

Step 1 Configure the router to update its system calendar from the software clock at periodic intervals.

Example:

```
Router# configure
Router(config)# ntp
Router(config-ntp)# update-calendar
Router(config-ntp)# end
```

Step 2 Verify the configured NTP profile details.

Example:

```
Router# show running-config ntp
ntp
 update-calendar
```

Verify the status of external reference clock

Ensure NTP is synchronized and external reference clocks are operating properly.

Procedure

Step 1 Display the status of NTP associations.

Example:

```
Router# show ntp associations
address         ref clock     st  when  poll reach  delay  offset    disp
 ~172.19.69.1      .AUTH.           16     -  1024    0    0.00   0.000   15937
 ~192.168.22.33    .AUTH.           16     -  1024    0    0.00   0.000   15937
*~127.127.1.1      .LOCL.            9    51    64   37    0.00   0.000  438.28
 * sys_peer, # selected, + candidate, - outlayer, x falseticker, ~ configured
```

Step 2 Display the status of NTP.

Example:

```
Router# show ntp status
Clock is synchronized, stratum 10, reference is 127.127.1.1
nominal freq is 1000000000.0000 Hz, actual freq is 1000000000.0000 Hz, precision is 2**24
reference time is E8CE945C.8E2A8B07 (15:01:48.555 UTC Mon Oct  9)
clock offset is 0.000 msec, root delay is 0.000 msec
root dispersion is 63.52 msec, peer dispersion is 63.40 msec
loopfilter state is 'FREQ' (Drift being measured), drift is 0.0000000000 s/s
system poll interval is 64, last update was 9 sec ago
```

```
authenticate is enabled, panic handling is disabled,
hostname resolution retry interval is 1440 minutes.
```

Disable NTP services on a specific interface

Prevent NTP packets from being received on a designated network interface.

By default, NTP services are disabled on all interfaces. However, when any NTP command is configured, NTP becomes active globally. You may need to selectively disable NTP on specific interfaces to enhance security or control synchronization sources.

Procedure

Step 1 Disable NTP services on the specified interface using one of these commands:

- interface

```
Router# configure
Router(config)# ntp
Router(config-ntp)# interface HundredGigE 0/0/0/1 disable
Router(config-ntp)# end
```

- no interface

```
Router# configure
Router(config)# ntp
Router(config-ntp)# no interface HundredGigE 0/0/0/1
Router(config-ntp)# end
```

Step 2 Verify the configured NTP profile details.

Example:

```
Router# show running-config ntp
ntp
 interface HundredGigE0/0/0/1
  disable
 !
```

FQDN for NTP server

A fully qualified domain name (FQDN) is a network identifier that

- uniquely specifies the complete path to a system within the Domain Name System (DNS) hierarchy,
- enables devices and applications to resolve hostnames dynamically to IPv4 or IPv6 addresses using DNS, and
- allows network services, such as NTP, to refer to servers without embedding static IP addresses, which simplifies service migration and management.

Starting Cisco IOS XR Software Release 7.9.1 you can configure FQDN in nondefault VRF also.

Table 24: Feature History Table

Feature Name	Release Information	Feature Description
FQDN for NTP Server on Nondefault VRF	Release 7.9.1	You can now specify a Fully Qualified Domain Name (FQDN) as the hostname for NTP server configuration over nondefault VRFs. FQDNs are easy to remember compared to numeric IP addresses. Service migration from one host to another can cause a change in IP address leading to outages. Prior releases allowed FQDN handling in only default VRFs.

Configure FQDN on NTP server on default VRF

Configure an NTP server on your router using a fully qualified domain name (FQDN) within the default VRF to synchronize system time.

Use this procedure when you want your router to synchronize time with an external NTP server identified by its FQDN, and you do not need to specify a custom VRF. This supports environments where only the default VRF is in use and DNS resolution is available.

Before you begin

- Ensure DNS resolution is configured and operational on the router.
- Confirm network connectivity to the intended NTP server.

Procedure

Step 1 Specify the NTP server using the FQDN

Example:

```
Router# configure
Router(config)# ntp server time.cisco.com
Router(config)# commit
```

You do not need to enter a VRF name; the default VRF is used automatically.

Step 2 Verify the NTP configuration.

Example:

```
Router# show running-config ntp
ntp
 server 192.0.2.1
!
```

Step 3 Verify the NTP association status.

Example:

```
Router# show ntp associations

      address       ref clock     st  when  poll reach  delay  offset    disp
 ~192.0.2.1       173.38.201.67    2    42   128    3  196.06  -14.25  3949.4
 * sys_peer, # selected, + candidate, - outlayer, x falseticker, ~ configured
```

Your router is now configured to use the specified NTP server via its FQDN in the default VRF, and NTP associations are established as verified in the output.

Configure FQDN on NTP server on nondefault VRF

Enable NTP synchronization using an FQDN in a nondefault VRF context.

Use this task when your NTP server is identified by FQDN and resides in a nondefault VRF, requiring DNS resolution on that VRF.

Before you begin

- Ensure DNS resolution is configured for the target VRF.
- Ensure the NTP server FQDN is reachable from the device.

Procedure

Step 1 Verify reachability of the FQDN using the **ping** command.

Example:

```
Router# ping time.cisco.com vrf vrf_1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.0.2.1 timeout is 2 seconds:
```

Step 2 Configure the FQDN as the NTP server or peer for the specific VRF.

Example:

```
Router# configure
Router(config)# ntp server vrf vrf_1 time.cisco.com minpoll 4 maxpoll 4 iburst
Router(config)# commit
```

Note If the FQDN you're trying to configure isn't reachable, the CLI treats it as invalid input.

Step 3 Verify the NTP configuration.

Example:

```
Router# show running-config ntp
 ntp
  server vrf vrf_1 192.0.2.1 minpoll 4 maxpoll 4 iburst
 !
```

Step 4 Verify that an NTP association is established.

Example:

```
Router# show ntp associations
 address         ref clock     st  when  poll reach  delay  offset    disp
~192.0.2.1 vrf vrf_1
                173.38.201.115  2    14    16   37  179.10  13.492  16.680
* sys_peer, # selected, + candidate, - outlayer, x falseticker, ~ configured
```

NTP-PTP interworking

NTP-PTP interworking is a time synchronization technique that

- enables the Network Time Protocol (NTP) to use Precision Time Protocol (PTP) and other high-precision time sources,
- improves system clock accuracy from milliseconds to nanosecond-level to support applications needing higher precision, and
- allows for robust synchronization, even during network delays, system bootup, switchovers, or hardware failures.

Starting with Cisco IOS XR Software Release 7.11.1, NTP-PTP interworking provides the ability to use PTP and other valid time-of-day sources, such as Data over Cable Service Interface Specification (DOCSIS) Timing Interface (DTI) and Global Positioning System (GPS), as reference clocks for the operating system. PTP delivers nanosecond-level accuracy, whereas NTP is typically accurate to within the millisecond range. By enabling NTP to reference PTP, overall synchronization precision increases, meeting the needs of demanding network and application environments.

NTP-PTP interworking also facilitates communication of status changes between NTP and PTP processes, supporting unambiguous control of the operating system time and backplane time—even in the event of bootup, switchover, or component failure. PTP's resilience against network delays ensures reliable synchronization, making NTP less likely to lose sync under adverse network conditions.

Table 25: Feature History Table

Feature Name	Release Information	Feature Description
NTP-PTP Interworking	Release 25.4.1	Introduced in this release on: Fixed Systems (8010 (ASIC: A100])(select variants only*) *This feature is now supported on: • 8011-32Y8L2H2FH • 8011-12G12X4Y-A/D

Feature Name	Release Information	Feature Description
NTP-PTP Interworking	Release 25.1.1	Introduced in this release on: Fixed Systems (8700 [ASIC: K100], 8010 (ASIC: A100])(select variants only*) *This feature is now supported on: • 8712-MOD-M • 8011-4G24Y4H-I
NTP-PTP Interworking	Release 24.4.1	Introduced in this release on: Fixed Systems (8200 [ASIC: P100], 8700 [ASIC: P100])(select variants only*); Modular Systems (8800 [LC ASIC: P100])(select variants only*) *This feature is now supported on: • 8212-48FH-M • 8711-32FH-M • 88-LC1-12TH24FH-E • 88-LC1-36EH+A8:B12 • 88-LC1-52Y8H-EM
NTP-PTP Interworking	Release 7.11.1	We have improved NTP synchronization and reliability to achieve nanosecond-level accuracy for applications that require high-precision timing. This is achieved by enabling NTP-PTP interworking which allows the use of PTP as the reference clock. As in previous releases, the NTP client continues to support polling NTP protocol-based external time servers to synchronize the local system clock and achieve accuracy within the millisecond range.

Configure NTP-PTP interworking

Enable synchronization between NTP and PTP systems for accurate timekeeping in your network.

NTP-PTP interworking allows devices using NTP to obtain time, directly or indirectly, from a PTP-enabled Grandmaster. This ensures network-wide time accuracy, especially when NTP and PTP domains coexist.

Before you begin

- Ensure that PTP is enabled on the device before configuring NTP-PTP interworking.
- For PTP, verify the Grandmaster (GM) receives its timing reference from a GPS/GNSS clock.
  - If you are configuring on a GM node, ensure the GM is locked to the GPS/GNSS clock.
  - On a Boundary Clock (BC) node, verify the BC is clocked by a GM (that is locked to GPS/GNSS).
  - On a Transparent Clock (TC) node, ensure the GM and BC are properly referenced in the chain; then configure the TC accordingly.
- If the GM doesn't have a GPS/GNSS reference, be aware the default PTP clock will be set to Jan 1, 1970.

Procedure

Step 1 Enable NTP and set the master primary reference clock to PTP.

Example:

```
Router(config)# ntp
   Router(config-ntp)# master primary-reference-clock
   Router(config-ntp)# commit
```

OR configure an NTP server that synchronizes to a nearby PTP interface (option 2)

```
Router(config)# ntp server 198.51.100.1
   Router(config-ntp)# commit
```

Replace `198.51.100.1` with the actual IP address of the PTP-synchronized NTP server or interface in your topology.

Step 2 Verify the NTP status.

Example:

```
Router# show ntp status
```

The output should indicate 'Clock is synchronized' with the correct reference.

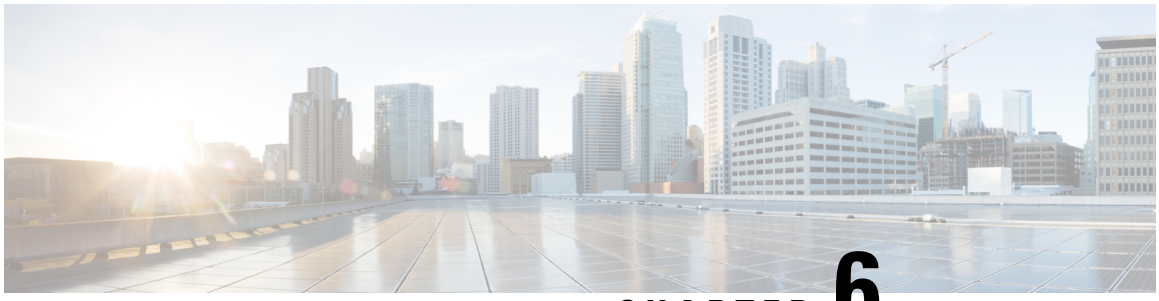
Step 3 Verify NTP associations.

Example:

```
Router# show ntp associations
```

The output should show an association to the configured NTP server with reference type PTP, if PTP is the underlying source.

NTP is now synchronized using a PTP reference, ensuring precise timekeeping across your network. Devices in the NTP domain can accurately obtain the time from a PTP-based Grandmaster or server.



CHAPTER 6

Global Navigation Satellite System (GNSS)

A global navigation satellite system (GNSS) is a satellite-based positioning and timing system that

- provides precise timing signals for synchronization,
- allows receivers to determine their position by decoding signals from multiple satellites, and
- enables direct access to accurate timing in distributed networks.

A GNSS receiver obtains signals from several satellites and determines its distance from each one. This information lets the receiver calculate its position and recover accurate clock timing. Telecommunications networks traditionally synchronize by distributing a stratum-1 clock in a hierarchy. GNSS removes this hierarchy so access networks can take timing directly from satellites using onboard chips.

For accurate operation, make sure all systems use a common time scale. If your system detects timing mismatches, your GNSS receiver may only use one satellite constellation. More satellites provide better coverage and reliability. This approach makes network synchronization planning more flexible and resilient. Cisco IOS XR routers now include support for onboard GNSS receivers to recover accurate timing.

- GNSS Modules and Operations, on page 113
- GNSS Prerequisites, on page 115
- Restrictions for GNSS, on page 115
- PRTC Mode with GNSS, on page 116
- Class Support Matrix, on page 116
- Configure GNSS, on page 117

GNSS Modules and Operations

A GNSS module is a hardware component that

- acquires and tracks satellite signals to determine precise geographic location
- provides accurate timing signals (including 1-PPS and 10 MHz frequency outputs) to synchronize network devices, and
- supports multiple operating modes (self-survey and over-determined clock) to ensure stable time and position reference for routers.

You can find the GNSS module on the front panel of the Route Processor (RP) module and order it separately. You do not need a license to enable the GNSS module.

When connected to an external antenna, the module can acquire satellite signals, track up to 32 GNSS satellites, and compute location, speed, heading, and time. GNSS provides an accurate one pulse-per-second (PPS), a stable 10 MHz frequency output for synchronizing wireless, aggregation, and pre-aggregation routers, and an accurate time-of-day (ToD).

By default, anti-jamming is enabled on the GNSS module.

A router with a GNSS module can maintain highly accurate network timing for broadband services even after a power cycle, resuming normal operation in over-determined clock mode using stored positional data.

Modes of GNSS module operation

Summary

A GNSS module operates in one of these modes. Both modes acquire and provide timing signals to Cisco 8000 routers.

Workflow

1. **Self-survey mode** - When the router is reset, the GNSS module comes up in self-survey mode.It tries to lock on to a minimum of four satellites. It computes approximately 2,000 different satellite positions to obtain a three-dimensional location (latitude, longitude, and height) of its current position. This operation takes about 35 to 40 minutes. During this stage, the module generates accurate timing signals and achieves a normal or phase-locked state.
2. **Over-determined clock mode** - The router switches to over-determined (OD) mode when self-survey mode is complete and the position information is stored in non-volatile memory. In this mode, the module only processes the timing information based on satellite positions captured in self-survey mode.

Best practice: Do not configure multiple time sources

Do not configure both the front panel (10M, 1PPS, and ToD) input configuration and the GNSS input configuration. Configuring multiple time sources can lead to synchronization issues.

Conditions for GNSS mode transitions

The Global Navigation Satellite System (GNSS) module operates in over-determined (OD) mode until you trigger one of these conditions:

- If you relocate the antenna by more than 100 meters, the system automatically restarts the self-survey mode.
- If you restart the self-survey mode manually.
- If you delete the stored reference position.
- If you consider a worst-case recovery scenario after a jamming-detection condition that you cannot resolve with other methods.

The router stores the tracking data. The tracking data remains available even after the router restarts. If you want to change the tracking data, use the **no shutdown** command to set the GNSS interface to its default value.

GNSS module default states and reboot behavior

The GNSS module operates in these ways:

- Configure the module to track any satellite constellation automatically or use a specific constellation. The module uses the configured satellites only in OD mode.



Note You cannot enable GLONASS and BeiDou satellites together.

- After you reload the router, the GNSS module switches to OD mode unless one of these conditions applies:
  - You reload the router during a self-survey operation.
  - If you move the router by more than 100 meters from its previous position.
- If you restart the self-survey using the default **gnss slot R0/R1** command in configuration mode, the 10 MHz, 1 PPS, and ToD signals stay up and do not change.



Note You can access the R1 slot only on modules that support dual RP.

GNSS Prerequisites

To ensure proper GNSS operation:

- Configure 1PPS, 10 MHz, and ToD to enable network synchronization and precision time protocol.
- Make sure your antenna has a clear view of the sky.
- Lock at least 4 satellites for accurate timing.

Restrictions for GNSS

- You must configure the GNSS module using commands; SNMP does not support GNSS module configuration.
- After the GNSS module has maintained lock for 12 hours, its holdover performance remains within 1 microsecond over a 2-hour holdover period.
- The GNSS FPD displays the current version and automatically executes necessary firmware upgrades during the boot sequence.

- Manual runtime upgrades or downgrades for GNSS FPD are not supported.

PRTC Mode with GNSS

A Primary Reference Time Clock (PRTC) mode with GNSS is a timing synchronization method for Cisco 8000 routers that

- requires GNSS lock and the absence of telecom profiles,
- provides ToD + 1PPS outputs in UBX format, and
- forces all boundary clocks into GMC-BC mode based on GNSS input.
- When you enable PRTC mode, the router disables ordinary and transparent clocks in LAN profiles. Boundary clocks operate in GMC-BC mode and retrieve timestamps from the GNSS input.
- Clock quality values provided by the GMS-BC master clock include:

```
Clock Quality:
    Class: 6                        //----GNSS CLASS
    Accuracy: Within 250ns          //----GNSS Accuracy
    Offset (log variance): 20061    //----GNSS Variance
```

- PRTC mode is supported on PTP Default and Power profiles, and conversion occurs automatically when GNSS moves to locked state.

Note GNSS cannot be configured if any of the following are present:

- 802.1AS
- PTP TC mode
- GMC-BC options

Class Support Matrix

Use this table to check which GNSS class is supported on Cisco 8000 series routers and line cards.

Table 26: GNSS Class Support Matrix

Hardware Module	Supported GNSS Class	Cisco IOS XR Release
8711-28H8F-M	PRTC-B	Release 26.3.1
8711-48Z-M	PRTC-B	Release 25.4.1
8011-12G12X4Y-A/D	PRTC-B	Release 25.4.1
8011-32Y8L2H2FH	PRTC-B	Release 25.4.1

Hardware Module	Supported GNSS Class	Cisco IOS XR Release
8011-4G24Y4H-I	PRTC-B	Release 25.1.1
8712-MOD-M	PRTC-B	Release 24.4.1
8711-32FH-M	PRTC-B	Release 24.3.1

Configure GNSS

Enable Global Navigation Satellite System (GNSS) reception and synchronization features to provide accurate timing and location information on your router.

Use this task to configure GNSS on supported router models so the device can synchronize its system clock with secure satellite sources. GNSS enables applications to use precise time and geographic data..

Before you begin

- Ensure the router model supports GNSS.
- Make sure you have administrative (privileged EXEC) access to the router.
- Find the correct slot and location to install the GNSS receiver module.

Follow these steps to configure GNSS on your router:

Procedure

Step 1 Enable the GNSS receiver and enter GNSS configuration submode:

At the router prompt, run:

```
Router(config)# gnss-receiver 0 location 0/0/CPU0
```

Step 2 Enable frequency synchronization for the receiver:

In GNSS configuration submode, run:

```
Router(config-gnss)# frequency synchronization
```

Step 3 Select the input source for frequency synchronization:

In frequency synchronization submode, run:

```
Router(config-gnss-freqsync)# selection input
```

Step 4 (Optional) Customize GNSS receiver settings as needed:

Example:

```
gnss-receiver 0 location 0/RP0/CPU0
frequency synchronization
  selection input
  priority 1
  wait-to-restore 0
  quality receive exact itu-t option 1 PRC
```

```
 !
!

Router(config)# gnss-receiver 0 location 0/0/CPU0
```

- Disable anti-jam protection.

  ```
  Router(config-gnss)# anti-jam disable
  ```

- Specify a constellation such as GPS.

  ```
  Router(config-gnss)# constellation GPS
  ```

- Adjust the signal-to-noise threshold.

  ```
  Router(config-gnss)# snr threshold 10
  ```

- Set the receiver priority and wait-to-restore values.

  ```
  Router(config-gnss-freqsync)# priority 5
  Router(config-gnss-freqsync)# wait-to-restore 0
  ```

Step 5 Verify GNSS receiver status and operation:

Example:

```
Router# show gnss-receiver
GNSS-receiver 0 location 0/RP0/CPU0
    Status: Available, Up
    Position: 741:12.12 N 4451:39.60 E 0.827km
    Time: 2019:01:17 14:43:08 (UTC offset: 18s)
    Firmware version: 1.4
    Lock Status: Phase Locked, Receiver Mode: 3D-fix
    Survey Progress: 100, Holdover Duration: 0
    Major Alarm: Not used
    Minor Alarm: Not used
    Anti-jam: Enabled, Cable-delay compensation: 0
    1PPS polarity: Positive
    PDOP: 6.000, HDOP: 0.000, VDOP: 0.000, TDOP: 1.000
    Constellation: GPS, Satellite Count: 10
```

Example:

```
Router# show gnss-receiver
Fri Jan 17 07:27:34.804 UTC
GNSS-receiver 0 location 0/RP0/CPU0
    Status: Available, Up
    Position: 12:56.18 N 77:41.77 E 0.823km
    Time: 2020:01:17 07:31:41 (UTC offset: 0s)
    Locked at: 2020:01:15 17:15:28
    Firmware version: TIM 1.10
    Lock Status: Phase Locked, Receiver Mode: Time fix only
    Survey Progress: 100, Holdover Duration: Unknown
    Major Alarms: Unknown
    Minor Alarms: Unknown
    Anti-jam: Enabled, Cable-delay compensation: 0
    1PPS polarity: Positive
    PDOP: 99.990, HDOP: 99.990, VDOP: 99.990, TDOP: 0.240
    Constellation: GPS, Satellite Count: 17
    Satellite Thresholds:
        SNR - 0 dB-Hz, Elevation - 0 degrees, PDOP - 0, TRAIM - 0 us
    Satellite Info:
        CHN: Channel, AQUN: Aquisition, EPH: Ephemeris
        PRN   CHN   AQUN   EPH    SV           Signal
        No.   No.   Flag   Flag   Type         Strength   Elevat'n   Azimuth
        ---   ---   ----   ----   -----------  --------   --------   --------
```

```
  1   n/a   On     On     GPS             44.000     19.000    220.000
  3   n/a   On     On     GPS             48.000     62.000    299.000
  4   n/a   On     On     GPS             46.000     30.000    338.000
  7   n/a   On     On     GPS             47.000      9.000    261.000
  8   n/a   On     On     GPS             41.000     17.000    172.000
  9   n/a   On     On     GPS             44.000      7.000    317.000
 11   n/a   On     On     GPS             42.000     10.000    202.000
 14   n/a   On     On     GPS             42.000     22.000     90.000
 16   n/a   On     On     GPS             46.000     66.000     59.000
 22   n/a   On     On     GPS             47.000     71.000    238.000
 23   n/a   On     On     GPS             46.000     27.000    332.000
 26   n/a   On     On     GPS             48.000     40.000     40.000
```

- Use the following command to display GNSS status and receiver details:

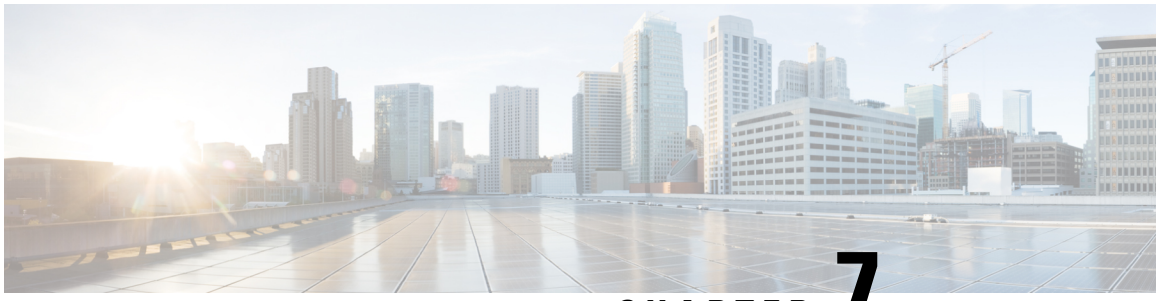
```
Router# show gnss-receiver
```

- Review information, including receiver status, position, time, firmware version, lock status, satellite count, and constellation type.

You have configured and activated the GNSS receiver. The router synchronizes its system clock and location information using the selected satellite constellation. You can verify correct operation using the **show gnss-receiver** command.

What to do next

- Monitor GNSS receiver status regularly for alarms or synchronization issues.
- Use the **show gnss-receiver** command as needed to confirm continued service availability.



CHAPTER 7

Network Synchronization Designs

A network synchronization design is a network design principle that

- ensures all devices in a network operate based on a common time reference,
- enables synchronized application behavior and accurate event correlation, and
- supports network reliability by minimizing timing discrepancies among devices.

Maintaining network synchronization is important for applications such as voice, video, and financial transactions that rely on precise timing. When designing synchronization, you must consider the network requirements, the timing budget, application needs, and the required level of synchronization accuracy.

Timing features implement timing concepts such as Packet Delay Variation (PDV), time error, and network asymmetry. These timing concepts directly affect the accuracy of synchronization technologies like PTP, SyncE, and NTP.

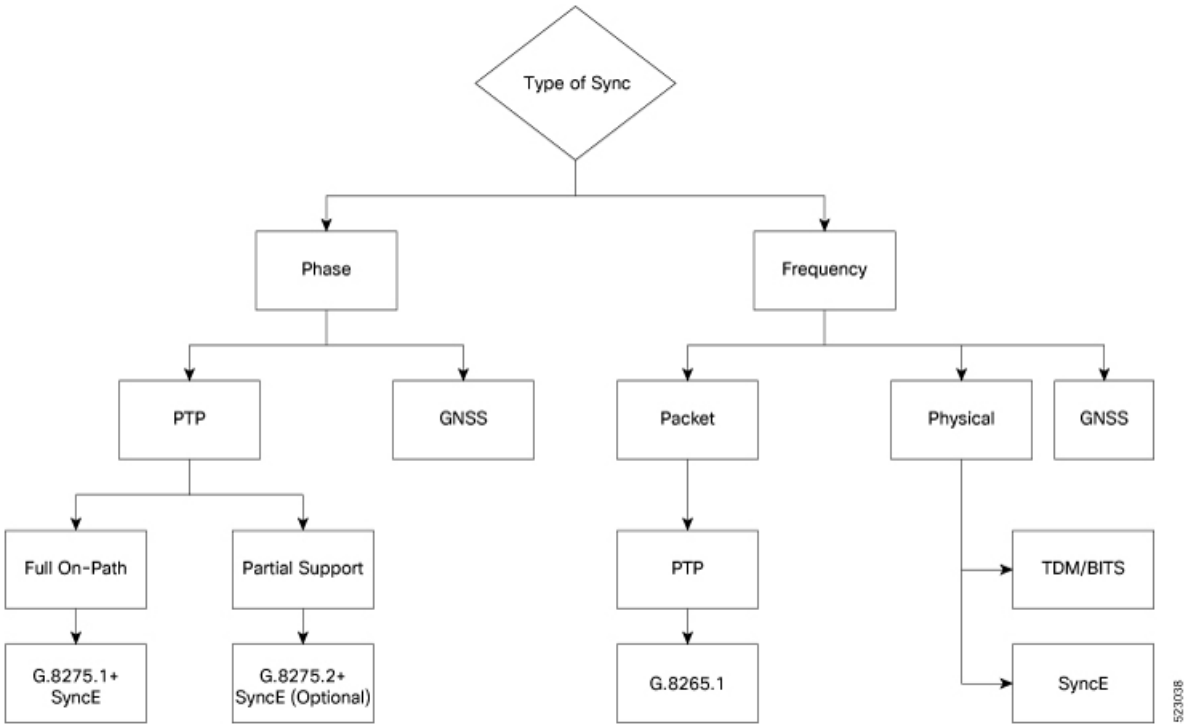
- Network Synchronization Decision Tree, on page 121
- Best practices for successful synchronization deployments, on page 122
- Guidelines for Phase Synchronization Deployments, on page 124
- PTP over IP Network Design, on page 125
- Selecting the Correct Profile For Network Synchronization, on page 125
- Reducing Asymmetry, on page 126

Network Synchronization Decision Tree

A network synchronization decision tree is a decision-making tool that

- guides users through a series of yes/no or conditional questions,
- helps identify the most suitable synchronization solution for a specific network deployment, and
- streamlines the evaluation process to ensure accurate and synchronized network operation.

Figure 5: Network Synchronization Decision Tree



Network Synchronization is a timing technology domain that uses multiple synchronization technologies—such as Precision Time Protocol (PTP), Synchronous Ethernet (SyncE), Network Time Protocol (NTP), and Global Navigation Satellite System (GNSS)—to provide a common time reference, synchronized application behavior, and accurate event correlation.

Best practices for successful synchronization deployments

To deploy successful network synchronization in your network, consider these guidelines.

- Use a standards-based solution for your network. Select the correct synchronization profile.
- Configure the clock source for your network. You can use one of these sources:
  - A Global Navigation Satellite System (GNSS) based source such as a GPS clock.
  - Use a Precision Time Protocol (PTP) grandmaster clock.
  - Frequency synchronization in networks uses Building Integrated Timing Supply (BITS) or synchronous Ethernet. Phase synchronization uses PTP or GNSS.
  - Use a combination of GNSS, which is delivered over the air, PTP, or synchronous Ethernet over transport. For more information, see SyncE and PTP .
- Set up the required synchronization protocols, such as PTP, Network Time Protocol (NTP), or synchronous Ethernet:
  - NTP uses the system clock for logging or to display clock output. PTP and GNSS work on the IEEE 1588 hardware clock.

- The NTP clock of a node cannot be used to synchronize the downstream network using PTP. However, a node can synchronize its NTP clock with an available PTP or GNSS clock.

Note Most NTP implementations are software-based. Software-based synchronization is less accurate than hardware-based solutions. However, it may provide sufficient accuracy for applications that can tolerate differences of 10 or 100 milliseconds.

- Use PTP for phase synchronization in the absence of GNSS.
- Synchronous Ethernet (SyncE) is a recommendation from ITU-T for delivering frequency in a network. If you require only frequency synchronization, use SyncE instead of PTP.

- Configure suitable synchronization profiles and preferences for your network. Evaluate parameters such as accuracy and priority to determine how synchronization events are managed.
- Design your network for phase synchronization so that it meets optimal time error budgets:
  - Use boundary clocks to reduce time error and reset packet delay variation (PDV).
  - Implement PTP awareness consistently, including in transport systems, and ensure boundary clocks accurately transmit time to minimize accumulated time error.
- For phase synchronization, use a hybrid clock incorporating both SyncE and PTP. For more information, see *PTP Hybrid Mode*.
- Reduce the number of network hops for time distribution:
  - Distribute time sources to meet accuracy budgets. If there are too many hops, install a GNSS receiver further out into the network.
  - Avoid centralizing two Primary Reference Time Clocks (PRTCs) and Telecom Grandmasters (T-GM) in different locations and attempting to run a synchronization signal accurately across the whole network.
- Minimize packet delay variation (PDV) and jitter. Ensure that technologies such as microwave, GPON, DSL, and DWDM are compatible with PTP.
- Monitor your synchronization deployment to ensure correct function and required accuracy. For more information, see *Verifying the Frequency Synchronization Configuration*.
- Be aware of relevant industry standards and practices when deploying synchronization.
- To reduce asymmetry in a PTP-unaware network, consider:
  - Implementing QoS to manage packet delays,
  - Using Telecom Boundary Clocks (T-BC) to handle node asymmetry.
- To avoid synchronization issues when you connect to other mobile networks:
  - Align all mobile networks to a common source of time. For example, align mobile networks to the Coordinated Universal Time (UTC) from a Global Navigation Satellite System (GNSS) such as Global Positioning System (GPS).

    - Monitor your clocks at the interconnect points.

- To correct transport asymmetry:
    - Ensure that your transport layer is Precision Time Protocol (PTP)-aware.

      If you use optical devices, apply wavelength division multiplexing (WDM) technologies, such as Optical Service Channel (OSC), to manage your fiber optic infrastructure effectively.

- To reduce Packet Delay Variation (PDV) and improve PTP clock recovery:
    - Install Telecom Boundary Clocks in nodes that do not support PTP to provide a time reference and enable synchronization.
    - Use a high-quality network connection between the Telecom Boundary Clock and the node that does not support the PTP. This minimizes PDV caused by network impairments.

Guidelines for Phase Synchronization Deployments

- Set up your network infrastructure to support phase synchronization. Install timing devices such as GPS receivers, synchronous-Ethernet interfaces, and timing servers.
- Configure phase-synchronization protocols as needed. Set up Precision Time Protocol (PTP) to enable accurate timing distribution in your network.
- Use the G.8275.1 telecommunication profile standard with complete on-path support, including Layer 2 multicast in combination with Synchronous Ethernet (SyncE) for best results.
- To minimize phase time error:
    - Remove asymmetric routing issues.
    - Reduce the number of hops unless telecommunication grandmaster (T-GM) clocks are deployed in the pre-aggregation network.
    - Decrease packet delay variation (PDV) or jitter.

- If you use IP protocols for PTP, consider potential challenges such as rerouting, asymmetric routing, Equal Cost Multi-Path (ECMP), and bundles.
- For tight timing budgets over many hops, make sure your hardware supports the highest level of clock accuracy.
- For GNSS deployments:
    - Meet all requirements for cable installations and antenna installations.
    - Contact a professional if you are not experienced with GNSS installation and calibration.

- Confirm that your deployment works as intended and monitor it regularly to identify potential issues.
- Contact Cisco technical support if you experience issues or have questions.

Note When PTP is used with MACsec, achieving high accuracy can be challenging. PTP requires exact timestamping to maintain tight network synchronization. MACsec affixes and detaches a header that is between 24 to 32 bytes in size. This process can lead to significant inconsistencies in the time delays between where the link is connected and where the egress timestamps are applied.

PTP over IP Network Design

In Precision Time Protocol networks, Packet Delay Variation (PDV) introduces time error, which directly degrades phase synchronization accuracy. To minimize Packet Delay Variation (PDV) and maintain precise frequency synchronization when using Precision Time Protocol over Internet Protocol (PTPoIP), follow these best practices:

- Place telecom grandmaster (T-GM) clocks in a centralized location if the network has a small number of hops. For larger networks with multiple hops, distribute T-GM clocks throughout the network. This ensures proper timing management at each hop.
- Use a dedicated frequency synchronization protocol such as Synchronous Ethernet or 1588v2 to maintain precise frequency synchronization between devices.
- Use the G.8265.1 standard to ensure multiple devices on the network operate at the same frequency for accurate and reliable communication.
- Configure Quality of Service (QoS) policies to prioritize network traffic and reduce delays. Use traffic shaping, traffic policing, and queue management as needed.

Selecting the Correct Profile For Network Synchronization

A network synchronization profile is a timing protocol profile that

- defines how time signals are distributed over a network,
- specifies the transport method, such as Ethernet or IP, and
- determines feature adaptability for precise synchronization.

There are two primary synchronization profiles that utilize the Precision Time Protocol (PTP), which is standardized for Ethernet and IP networks.

- G.8275.1 PTPoE: Used for multicast timing over layer 2 Ethernet networks.
- G.8275.2 PTPoIP: Used for packet-based timing over IP networks.

Table 27: Feature adaptability for G.8275.1 PTPoE and G.8275.2 PTPoIP profiles

Feature	G.8275.1 PTPoE	G.8275.2 PTPoIP
Network Model	Full on-path support	Partial on-path support

Feature	G.8275.1 PTPoE	G.8275.2 PTPoIP
IP Routing	Not applicable	IP routing can cause issues in rings and may introduce asymmetry.
Transit Traffic	Not allowed	Transit traffic can result in jitter and asymmetry.
Performance	Optimal	Variable
Configuration Model	Physical port	L3 device
PTP over Bundles	No issues	Development in progress for Telecom Boundary Clocks (T-BC)
Asymmetry	Reduced due to T-BC on every node	Optimal when deployed as a Partial Support Telecom Boundary Clock (T-BC-P)
PDV/Jitter	Reduced due to T-BC on every node	Optimal when deployed as a T-BC-P

Reducing Asymmetry

A network asymmetry is a timing concept that

- increases Packet Delay Variation
- results in unequal forward and reverse delay, and
- leads to accumulated time error in PTP-based synchronization.

Network asymmetries in PTP-unaware networks can arise due to:

- routing in large or complex topologies such as rings or networks with Equal-cost multi-path (ECMP),
- use of transit nodes that do not recognize PTP and varying traffic patterns,
- or transport technologies like Passive Optical Network (PON), cable, or DWDM.

Note Every two seconds of asymmetry results in approximately one microsecond of time error.

To reduce asymmetry in a PTP-unaware network, consider:

- Implementing QoS to manage packet delays,
- Using Telecom Boundary Clocks (T-BC) to handle node asymmetry.