

Timing and Synchronization Configuration Guide, Cisco IOS XE (Cisco Catalyst IR8340 Rugged Series Router)

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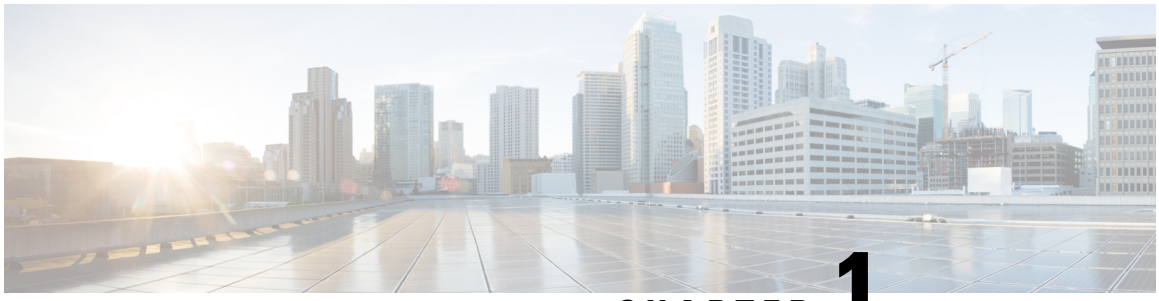
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CHAPTER 1

Synchronization

The terms *IR8340* and *router* are used throughout this document in text and CLI examples to refer to the Cisco Catalyst IR8340 Rugged Series Router, unless otherwise noted.

Synchronization is the process of coordinating or aligning two or more events, signals, systems, or processes to work together in time, frequency, or phase. It ensures consistency, precision, and smooth interaction.

- Synchronization, on page 1
- Inter-Range Instrumentation Group codes evolution and applications, on page 3

Synchronization

Frequency and time distribution are key capabilities of the Cisco Catalyst IR8340 Rugged Series Routers. These routers support:

- WAN ports (Gigabit Ethernet ports (0/0/0 and 0/0/1)) distribute both frequency and phase information,
- LAN ports (Gigabit Ethernet 0/1/0 to Gigabit Ethernet 0/1/11) distribute phase information,
- GPS source synchronization, and
- phase distribution through an external Inter-Range Instrumentation Group - Time Code Format B (IRIG-B) interface and an external The time of Day (ToD) RS485 interface.

Frequency synchronization

Router can recover the reference clock frequency from GNSS, SyncE, PTP Telecom Profile (G.8265.1/G.8275.1), or local oscillator input sources:

When a reference clock is selected, it is propagated to downstream network elements via SyncE or Precision Time Protocol (PTP) telecom profile (G.8265.1 or G.8275.1).

Time or phase synchronization

Accurate Time of Day (TOD) synchronization between network devices is critical for ensuring precise calculation of network delays.

The time or phase synchronization can be achieved using GNSS, PTP, IRIG-B, or handset input sources:

Time module and license

Starting from Cisco IOS-XE Release 17.9.1, the Cisco Catalyst IR8340 Rugged Series Routers support a pluggable time module (Cisco PID: IRM-TIMING-MOD), which includes:

- ToD and one pulse-per-second (1 PPS) output provide or receive ToD messages or one PPS messages,
- IRIG-B interfaces (analog and digital input and output), and
- Global Navigation Satellite System (GNSS) receiver

Note The Network-Advantage license is required on the Cisco Catalyst IR8340 Rugged Series Routers to enable all timing features, including GNSS, IRIG-B, and PTP profiles such as G.8265.1, G.8275.1, 1588v2, Power, and 802.1AS profiles. Use the **license boot level network-advantage** command to activate the Network-Advantage license.

Time module status

You can monitor the status of the time module.

Procedure

Use the **show inventory** command to display the status of the time module.

Example:

```
Router# show inventory
                    ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
                    INFO: Please use "show license UDI" to get serial number for licensing.
                    ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
                    NAME: "Chassis", DESCR: "Cisco IR8340-K9 Chassis Type"
                    PID: IR8340-K9         , VID: V00  , SN: FDO2523J1BL
                    NAME: "Power Supply Module 0", DESCR: "150W AC Power Supply Module for Cisco
IR8340-K9"
                    PID: PWR-RGD-AC-DC-H   , VID: V01  , SN: DTH251705BY
                    NAME: "module 0", DESCR: "Cisco IR8340 Built-In NIM controller"
                    PID: IR8340-K9         , VID: V00  , SN: FDO252207UG

                        NAME: "Timing", DESCR: "Timing Module"
                            PID: IRM-TIMING-MOD    , VID: V00  , SN: FDO253409KG

                    NAME: "NIM subslot 0/0", DESCR: "Front Panel 2 ports Gigabitethernet Module"
                    PID: IR8340K9-2x1GC    , VID: V01  , SN:
```

Inter-Range Instrumentation Group codes evolution and applications

Inter-Range Instrumentation Group (IRIG) is a standardized format for precise time synchronization. It provides:

- Accurate time data, including date, hours, minutes, and seconds.
- A one Pulse Per Second (1 PPS) signal for stable timing and frequency reference.
- Enhancement of frequency accuracy through phase-locking and stable oscillators.
- Availability in both analog (modulated) and digital (binary) formats.
- Applications in telecommunications, power grids, GPS, and industrial automation.
- Accurate global time distribution when combined with GNSS.

IRIG-B time protocol for synchronization

The IRIG standard was first published in 1960, with the latest version, IRIG standard 200-04 (IRIG Serial Time Code Formats), updated in September 2004.

IRIG time codes are a result of the U.S. military's initiative in the late 1950s to standardize timing codes. This effort resolved compatibility issues and enabled the seamless exchange of synchronized test data across test ranges.

Six IRIG code variations were developed (A, B, D, E, G, H) of which IRIG time code B (IRIG-B) became widely accepted for time distribution in the power, industrial automation, and control industries.

Industrial applications and functionality of IRIG-B

IRIG-B is widely used in industries such as electric utilities to synchronize system devices like power breakers, relays, and meters. It transmits a 100-bit time frame each second, containing time-of-year and year information in a BCD format, with an optional field for seconds-of-day in SBS. Although IRIG-B is a reliable and predictable framework for distributing timing signals, it traditionally relies on an accurate timing source, such as GPS, for precision.

IRIG-B with GNSS timecode

The IRIG protocol supports format-B (IRIG-B), as defined in the IRIG standard 200-04. In addition to the GNSS interface, it can handle both receive (INPUT) and transmit (OUTPUT) of 4 analog (AM) and 4 digital (TTL) time code formats, as shown in the table.

IRIG-B modes		Format ID	IRIG signal
Analog (AM)	AM02	AM-B122	Amplitude Modulated, 1 kHz, 1 millisecond resolution, BCD_{TOY}
	AM03	AM-B123	Amplitude Modulated, 1 kHz, 1 millisecond resolution, BCD_{TOY}, SBS
	AM06	AM-B126	Amplitude Modulated, 1 kHz, 1 millisecond resolution, BCD_{TOY}, BCD_{YEAR}
	AM07	AM-B127	Amplitude Modulated, 1 kHz, 1 millisecond resolution, BCD_{TOY}, BCD_{YEAR}, SBS

IRIG-B modes		Format ID	IRIG signal
Digital (TTL)	TTL02	TTL-B002	Unmodulated, DCLS, pulse-width-coded, BCD_{TOY}
	TTL03	TTL-B003	Unmodulated, DCLS, pulse-width-coded, BCD_{TOY}, SBS
	TTL06	TTL-B006	Unmodulated, DCLS, pulse-width-coded, BCD_{TOY}, BCD_{YEAR}
	TTL07	TTL-B007	Unmodulated, DCLS, pulse-width-code, BCD_{TOY}, BCD_{YEAR}, SBS

Note

- BCD: Contains day of year, hours, minutes, and seconds.
- BCD_Year: Includes BCD and year 00–99, which does not include the century in its coding.
- SBS: Represents Straight Binary Seconds. Its value ranges from 0 to 86339.

Physical interfaces

The router includes two physical interfaces, analog (AM) and digital (TTL), both capable of handling INPUT and OUTPUT signals. The support for IRIG-B signaling enables the router to function as a central timing device in various scenarios:

- INPUT: The router receives IRIG-B timing signals (AM or TTL) from an external IRIG-B time source when required. In this case, IRIG-B can serve as the clock source for PTP, with the router configured as a Grand Master Clock (GMC) for time distribution.
- OUTPUT: The router uses other precise timing sources, such as GNSS or GPS, PTP, or NTP, as its clock source. It can then transmit IRIG-B timing signals to devices that depend on IRIG-B at the location.

This table illustrates how time sources are mapped to corresponding time distribution protocols, showing how one source can serve as the reference for another.

Time Source	Time Distribution
IRIG-B IN	PTP
GNSS, PTP, and NTP	IRIG-B OUT

Configure IRIG-B

You can configure IRIG mode (AM or TTL) and direction (IN or OUT) on the interface.

Procedure

Step 1 Use the **config terminal** command to enter global configuration mode.

Example:

```
Router# configure terminal
```

Step 2 Use the **irig mode** *mode_type* **dir** *direction* command to configure IRIG mode.

Example:

```
Router(config)# irig mode TTL2 dir IN
```

The possible options to configure IRIG mode are: TTL2, TTL3, TTL6, TTL7, AM2, AM3, AM6, and AM7

- TTL2 = IRIG-B002, TTL3 = IRIG-B003, TTL6 = IRIG-B006, TTL7 = IRIG-B007
- AM2 = IRIG-B122, AM3 = IRIG-B123, AM6 = IRIG-B126, AM7 = IRIG-B127

The possible values for direction are: IN and OUT

Use the **no** form of the command to disable the IRIG feature on the interface.

Note
To switch input from digital to analog or vice versa, you must remove the input configuration on one port before reconfiguring the input on another port.

Step 3 (optional) Use the **show irig** command to display IRIG-B mode and direction configurations on the IR8340.

Example:

This example shows output for the OUT direction.

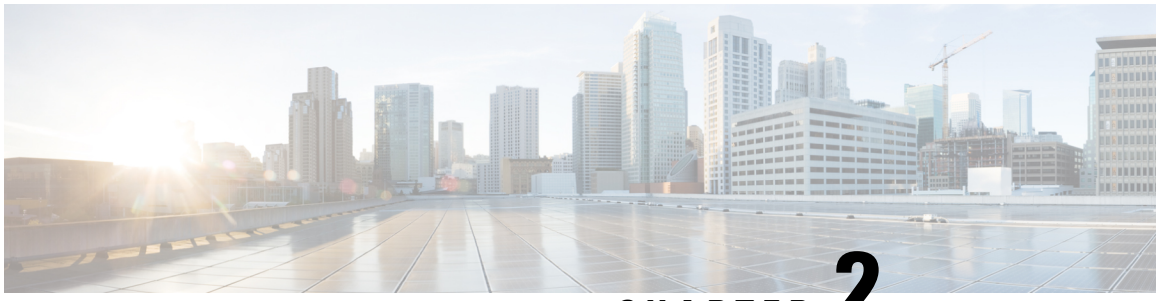
Example:

```
Router# show irig
IRIG-B Digital mode disabled
IRIG-B Analog mode AM02 dir OUT
IRIG-B Clk Id 1 Source PTP  time: Year: 2021 Day: 343 Hour 8 Min 33 Sec 35.
                            ns 1639038815645806587 [0x16BF091E6BA52FFB]
IRIG-B Virtual Clock State: INACTIVE
*** IRIG-B input is disabled ***
```

Example:

This example shows output for the IN direction.

```
Router# show irig
IRIG-B Digital mode disabled
IRIG-B Analog mode AM02 dir IN
IRIG-B Clk Id 5 Source IRIG-B  time: Year: 2021 Day: 343 Hour 8 Min 36 Sec 25.
IRIG-B Virtual Clock State: ACTIVE
*** IRIG-B AM input mode ***
B122: Day 343 Hour 8 Min 36 Sec 24
NOTE: Input time shown is the last received frame time
```



CHAPTER 2

Precision Time Protocol

Precision Time Protocol (PTP) synchronizes time within a network and is defined in IEEE 1588 as Precision Clock Synchronization for Networked Measurement and Control Systems. PTP:

- synchronizes clocks in packet-based networks, accommodating devices with varying precision and stability,
- is widely used in industrial, networked measurement, and control systems, and
- operates efficiently, requiring minimal bandwidth and processing power, making it ideal for distributed systems.

- PTP on Cisco Catalyst IR8340 Rugged Series Routers, on page 7
- Configure GMC Mode, on page 31
- Configure PTP Default profile, on page 32
- Configure PTP Power profile, on page 36
- Generalized Precision Time Protocol, on page 40
- Disable PTP, on page 41
- PTP multi-domain, on page 41
- GMC-BC time source, on page 42
- GNSS as a reference to PTP, on page 44
- PTP profile configuration on WAN and LAN ports, on page 46
- PTP commands, on page 46

PTP on Cisco Catalyst IR8340 Rugged Series Routers

Starting from Cisco IOS XE Release 17.7.x, Cisco Catalyst IR8340 Rugged Series Router supports PTP.

PTP requires a Network Advantage license.

Table 1: Feature History Table

Feature name	Release information	Feature description
Timing Support for 1588-2017 Boundary clock on IR8340	Release 26.1.1	Cisco Catalyst IR8340 Rugged Series Router now supports Power Profile-2017 in Boundary clock.

Note When the IR8340 router has a GNSS lock, it always acts as the PTP primary clock (FREERUN) and will not enter the secondary state.

PTP in Ethenet networks

PTP provides time accuracy and synchronization on packet-based networks, such as Ethernet.

Smart grid power automation applications, such as peak-hour billing, virtual power generators, and outage monitoring, need precise time accuracy and stability. Accurate timing improves network monitoring and troubleshooting.

PTP in Ethernet networks offers:

- low cost and easy setup in existing Ethernet networks, and
- limited bandwidth usage for PTP data packets.

PTP clocks

A PTP network includes both PTP-enabled devices and devices that do not use PTP.

PTP-enabled devices typically consist of these clock types.

Grandmaster clock

The grandmaster clock connects directly to the server time source and serves as the synchronization point for all clocks. In a PTP domain, it acts as the primary time source for synchronization using PTP. The grandmaster clock typically relies on a highly accurate time source, such as a GPS or atomic clock. When the network requires only internal synchronization and no external time reference, the grandmaster clock can operate freely.

Ordinary clock

An ordinary clock is a 1588 clock with a single PTP port that can operate in one of these modes:

- server mode—distributes timing information to one or more client clocks, allowing them to synchronize with the server clock.
- client mode—synchronizes its clock to a server clock. It can connect to two different server clocks simultaneously by enabling client mode on up to two interfaces.

Ordinary clocks are the most common clock type in a PTP network and serve as end nodes connected to devices that require synchronization.

Boundary clock

A boundary clock in a PTP network replaces a standard network switch or router. It has multiple PTP ports, with each port supporting a separate PTP communication path. Boundary clocks act as interfaces between PTP domains, intercepting and processing all PTP messages while passing other network traffic.

The boundary clock uses the BMCA to identify the best clock from any port. The selected port is set to non-master mode, synchronizing with the upstream master clock. Meanwhile, the master port synchronizes all downstream clocks.

Transparent clock

A transparent clock in a PTP network updates the time-interval field in PTP event messages. This update compensates for switch delays with up to one-picosecond accuracy.

There are two types of transparent clocks:

- End-to-end (E2E) transparent clocks: E2E transparent clocks measure the transit time (resident time) of PTP event messages, such as Sync and Delay_Req messages. They add the measured transit time to the correction field of the corresponding messages:
  - For Sync messages, the transit time is added to the correction field of the Sync or Follow_Up message.
  - For Delay_Req messages, the transit time is added to the correction field of the Delay_Resp message.

  This information helps the time recipient to calculate the offset between its time and the time source's time. E2E transparent clocks do not provide the propagation delay of the link itself.
- Peer-to-peer (P2P) transparent clocks: The P2P transparent clocks measure PTP event message transit time in the same way E2E transparent clocks do. In addition, P2P transparent clocks measure the upstream link delay. The upstream link delay is the estimated packet propagation delay between the upstream neighbor P2P transparent clock and the P2P transparent clock under consideration.

  The message transit time and upstream link delay are both added to the correction field of the PTP event message. The correction field received by the time recipient contains the total of all link delays.

  Theoretically, this is the total end-to-end delay of the Sync packet from the source time to the recipient.

PTP clock hierarchy

Summary

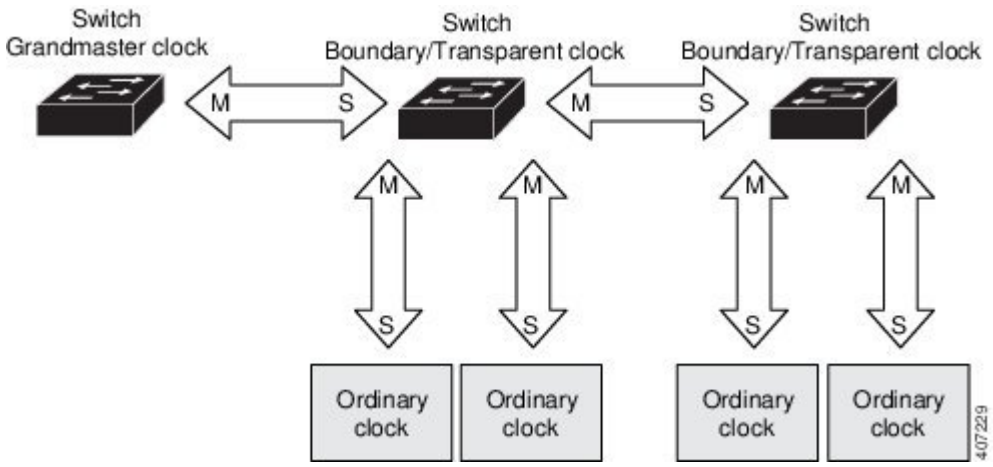
The PTP hierarchy ensures precise time synchronization across a network by establishing a primary-secondary relationship among different clock types.

The key components involved in the process are:

- Grandmaster clock (Switch): The primary and most accurate time source in the hierarchy, acting as the primary clock source for all downstream clocks.
- Boundary or Transparent clock (Switch): A network device that acts as a secondary clock to an upstream primary clock and as a primary clock source to downstream secondary clocks, relaying and potentially correcting time information.
- Ordinary clock: An end-device clock that acts solely as a secondary, synchronizing its time to an upstream primary clock.
- Primary (M) role: The clock sending synchronization messages to a secondary.
- Secondary(S) role: The clock receiving and synchronizing its time based on the messages from a primary.

Workflow

Figure 1: PTP clock hierarchy



The process involves these stages:

- Grandmaster initiation: The Grandmaster clock, positioned at the top of the hierarchy, sends precise time information to the first-level clocks to initiate the time synchronization process.
- First-level synchronization: The first boundary or transparent clock receives time information from the Grandmaster, acting as a secondary to synchronize its own clock with the Grandmaster's time.
- Hierarchical propagation: Each Boundary or transparent clock, having synchronized with its upstream primary clock, acts as a primary clock to its connected downstream Boundary,Transparent, or Ordinary clocks. It propagates the precise time synchronization further down the hierarchy.
- End-device synchronization: Ordinary clocks receive time synchronization messages from their respective primary boundary or transparent clocks and adjust their internal clocks accordingly, operating as secondary.
- Continuous synchronization: This primary-secondary relationship is continuously maintained throughout the PTP hierarchy, ensuring all clocks remain precisely synchronized to the Grandmaster clock.

Result

The PTP clock hierarchy provides highly accurate and distributed time synchronization across a network, which is critical for applications requiring precise timing, such as industrial automation, financial trading, and telecommunications.

Message-based PTP synchronization

PTP synchronizes clocks across network devices. It:

- exchanges messages between the time source (Grandmaster Clock) and the time recipient to synchronize clocks,
- measures the precise transmit and receive times of these messages to calculate the communication path delay, and

- adjusts the current time information in network data based on the calculated delay to achieve highly accurate time synchronization.

Delay measurement in PTP synchronization

The delay measurement calculates the path delay between devices on the network and adjusts local clocks accordingly. It uses a series of messages exchanged between the time source and time recipient devices. The one-way delay is determined by averaging the path delay of the transmit and receive messages. This calculation assumes a symmetrical communication path, but switched networks may not have symmetrical paths due to the buffering process.

Transparent Clocks in PTP synchronization

PTP uses transparent clocks to measure and account for the delay in the time-interval field of network timing packets. This approach makes switches temporarily transparent to the time source and time recipient nodes on the network. An end-to-end transparent clock forwards all messages across the network similar to a switch.



Note Cisco PTP supports multicast PTP messages only.

For more details on synchronization messages, refer to PTP event message sequences, on page 12.

For more details on calculation of network delays, refer to Transparent clock, on page 9.

PTP network

The key components involved in the process are:

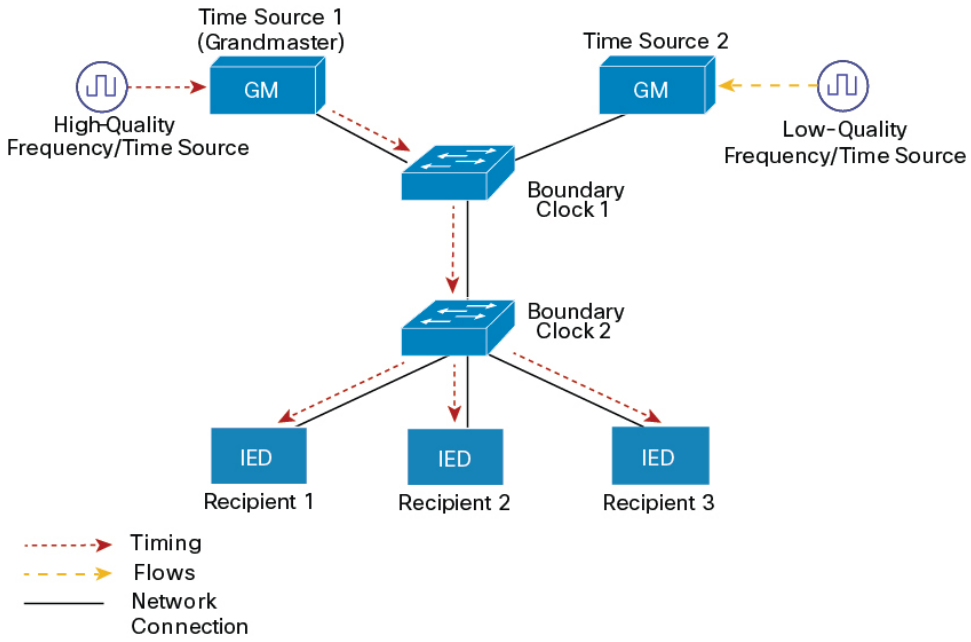
- Time Source 1 (Grandmaster): The primary, high-quality source of time and frequency that initiates the timing distribution.
- Time Source 2: A secondary, lower-quality source of time and frequency, potentially serving as a backup or alternative.
- Boundary Clock 1: A network device (example: a switch) that synchronizes its internal clock with the Grandmaster and then acts as a time source for downstream devices.
- Boundary Clock 2: A network device that synchronizes its internal clock with Boundary Clock 1 and distributes the precise timing to the end-point recipients.
- IED (Intelligent Electronic Device) or recipient: End devices that receive and utilize the precise timing information for their operations.

Summary

PTP networks distribute precise timing information from a highly accurate source to various network devices, ensuring synchronization across the system.

Workflow

Figure 2: PTP network topology



The process involves the following stages:

- Grandmaster Initialization: A high-quality frequency or time source provides highly accurate timing to Time Source 1, which functions as the Grandmaster.
- Grandmaster to Boundary Clock 1 distribution: The Grandmaster transmits its precise timing information to Boundary Clock 1 over a network connection.
- Boundary Clock 1 to Boundary Clock 2 synchronization: Boundary Clock 1 synchronizes its clock with the Grandmaster and then forwards the timing information to Boundary Clock 2.
- Boundary Clock 2 to recipient distribution: Boundary Clock 2 synchronizes its clock with Boundary Clock 1 and distributes the precise timing to the connected IEDs (Recipient 1, Recipient 2, and Recipient 3).

Result

All connected IEDs (Recipients) receive synchronized and precise timing information, enabling coordinated and time-sensitive operations across the network.

PTP event message sequences

This section explains the sequence of PTP event messages during synchronization.

Synchronize with Boundary clocks

Use these event messages to configure Ordinary and Boundary Clocks for the delay request-response mechanism and communicate timing information:

- Sync,
- Delay_Req,
- Follow_Up, and
- Delay_Resp messages.

Boundary Clock synchronization

The key components involved in the process are:

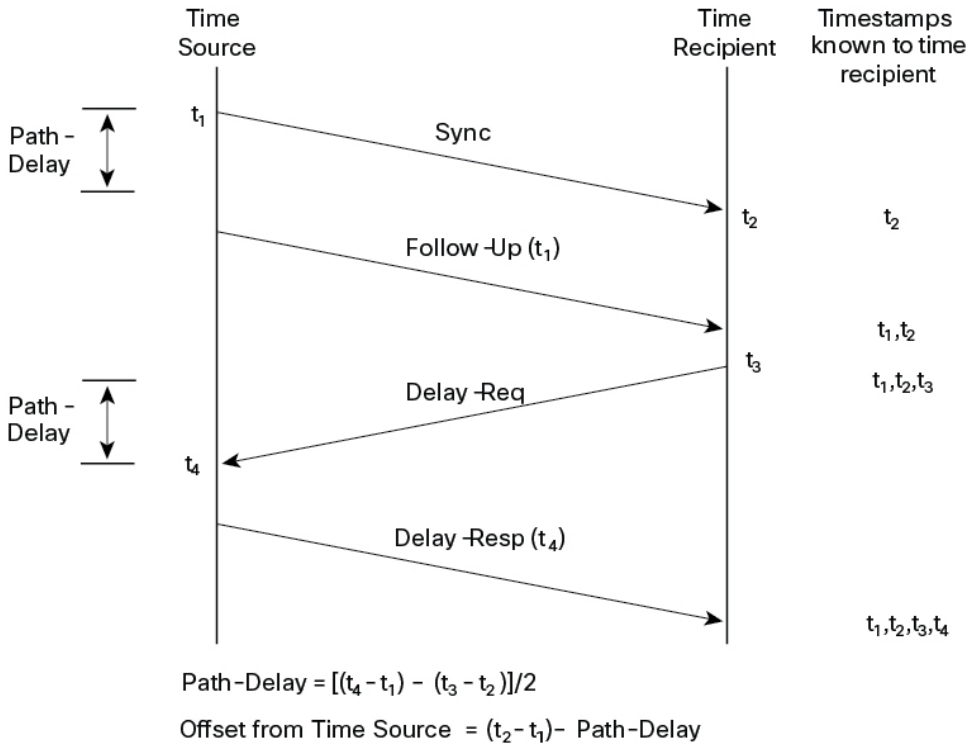
- Time Source: The entity that provides the reference time.
- Time Recipient: The entity that seeks to synchronize its clock with the Time Source.
- Sync message: A message sent by the Time Source to initiate synchronization.
- Follow-Up message: A message sent by the Time Source to provide the precise departure timestamp (t1) of the Sync message.
- Delay-Req message: A message sent by the Time Recipient to the Time Source to request delay measurement.
- Delay-Resp message: A message sent by the Time Source to the Time Recipient, containing the arrival timestamp (t4) of the Delay-Req message.
- Path-Delay: The calculated one-way network latency between the Time Source and Time Recipient.
- Offset from Time Source: The calculated time difference between the Time Recipient's clock and the Time Source's clock.

Summary

Network time synchronization ensures that different devices or systems maintain a consistent and accurate understanding of time, which is crucial for logging, data correlation, and distributed operations.

Workflow

Figure 3: Boundary Clock Synchronization



The network time synchronization process involves these stages:

- Sync message transmission: The Time Source sends a Sync message to the Time Recipient and notes the time (t1) it sends the message.
- Sync message reception: The Time Recipient receives the Sync message and notes the time (t2) it receives the message.
- Follow-Up message transmission: The Time Source sends the timestamp t1 to the Time Recipient in a Follow-Up message.
- Delay request transmission: The Time Recipient sends a Delay-Req message to the Time Source and notes the time (t3) it sends the message.
- Delay request reception: The Time Source receives the Delay-Req message and notes the time of reception (t4).
- Delay response transmission: The Time Source sends the timestamp t4 to the Time Recipient in a Delay-Resp message.
- Path-Delay calculation: The Time Recipient calculates the Path-Delay using the formula `[(t4 - t1) - (t3 - t2)] / 2`.
- Offset calculation: The Time Recipient calculates the offset from the Time Source using the formula `(t2 - t1) - Path-Delay`.

Result

This process enables the Time Recipient to obtain all four necessary timestamps (t1, t2, t3, t4) to calculate the network path delay and its clock's offset relative to the Time Source. This allows the Time Recipient to adjust its clock for precise synchronization. It is important to note that the calculation assumes symmetrical propagation time between the source and recipient; however, this assumption may not hold true on all networks, such as Ethernet, due to asymmetrical packet delay times.

Synchronize with peer-to-peer Transparent clocks

The network includes multiple levels of boundary clocks in the hierarchy with non-PTP-enabled devices between them, which decreases synchronization accuracy. The calculation typically assumes the round-trip time equals mean_path_delay divided by 2, but this is not always accurate for Ethernet networks.

To improve accuracy, an end-to-end TC adds the resident time of each intermediary clock to the offset. However, the resident time does not include the link delay between peers, which a peer-to-peer TC manages.

Peer-to-peer TCs use the peer delay mechanism to calculate the link delay between two clock ports. This link delay is used to adjust the timing information in Sync and Follow_Up messages.

Peer-to-peer TC use these event messages:

- Pdelay_Req,
- Pdelay_Resp, and
- Pdelay_Resp_Follow_Up

Peer-to-Peer Transparent Clock synchronization

Summary

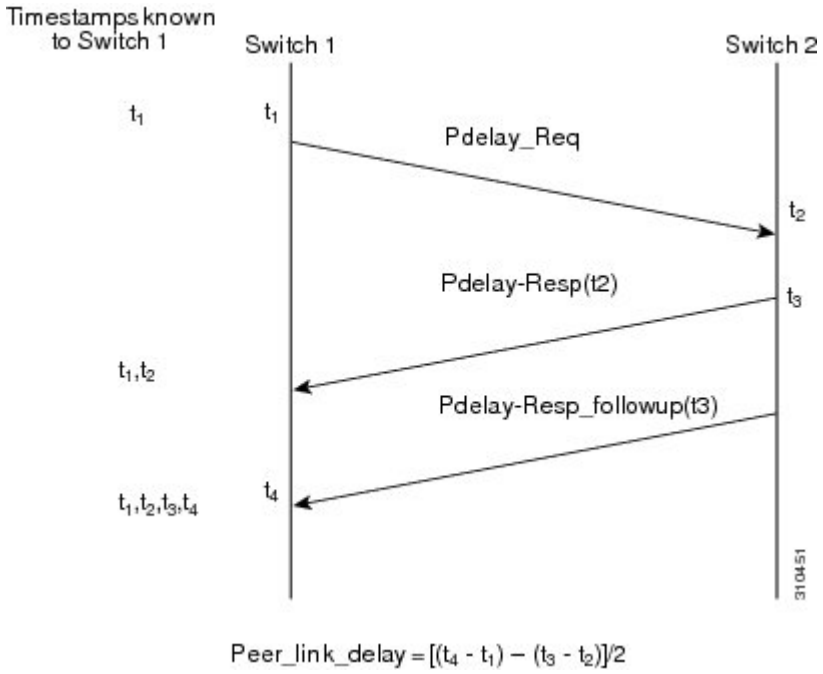
Peer link delay measurement is a mechanism used to precisely determine the communication delay over a direct link between two network devices. This process is essential for accurate time synchronization protocols like PTP.

The key components involved in the process are:

- Switch 1: The initiating device that sends delay requests and calculates the peer link delay.
- Switch 2: The responding device that receives delay requests, sends responses, and provides its internal timestamps.
- Pdelay_Req: A message sent by Switch 1 to initiate the delay measurement process.
- Pdelay-Resp: A message sent by Switch 2 in response to a Pdelay_Req, containing the timestamp of its reception (`t2`).
- Pdelay-Resp_followup: A subsequent message sent by Switch 2 that provides the precise timestamp of when it transmitted the Pdelay-Resp message (`t3`).
- Timestamps (t1, t2, t3, t4): Specific points in time recorded by the switches during the message exchange to measure transmission and reception times.

Workflow

Figure 4: Peer-to-Peer transparent clock synchronization



These messages are sent in this sequence:

1. Switch 1 generates timestamp t1 for a Pdelay_Req message.
2. Switch 2 receives Pdelay_Req and generates timestamp t2 for this message.
3. Switch 2 generates timestamp t3 for a Pdelay_Resp message.

   To minimize errors due to any frequency offset between the two switches, switch 2 returns the Pdelay_Resp message as quickly as possible after the receipt of the Pdelay_Req message.
4. Switch 2 returns timestamps t1, t2, and t3 in the Pdelay_Resp and Pdelay_Resp_Follow_Up messages respectively.
5. Switch 1 generates timestamp t4 after receiving the Pdelay_Resp message. switch 1 then uses the four timestamps (t1, t2, t3, and t4) to calculate the mean link delay between switch1 and switch 2

The process involves these stages:

- Request initiation: Switch 1 sends a Pdelay_Req message to switch 2 and records the precise time of transmission as `t1`.
- Request reception: Switch 2 receives the Pdelay_Req message from switch 1 and records the precise time of reception as `t2`.
- Response transmission: Switch 2 prepares and sends a Pdelay-Resp message back to switch 1. This message includes the `t2` timestamp. Switch 2 also records the precise time of transmitting this Pdelay-Resp message as `t3`.

- Follow-up transmission: Shortly after sending the Pdelay-Resp, switch 2 sends a Pdelay-Resp_followup message to switch 1. This Follow-up message contains the `t3` timestamp, providing a precise record of the Pdelay-Resp's transmission time.
- Response reception and calculation: Switch 1 receives both the Pdelay-Resp and Pdelay-Resp_followup messages. It records the precise time of receiving these messages as `t4`. Switch 1 then calculates the peer link delay using the formula: `Peer_link_delay = [(t4 - t1) - (t3 - t2)]/2`.

Result

The process accurately determines the one-way communication delay over a specific network link, allowing devices to compensate for propagation delays and achieve highly precise time synchronization across the network.

Synchronize the local clock

In an ideal PTP network, the time source and time recipient clocks operate at the same frequency. Drift occurs when their frequencies differ. PTP uses timestamp information from device hardware and the FollowUp messages intercepted by the switch to correct clock drift and align the local clock with the time source.

Best Master Clock Algorithm

The Best Master Clock Algorithm (BMCA) serves as the basis for PTP functionality. It defines how each clock in the network identifies the best time source clock within its subdomain from all visible clocks, including itself. BMCA continuously operates on the network and quickly adapts to changes in the network configuration.

The BMCA identifies the best time source clock in the subdomain based on:

- clock quality (example: GPS is considered the highest quality),
- accuracy of the clock's time base,
- stability of the local oscillator, and
- proximity to the grandmaster clock.

The BMCA prevents clock conflicts on the PTP network by ensuring:

- clocks do not negotiate with one another, and
- misconfigurations, such as multiple or missing time source clocks, do not occur during the time source clock identification process.

PTP profiles

Cisco Catalyst IR8340 Rugged Series Router supports these PTP profiles:

- Default,
- Power (2011 and 2017), and
- 802.1AS.

Cisco IOS-XE Release 17.7.1 supports Power Profile-2011, defined in the PC37.238-2011 IEEE Draft Standard Profile for using IEEE 1588 PTP in Power System Applications.

Note This documentation uses the terms Power Profile mode and Default Profile mode to refer to the IEEE 1588 profile and its configuration values.

Starting from Cisco IOS-XE Release 17.8.1, Cisco Catalyst IR8340 Rugged Series Router supports Power Profile-2017 in Transperant clock. Power Profile-2017 is defined in IEEE Standard C37.238™-2017 (a Revision of IEEE Std C37.238-2011) for use of IEEE 1588 PTP in Power System Applications.

Starting from Cisco IOS-XE Release 26.1.1, Cisco Catalyst IR8340 Rugged Series Router supports Power Profile-2017 in Boundary clock.

IEEE 1588 defines a PTP profile as a set of allowed PTP features for a device. A PTP profile is tailored to a specific application or environment and specifies these values:

- Best master clock algorithm options
- Configuration management options
- Path delay mechanisms (peer delay or delay request-response)
- Range and default values of all PTP configurable attributes and data set members
- Transport mechanisms that are required, permitted, or prohibited
- Node types that are required, permitted, or prohibited
- Options that are required, permitted, or prohibited

Default Profile mode

The Cisco Catalyst IR8340 Rugged Series Router uses Default Profile mode as its default PTP profile. In this mode:

- It supports Ordinary Clock (OC)- slave, Boundary Clock (BC), and Transparent Clock (TC).
- It does not support OC-master.
- All PTP profiles over bundles or port-channels are not supported.

Power Profile mode (2011 and 2017)

The IEEE Power Profile specifies the allowed values for PTP networks used in power substations. These values include the optimal physical layer, the higher-level protocol for PTP messages, and the preferred BMCA. The Power Profile ensures consistent and reliable time distribution within substations, between substations, and across wide geographic areas.

The router is optimized for PTP in these ways:

- Hardware—The router uses FPGA and PHY for the PTP function. The PHY time stamps the Fast Ethernet and Gigabit Ethernet ports.
- Software—In Power Profile mode, the router uses the configuration values defined in the IEEE 1588 Power Profile standard.

This table displays the IEEE 1588 power profile configuration values and shows how the Cisco Catalyst IR8340 Rugged Series Router applies them for each PTP profile mode.

Table 2: Configuration values for the IEEE PTP Power profile and Default profile modes

PTP field	Router configuration value	
	Power profile modes (2011 and 2017)	Default profile mode
Message transmission	Access Ports –Untagged Layer 2 packets. Trunk Ports –802.1Q tagged Layer 2 packets. PTP packets are tagged with the PTP VLAN. If the PTP VLAN is not configured, packets go untagged over the native VLAN.	Layer 3 packets. By default, 802.1q tagging is disabled.
MAC address–Non-peer delay messages	01-00-5e-00-01-81.	Default profile uses L3 transport multicast address 224.0.1.129 for all PTP messages. Equivalent MAC address is 01-00-5e-00-01-81
MAC address-Peer delay messages	01-80-C2-00-00-0E.	Not applicable to this mode.
Domain number	0.	0.
Path delay calculation	Peer-to-peer transparent clocks using the peer_delay mechanism.	End-to-end transparent clocks using the delay_request mechanism.
BMCA	Enabled.	Enabled.
Clock type	Two-step.	Two-step.
Time scale	Epoch.	Epoch.

Grandmaster ID and local time determination	• 16-bit grandmasterID and configurability:
	  • Power 2011: 0x0003 – 0x00FE [2 bytes wide but limited to this range]
	  • Power 2017: 0x0000 – 0xFFFF [Full 2 bytes]
	• organizationSubType:
	  • 0x01 indicates the 2011 profile
	  • 0x02 identifies the 2017 revision
		PTP-specific type, length, and value to indicate Grandmaster ID.

PTP field	Router configuration value	
Time accuracy over network hops	Over 16 hops, slave device synchronization accuracy is within 1 usec (1 microsecond).	Not applicable in this mode.

802.1AS profile

The IEEE 802.1AS standard, *Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks*, defines the protocol and procedures to meet synchronization requirements for time-sensitive applications in bridged and virtual bridged local area networks.

The 802.1AS standard applies IEEE 1588 (PTP) specifications where its relevant within the context of IEEE Std 802.1D-2004 and IEEE Std 802.1Q-2005. It is one of three 802.1 Audio Video Bridging (AVB) draft standards. 802.1AS over Ethernet (802.3) serves as a profile of IEEE 1588-2008, simplifying IEEE 1588 and enabling synchronization across various types of media.

Note On Cisco Catalyst IR8340 Rugged Series Routers, 802.1AS can only be configured with domain 0."

802.1AS key characteristics

These are the key characteristics of 802.1AS.

- It uses the peer delay mechanism for Ethernet full-duplex links.
- All devices in the domain must be 802.1AS capable.
- It transports 802.1AS packets as L2 multicast only, without VLAN tags.
- It requires two-step processing using Follow_Up and Pdelay_Resp_Follow_Up messages to communicate timestamps.
- A time-aware network has only one active grandmaster and a single 802.1AS domain.
- The BMCA is the same as IEEE 1588, with these exceptions:
  - It uses Announce messages received on a time recipient port immediately, without foreign-time source qualification.
  - A port determined as a time source port by the BMCA enters the time source state immediately, skipping the pre-time source state.
  - It does not use the uncalibrated state.
  - All time-aware systems must participate in best master selection (even if the system is not grandmaster capable).

802.1AS Timing for Time Sensitive Networks

802.1AS is used in Time Sensitive Networking (TSN). However, it operates independently as a precise timing distribution mechanism without requiring TSN configuration or inputs. It uses the existing FPGA time-stamping functionality and does not require additional hardware beyond other PTP profiles.

802.1AS for end-to-end synchronization

The 802.1AS standard ensures these end-to-end time synchronizations.

- Any two time-aware systems separated by six or fewer time-aware systems (seven hops or less) achieve synchronization within 1 microsecond peak-to-peak during steady-state operation.
- Synchronization performance beyond seven hops is not defined.

PTP profile comparison

This table provides the comparison of different PTP power profiles on IE switches.

Table 3: PTP profiles comparision on IE switches

Profile	**Default (*)**		**Power profile-2011**		**Power profile-2017**		**802.1AS**
Standard	IEEE1588 v2 (J.3)		IEEE C37.238-2011		IEEE C37.238-2017		IEEE802.1AS
Mode	Boundary	End-to-End transparent	Boundary	Peer-to-Peer transparent	Boundary	Peer-to-Peer transparent	**
Path Delay	Delay req/res	Delay req/res	Peer delay req/res	Peer delay req/res	Peer delay req/res	Peer delay req/res	Peer delay req/res
Non-PTP device allowed in PTP domain	Yes	Yes	No	No	No	No	No
Transport	UDP over IP (multicast)		L2 Multicast		L2 Multicast		L2 Multicast

* Delay Request-Response Default PTP profile (as defined in IEEE1588 J.3).

** 802.1AS has no mode setting. It is mathematically similar to P2P transparent but operates differently from a transparent clock.

PTP clock modes

PTP synchronization behavior relies on the PTP clock mode configured on the router. You can set the router to one of these global modes.

The router supports these PTP device types:

- OC-slave, Boundary Clock (BC), and Transparent Clock(TC) on Default Profile or IEEE 1588.
- BC and TC on Power profile-2011 and Power profile-2017.
- BC on 802.1AS profile.

For guidelines on each clock configuration. See Restrictions of PTP, on page 28

Note All the above profiles support two-step mode and do not support one-step mode.

Default settings

By default, the router is configured with these PTP settings.

- PTP is enabled.
- Default profile mode is enabled, using configuration values defined in the Default profile.
- The PTP clock mode is set to End-to-End (E2E) Transparent Clock mode.
- The Boundary Clock (BC) synchronization algorithm is set to the linear filter.

Boundary Clock Synchronization algorithm

You configure the Boundary Clock (BC) Synchronization algorithm based on your PTP use case, prioritizing either filtering input time errors or achieving faster convergence. A PTP algorithm that filters packet delay variation (PDV) converges more slowly than one without filtering

By default, the BC uses a linear feedback controller (servo) to adjust its time output to the next clock. The linear servo offers minimal PDV filtering and achieves average convergence time. For faster convergence, the BC can use the TC feedforward algorithm, which measures the delay introduced by the network elements' forwarding plane (the disturbance) and uses this delay to control the time output.

The feedforward BC significantly improves BC performance but does not filter PDV. The adaptive PDV filter ensures high-quality time synchronization even when wireless access points (APs) and enterprise switches, which do not support PTP, introduce significant PDV.

BC synchronization supports three options which are compliant with IEEE 1588-2008:

- Feedforward—For very fast and accurate convergence but does not filter PDV.
- Adaptive—Adaptive filters maximize PDV filtering based on assumptions about PDV characteristics, hardware configuration, and environmental conditions.

Note With the adaptive filter, the switch does not meet the time performance requirements specified in ITU-T G.8261.

- Linear—Provides simple linear filtering which is the default.

Adaptive mode ptp transfer filter adaptive is not available in Power Profile mode.

PTP profile switch tag behavior

This table describes the switch tagging behavior in Power profile and Default profile mode.

Table 4: Switch behavior for PTP tags in Power and Default profile modes

Switch Port Mode	Configuration	Power Profile Modes (2011 and 2017)		Default Profile Mode	
		Behavior	Priority	Behavior	Priority
Trunk Port	**vlan dot1q tag native** enabled	Switch tags packets	7	Switch tags packets	7
Trunk Port	**vlan dot1q tag native** disabled	PTP software tags packets	4	Untagged	None
Access Port	N/A	Untagged	None	Untagged	None

PTP packet flow

The key components involved in the process are:

- Boundary Clock (BC): A network device that participates in PTP, synchronizing its clock to a primary and acting as a primary clock source to downstream clocks.
- Grandmaster Clock (GMC): The primary source of time within a PTP domain, typically located in a foreign network.
- GMC-Block configuration: A specific feature enabled on an interface (Example: Gig 1/4) of a Boundary Clock.
- PTP packets (Sync, Announce, Follow_Up): Messages used by PTP for time synchronization.
- Existing Network: The local network containing the Boundary Clock with the GMC-Block configuration.
- Foreign Network: An external network that may be a source of PTP packets.

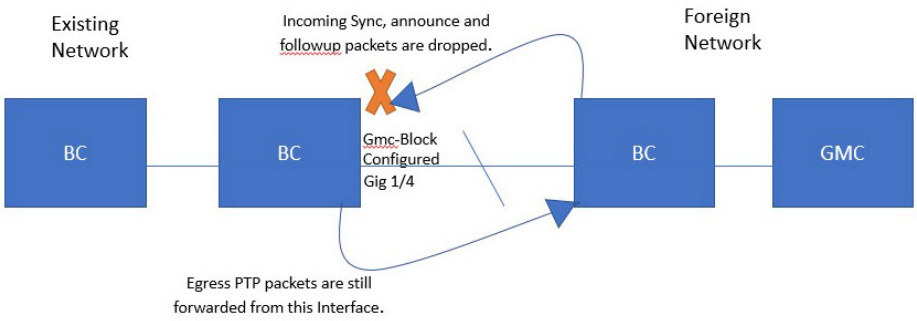
Summary

A network interface configured with GMC-Block processes and then drops incoming synchronization messages while allowing outgoing ones, controlling the flow of PTP packets. This ensures that the local network's PTP synchronization is maintained by its own Grandmaster Clock (GMC).

Workflow

This figure shows an example of a PTP network topology with the GMC Block feature configured on an interface.

Figure 5: Packet flow



The process involves these stages:

- Configuration of Gmc-Block: A network administrator configures the Gmc-Block feature on a specific interface, such as Gig 1/4, of a Boundary Clock within the existing network.
- Incoming PTP packet handling: When PTP Sync, announce, and followup packets arrive on the configured interface from a Foreign Network, the Boundary Clock retrieves necessary information from these packets and drops them due to the Gmc-Block configuration.
- Egress PTP packet handling: The Boundary Clock continues to forward egress PTP packets from the configured interface to the Foreign Network, even with the Gmc-Block enabled.

Result

The Gmc-Block configuration effectively prevents a specific Boundary Clock interface from accepting incoming PTP synchronization messages from a designated foreign network by processing and then dropping them. This allows the system to restrict synchronization from external sources, ensuring the local network synchronizes with its own GMC. Simultaneously, it allows the interface to continue sending its own PTP information, maintaining its role as a primary to other devices within its domain. This provides granular control over PTP domain boundaries and ensures that the clock synchronization source is managed as intended.

Configure PTP

Use this procedure to configure PTP on the router.

Procedure

Step 1 Use the **config terminal** command to enter configuration mode.

Example:

```
Router# config terminal
```

Step 2 Use the **license boot level network-advantage** command to configure the license as Network Advantage.

Example:

```
Router(config)# license boot level network-advantage Y
```

Step 3 Use the **end** command to exit from configuration mode and enter into EXEC mode.

Example:

```
Router(config)# end
```

NTP to PTP time conversion

NTP to PTP time conversion lets you use Network Time Protocol (NTP) as a time source for PTP. You can use PTP for precise synchronization within a site and rely on NTP across sites where precision is unnecessary.

NTP is the traditional method to synchronize clocks in packet-based networks. It uses a two-way time transfer mechanism between a time source and an end device. NTP synchronizes a device within a few hundred milliseconds over the Internet and within a few milliseconds in a controlled LAN. Using NTP as a PTP time source lets you correlate data from your PTP network with data in enterprise data centers running NTP.

NTP to PTP conversion

Summary

This process describes the hierarchical distribution of time synchronization, starting from a global UTC source and extending down to industrial control systems, enabling the precise time synchronization often required by devices in operational technology (OT) environments through eventual NTP to PTP conversion.

The key components involved in the process are:

Time sources and network zones

- UTC Time: The global reference for highly accurate time synchronization.
- NTP Time Server Pool: A collection of servers that acquire accurate time from UTC sources and distribute it via NTP.
- Internet: The wide area network (WAN) used to access the NTP Time Server Pool and connect the Enterprise WAN.
- Enterprise WAN: The WAN connecting the enterprise infrastructure to the internet.
- Enterprise zone: The primary network segment for general enterprise operations.
- Demilitarized zone (DMZ): A network segment that provides a secure buffer between the internal network and external networks, hosting services like the NTP Time Mirror.
- Manufacturing zone: A network segment dedicated to manufacturing operations, relying on accurate time for process control.

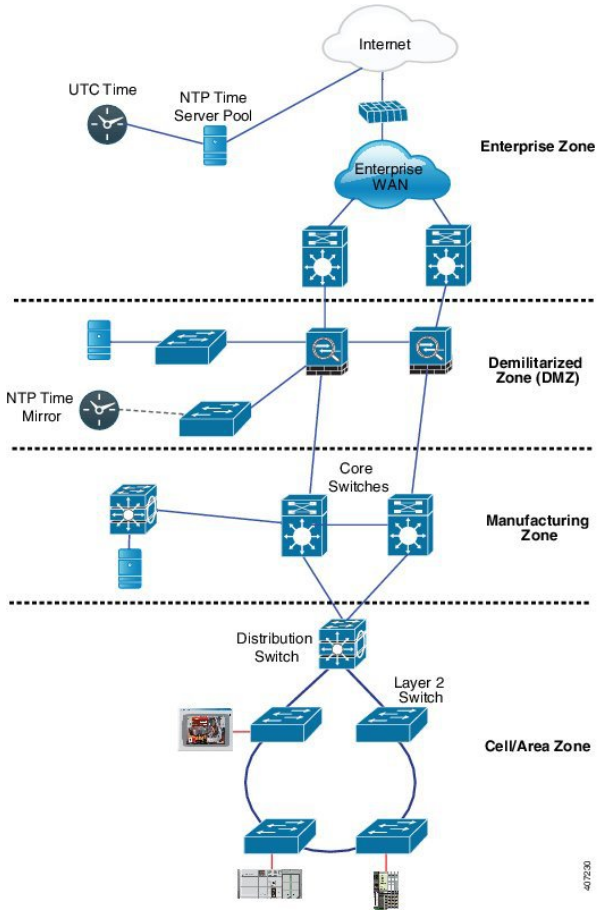
Network infrastructure and end devices

- NTP time mirror: A local NTP server within the DMZ that synchronizes with the external NTP Time Server Pool, providing a secure and reliable internal time source.
- Core switches: High-performance switches forming the backbone of the network, connecting different zones and distributing network traffic.
- Distribution switch: A switch that aggregates connections from core switches and distributes them to lower-level network segments like the Cell/Area Zone.

- Layer 2 switch: Switches operating at the data link layer, providing connectivity to end devices within a local network segment.
- Industrial Devices: Equipment such as Programmable Logic Controllers (PLCs) and Human-Machine Interfaces (HMIs) in the Cell/Area Zone that require highly precise time synchronization, often via PTP.

Workflow

Figure 6: Industrial network with NTP and PTP



The process involves these stages:

- Global time source acquisition: The NTP Time Server Pool obtains highly accurate time from a UTC time source over the internet, ensuring a precise global time reference.
- Enterprise network distribution: The NTP Time Server Pool distributes this synchronized NTP time to the Enterprise Zone, which includes the Enterprise WAN and core network infrastructure, providing time synchronization for general IT systems.
- DMZ time mirroring: An NTP Time Mirror located within the Demilitarized Zone (DMZ) synchronizes with the external NTP Time Server Pool, establishing a secure and reliable local NTP time source for internal networks.

- Manufacturing zone synchronization: Core switches and connected devices within the Manufacturing Zone obtain their time synchronization from the NTP Time Mirror in the DMZ, ensuring operational consistency for manufacturing processes.
- Industrial network connectivity: The Distribution Switch connects the Manufacturing Zone's core network to the Cell/Area Zone, which contains critical industrial control systems and devices. Layer 2 switches further distribute network connectivity within this zone to the industrial equipment.
- PTP conversion enablement: Within the cell or area zone, the distributed NTP time serves as a reference for specialized devices that convert NTP to PTP. This conversion provides the extremely precise time synchronization required by industrial automation equipment like PLCs and HMIs for coordinated operations.

Result

This hierarchical time synchronization process ensures that all network zones, from enterprise IT to critical industrial operational technology (OT), receive accurate and consistent time. This enables precise timestamping, synchronized operations, and the high-fidelity timing required for sensitive industrial control applications through the enablement of NTP to PTP conversion at the network edge.

Clock manager

The clock manager in the Cisco NTP to PTP software architecture tracks various time services and selects the active clock providing time. It also notifies time services of key changes, such as state changes, leap seconds, or daylight saving time.

The clock manager prioritizes the NTP or manually set clock first, followed by PTP, and then the real-time clock if NTP is inactive. This table shows the results of the clock selection process.

Table 5: Time Service Selection

NTP (Active) or Manually Set	PTP (Active)	Real-Time Clock	Selected Output
True	Don’t care	Don’t care	NTP or Manually Set
False	True	Don’t care	PTP
False	False	True	Real-Time Clock

In general, the clock manager ensures that the time displayed in the Cisco IOS commands show ptp lan clock and **show clock** match. The **show clock** command always follows this priority, but there are two corner cases where the show ptp lan clock time may differ:

- The router acts as a TC or BC with no other active reference on the network. To maintain backward compatibility, the TC and BC take their time only from the network’s PTP GMC, not from the clock manager. If no active PTP GMC exists, the **show clock** and **show ptp lan clock** command outputs may differ.
- The router is a syntonizing TC, a BC with a secondary port, or a GMC-BC with a secondary port, and the time from the PTP GMC does not match the time from NTP or the user (manually set). In this case, the PTP clock must forward the time from the PTP GMC. If the PTP clock does not follow the PTP GMC, the PTP network has two different time bases, disrupting control loops or sequence-of-event applications that rely on PTP.

This table shows how the Cisco IOS and PTP clocks behave given the various configurations. Most of the time, the two clocks match. Occasionally, the two clocks are different; those configurations are highlighted in the table.

Table 6: Expected time flow

IOS Clock Configuration	PTP Clock Configuration	IOS Clock Source	PTP Clock Source
Calendar	PTP BC, E2E TC, or GMC-BC in BC Mode	PTP	PTP
Manual	PTP BC, E2E TC, or GMC-BC in BC Mode	Manual	PTP
NTP	PTP BC, E2E TC, or GMC-BC in BC Mode	NTP	PTP
Calendar	GMC-BC in GM Mode	Calendar	Calendar
Manual	GMC-BC in GM Mode	Manual	Manual
NTP	GMC-BC in GM Mode	NTP	NTP

Grandmaster clock

Grandmaster clock (GMC) block protects a network from rogue GMC that is attempting to synchronize with devices inside the network. Similarly, this is supported for all PTP clock modes except forward mode. Once it is enabled on an interface, it allows only egress Announce, Sync, and Follow_Up PTP packets while dropping all ingress Announce, Sync, and Follow_Up packets on the interface. This prevents the port state from transitioning to a time recipient.

Information about a rogue GMC is retrieved from its packets before they are dropped. Similarly, egress PTP packets are allowed from this interface, enabling it to act as a GMC. To identify the rogue device, details such as its IP address and clock ID are stored and displayed for the interface. Additionally, two Syslog messages are generated to notify both the detection and clearance of rogue devices.

You can configure PTP gmc-block on multiple ports if you suspect multiple foreign networks are connected to your system. The system displays per-port Syslog messages 30 seconds after receiving rogue packets and 180–240 seconds after the packets stop. It also generates relay minor alarms and SNMP traps to notify you about the presence of foreign rogue devices.

Restrictions of PTP

PTP messages

The Cisco Catalyst IR8340 Rugged Series Router supports two-step clock and multicast PTP messages.

PTP mode and profile

- The router and the grandmaster clock must be in the same PTP domain.
- When Power Profile mode is enabled, the router drops PTP announce messages that do not include the Organization_extension and Alternate_timescale TLV message extensions.

  If the GMC is not compliant with PTP and sends announce messages without these TLVs, configure the router to process the announce message by entering this command:

```
ptp clock boundary domain 1 profile {power | power-2017}
allow-without-tlv
```

- When the router is in Power Profile mode, only the peer_delay mechanism is supported.

  To enable Power Profile boundary mode and associate interfaces using the clock-port suboption, enter these commands:

  ```
  ptp clock boundary domain 1 profile {power | power-2017}
  clock-port 1
  transport ethernet multicast interface gi0/1/1
  ```

- To disable power profile transparent mode, enter this command, which returns the router to forward mode.

  ```
  no ptp clock transparent domain x profile {power | power-2017}
  ```

- To enable the E2E transparent clock, use this command:

  ```
  ptp clock transparent domain x profile default
  ```

- In Default Profile mode, only the delay_request mechanism is supported.

  To enable Default Profile BC mode and interfaces associated with clock-port suboption, enter this command:

  ```
  ptp clock boundary domain 1 profile default
  clock-port 1
  transport ipv4 multicast interface gi0/1/1
  ```

- The 802.1AS profile does not have a clock mode setting.
- For Power Profile 2017:
  - TLVs in Announce messages must always be arranged in a specific, fixed order. If the order of TLVs in Announce messages changes, some constrained devices might fail to parse the message correctly.
  - Each BC or TC must increment the TotalTimeInaccuracy field accurately in every message.
  - The Alternate Time Offset Indicator (ATOI) is optional; however, its use can lead to divergence. If some devices send the ATOI and others ignore or misinterpret it, the local time offset representation may become inconsistent.

Packet format

The router handles PTP packet formats and behavior as specified:

- PTP messages can use 802.1q tagged packets or untagged packets.
- The router does not support 802.1q QinQ tunneling.
- In Power Profile mode:
  - When the PTP interface is configured as an access port, PTP messages are sent as untagged Layer 2 packets.
  - When the PTP interface is configured as a trunk port, PTP packets are sent as 802.1q tagged Layer 2 packets over the port's native VLAN.
- Time recipient IEDs must support tagged and untagged packets.

- In E2E TC mode, PTP packets sent on the native VLAN are untagged. To send them as tagged packets, use the`vlan dot1q tag native` command in global configuration mode.

PTP VLAN characteristics

Key details and considerations for configuring PTP VLANs and related settings include:

- Set the PTP VLAN on a trunk port. The range is from 1 to 4094, with the default VLAN being the native VLAN of the trunk port.
- In Boundary mode, the device processes only PTP packets in the PTP VLAN and drops packets from other VLANs.
- Before configuring the PTP VLAN on an interface, ensure the PTP VLAN is created and allowed on the trunk port.
- Most GMC use the default VLAN 0.
- In Power Profile mode, the router defaults to VLAN 1, while VLAN 0 is reserved.
- When changing the default GMC VLAN, ensure it is set to a VLAN other than 0.
- If VLAN is disabled on the GMC, configure the PTP interface as an access port.

PTP VLAN and synchronization

The key aspects of PTP VLAN functionality and synchronization include:

- All PHY PTP clocks synchronize to the GC.
- The router system clock does not synchronize as part of PTP configuration and processes.
- When VLAN is enabled on the GMC, it must be in the same VLAN as the native VLAN of the PTP port on the router.
- GMC can drop untagged PTP messages when a VLAN is configured on the GMC.
- To ensure the router sends tagged packets to the GMC, use the `vlan dot1q tag native` command in the global configuration mode.

PTP and clock modes

PTP support and clock modes for the router are:

- PTP over port channels is not supported.
- These PTP clock modes operate on a single VLAN:
  - e2etransparent
  - p2ptransparent

NTP to PTP conversion

- The NTP to PTP conversion supports the Default E2E profile and Power profile.

Configure GMC Mode

These sections provide steps for configuring GMC mode for default and power profiles.

Configure GMC mode for a Default Profile

Use this procedure to configure GMC mode for a default profile.

Procedure

Step 1 Use the **configure terminal** command to enter configuration mode.

Example:

```
Router# configure terminal
```

Step 2 Use the **ptp clock boundary domain** command to enable the default profile boundary mode.

Example:

```
Router(config)# ptp clock boundary domain 0 profile default
```

Step 3 Use the **gmc-default** command to enable the GMC BC.

Example:

```
Router(config-ptp-clk)# gmc-default
```

Step 4 Use the **clock-port** Command to define a new clock port.

Example:

```
Router(config-ptp-clk)# clock-port port1
```

Step 5 Use the **transport ipv4 multicast** command to specify the transport mechanism for clocking traffic.

Example:

```
Router(config-ptp-port)# transport ipv4 multicast interface Gi0/1/1
```

Configure GMC mode for a Power Profile

Use this procedure to configure the grandmaster clock (GMC) mode for a power profile.

Procedure

Step 1 Use the **configure** command to enter into configuration mode.

Example:

```
Router# configure
```

Step 2 Use the **ptp clock boundary domain** *domain-number* **profile** {**power | power-2017**} command to enter the power profile boundary mode.

Example:

```
Router(config)# ptp clock boundary domain 0 profile power-2017
```

Enable the power profile boundary mode.

You can configure these profiles:

- power—Power Profile-2011
- power-2017—Power Profile-2017

Step 3 Use the **gmc-default** command to enable the GMC Boundary Clock.

Example:

```
Router(config-ptp-clk)# gmc-default
```

Step 4 Use the **clock-port** command to define a new clock port.

Example:

```
Routerrouter(config-ptp-clk)# clock-port port1
```

Step 5 Use the **transport ethernet multicast** command to specify the transport mechanism for clocking traffic.

Example:

```
Router(config-ptp-port)# transport ethernet multicast interface gi0/1/1
```

Configure PTP Default profile

This section describes how to configure the router to operate in Default profile mode.

Configure an Ordinary Clock client

Use this procedure to configure the router as an Ordinary clock client.



Note An Ordinary clock is supported only in slave mode, not in master mode.

Procedure

Step 1 Use the **enable** command to enable privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** commandto enter into configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ptp clock ordinary domain** *domain-number* **profile default** command to set the PTP clock domain and profile.

Example:

```
Router(config)# ptp clock ordinary domain 0  profile default
```

You can create these PTP clock types:

- Ordinary—A 1588 clock with a single PTP port that can operate in Server or Client mode.
- Boundary—Terminates PTP session from Grandmaster and acts as PTP Server or Client clocks downstream.
- Transparent—Updates the PTP time correction field to account for the delay in forwarding the traffic. This helps improve the accuracy of 1588 clock at client.

Step 4 Use the **clock-port** command to define a new clock port and sets the port to PTP Server or Client mode; in client mode, the port exchanges timing packets with a PTP server clock.

Example:

```
Router(config-ptp-clk)# clock-port slave
```

Step 5 Use the **transport ipv4 multicast interface** command to specify the transport mechanism for clocking traffic.

Example:

```
Router(config-ptp-port)# transport ipv4 multicast interface Gi0/1/11
```

Example of untagged:

```
Router(config)# ptp clock ordinary domain 0  profile default
 Router(config-ptp-clk)# clock-port slave
 Router(config-ptp-port)# transport ipv4 multicast interface Gi0/1/11
```

Step 6 (Optional) Use the **vlan** command to configure the VLAN for the tagged packets.

Example:

```
Router(config-ptp-port)# vlan 100
```

Example of tagged

```
Router(config)# ptp clock ordinary domain 0  profile default
 Router(config-ptp-clk)# clock-port slave slave
 Router(config-ptp-port)# transport ipv4 multicast interface Gi0/1/11
 Router(config-ptp-port)# vlan 100
```

Configure a Boundary clock

If an interface is not part of the BC clock, it operates in forward mode and exchanges PTP packets, causing instability.

Use this procedure to configure the router as a boundary clock.

Procedure

Step 1 Use the **enable** command to enable privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enterinto configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ptp clock boundary domain** *domain-number* **profile default** command to set the PTP clock domain and profile.

Example:

```
Router(config)# ptp clock boundary domain 0  profile default
```

You can create these PTP clock types:

- ordinary—A 1588 clock with a single PTP port that can operate in Server or Client mode.
- boundary—Terminates PTP session from Grandmaster and acts as PTP Server or Client clocks downstream.
- transparent—Updates the PTP time correction field to account for the delay in forwarding the traffic. This helps improve the acuracy of 1588 clock at client.

Step 4 Use the **clock-port** command to define a new clock port.

Example:

```
Router(config-ptp-clk)# clock-port dyn1
```

Step 5 Use the **transport ipv4 multicast interface** command to specify the transport mechanism for clocking traffic.

Example:

```
Router(config-ptp-port)# transport ipv4 multicast interface Gi0/1/0
```

Example of untagged:

```
Router(config)# ptp clock boundary domain 0  profile default
 Router(config-ptp-clk)# clock-port dyn1
 Router(config-ptp-port)# transport ipv4 multicast interface Gi0/1/0
 Router(config-ptp-port)# exit
 Router(config-ptp-clk)# clock-port dyn2
 Router(config-ptp-port)# transport ipv4 multicast interface Gi0/1/2
```

Step 6 (Optional) Use the **vlan** command to configure VLAN for tagged packets.

Example:

```
Router(config-ptp-port)# vlan 100
```

Example of tagged:

```
Router(config)# ptp clock boundary domain 0  profile default
 Router(config-ptp-clk)# clock-port dyn1
 Router(config-ptp-port)# transport ipv4 multicast interface Gi0/1/0
 Router(config-ptp-port)# exit
```

```
Router(config-ptp-clk)# clock-port dyn2
Router(config-ptp-port)# transport ipv4 multicast interface Gi0/1/2
Router(config-ptp-port)# vlan 100
```

Configure a Transparent clock

All interfaces will be part of TC mode once configured.

Follow these steps to configure the router as a transparent clock.

Procedure

Step 1 Use the **enable** command to enable privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ptp clock transparent domain** *domain-number* **profile default** command to set the PTP clock domain and profile.

Example:

```
Router(config)# ptp clock transparent domain 0  profile default
```

You can create these PTP clock types.

- ordinary—A 1588 clock with a single PTP port that can operate in Server or Client mode.
- boundary—Terminates PTP session from Grandmaster and acts as PTP Server or Client clocks downstream.
- transparent—Updates the PTP time correction field to account for the delay in forwarding the traffic. This helps improve the acuracy of 1588 clock at client.

Example of Untagged:

```
Router(config)# ptp clock transparent domain 0  profile default
```

Step 4 (Optional) Use the **vlan** command to configure VLAN for tagged packets.

Example:

```
Router(config-ptp-port)# vlan 100
```

Example of tagged :

```
Router(config)# ptp clock transparent domain 0  profile default
Router(config-ptp-port)# vlan 100
```

Configure PTP Power profile

This section describes how to configure the router to use the PTP Power Profile.

The Power Profile defines a subset of PTP designed to operate over Layer 2 networks, such as Ethernet, without using IP.

Configure an Ordinary Clock

Use this procedure to configure the router as an ordinary clock.

An Ordinary clock is supported only in slave mode, not in master mode.

Procedure

Step 1 Use the **enable** command to enable privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter into configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ptp clock boundary domain** *domain-number* **profile** {**power | power-2017**} command to configure the PTP clock.

Example:

```
Router(config)# ptp clock ordinary domain 0  profile power
```

You can create these PTP clock types:

- ordinary—A 1588 clock with a single PTP port that can operate in Server or Client mode.
- boundary—Terminates PTP session from Grandmaster and acts as PTP Server or Client clocks downstream.
- transparent—Updates the PTP time correction field to account for the delay in forwarding the traffic. This helps improve the acuracy of 1588 clock at client.

You can configure these profiles:

- power—Power Profile-2011
- power-2017—Power Profile-2017

Step 4 Use the **clock-port** command to define a new clock port and sets the port to PTP Server or Client mode; in client mode, the port exchanges timing packets with a PTP server clock.

Example:

```
Router(config-ptp-clk)# clock-port slave
```

Step 5 Use the **transport ethernet multicast interface** command to specify the transport mechanism for clocking traffic.

Example:

```
Router(config-ptp-port)# transport ethernet multicast interface Gi0/1/11
```

Example of Untagged:

```
Router(config)# ptp clock ordinary domain 0  profile power
 Router(config-ptp-clk)# clock-port slave slave
 Router(config-ptp-port)# transport ethernet multicast interface Gi0/1/11
```

Step 6 (Optional) Use the **vlan** command to configure VLAN for tagged packets.

Example:

```
Router(config-ptp-port)# vlan 100
```

Example of Tagged:

```
Router(config)# ptp clock ordinary domain 0  profile power
 Router(config-ptp-clk)# clock-port slave slave
 Router(config-ptp-port)# transport ethernet multicast interface Gi0/1/11
 Router(config-ptp-port)# vlan 100
```

Configure a Boundary clock

Use this procedure to configure the router as a boundary clock.

Disable PTP on interfaces not part of the BC clock to prevent instability caused by forwarding PTP packets. Use the `no ptp enable` command to do this.

Procedure

Step 1 Use the **enable** command to enable privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter into configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ptp clock boundary domain** *domain-number* **profile** {**power | power-2017**} command to configure the PTP clock.

Example:

```
Router(config)# ptp clock boundary domain 0  profile power-2017
```

You can create these PTP clock types:

- boundary—Terminates PTP session from Grandmaster and acts as PTP Server or Client clocks downstream.

- transparent—Updates the PTP time correction field to account for the delay in forwarding the traffic. This helps improve the acuracy of 1588 clock at client.

You can configure these profiles:

- power—Power Profile-2011
- power-2017—Power Profile-2017

Step 4 Use the **clock-port** command to define a new clock port.

Example:

```
Router(config-ptp-clk)# clock-port dyn1
```

Step 5 Use the **transport ethernet multicast interface** command to specify the transport mechanism for clocking traffic.

Example:

```
Router(config-ptp-port)# transport ethernet multicast interface Gi0/1/0
```

Example of untagged:

```
Router(config)# ptp clock boundary domain 0  profile power-2017
 Router(config-ptp-clk)# clock-port dyn1
 Router(config-ptp-port)# transport ethernet multicast interface Gi0/1/0
 Router(config-ptp-port)# exit
 Router(config-ptp-clk)# clock-port dyn2
 Router(config-ptp-port)# transport ethernet multicast interface Gi0/1/2
```

Step 6 (Optional) Use the **vlan** *vlan-id* command to configure VLAN for tagged packets.

Example:

```
Router(config-ptp-port)# vlan 100
```

Example of tagged:

```
Router(config)# ptp clock boundary domain 0  profile power-2017
 Router(config-ptp-clk)# clock-port dyn1
 Router(config-ptp-port)# transport ethernet multicast interface Gi0/1/0
 Router(config-ptp-port)# exit
 Router(config-ptp-clk)# clock-port dyn2
 Router(config-ptp-port)# transport ethernet multicast interface Gi0/1/2
 Router(config-ptp-port)# vlan 100
```

Step 7 (Optional) Use the **ptp power-2011** command under the interface configuration to continue to send power-2011 packets on that particular port even when the clock created is power-2017.

Example:

```
Router(config)# interface gi0/1/0
Router(config-if)# ptp power-2011
```

Configure a Transparent clock

Use this procedure to configure the router as a Transparent Clock (TC).

Procedure

Step 1 Use the **enable** command to enable privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter into a configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ptp clock transparent domain** *domain-number* **profile** {**power | power-2017**} command to configure a PTP clock.

Example:

```
Router(config)# ptp clock transparent domain 0  profile power
```

You can create these PTP clock types:

- boundary—Terminates PTP session from Grandmaster and acts as PTP Server or Client clocks downstream.
- transparent—Updates the PTP time correction field to account for the delay in forwarding the traffic. This helps improve the acuracy of 1588 clock at client.

You can configure these profiles:

- power—Power Profile-2011
- power-2017—Power Profile-2017

Step 4 (Optional) Use the **vlan** command to configure VLAN for tagged packets.

Example:

```
Router(config-ptp-port)# vlan 100
```

Example of untagged:

```
Router(config)# ptp clock transparent domain 0  profile power
```

Example of not including TLV Extensions: Power Profile-2011:

```
Router(config)# ptp clock transparent domain 0 profile power
Router(config-ptp-port)# allow-without-tlv
```

Example of not including TLV Extensions: Power Profile-2017:

```
Router(config)# ptp clock transparent domain 0 profile power-2017
Router(config-ptp-port)# allow-without-tlv
```

Generalized Precision Time Protocol

Generalized Precision Time Protocol (gPTP) is an IEEE 802.1AS standard that synchronizes clocks in bridges and endpoint devices within an AVB network. It defines a mechanism (BMCA) to elect the grandmaster clock among time-aware bridges, the talker, and the listener. The grandmaster acts as the root of the timing hierarchy, distributing time to nodes below to ensure synchronization.

gPTP domain, or simply a domain, includes one or more time-aware systems and links that comply with the standard and communicate using the IEEE 802.1AS protocol. The domain defines the scope of gPTP message communication, state, operations, data sets, and timescale.

The domain number of a gPTP domain is zero.

These are two types of time-aware systems used in a gPTP domain.

- time-aware end station
- time-aware Bridge



Note IEEE 802.1AS profile supports BC type only. It does not support TC and OC-slave.



Note IEEE 802.1AS profile is not supported when GNSS is enabled on the device.

Configure a Boundary Clock

Use this procedure to configure the router as a boundary clock.

If an interface is not part of the BC clock, it operates in forward mode and exchanges PTP packets, causing instability. Use the **no ptp enable** command to disable PTP on all such interfaces.

Procedure

Step 1 Use the **enable** command to enable privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter into a configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ptp clock boundary domain** *domain-number* **profile dot1as** command to set the PTP clock domain and profile.

Example:

```
Router(config)# ptp clock boundary domain 0  profile dot1as
```

You can create these PTP clock types:

- boundary—Terminates PTP session from Grandmaster and acts as PTP Server or Client clocks downstream.

Step 4 Use the **clock-port** command to define a new clock port.

Example:

```
Router(config-ptp-clk)# clock-port dyn1
```

Step 5 Use the **transport ethernet multicast interface** command to specify the transport mechanism for clocking traffic.

Example:

```
Router(config-ptp-port)# transport ethernet multicast interface Gi0/1/0
```

Disable PTP

Use this procedure to disable PTP on an interface.

This procedure applies to both Default and Power modes.

Procedure

Step 1 Use the **configure terminal** command to enter into configuration mode.

Example:

```
Router# configure terminal
```

Step 2 Use the **interface** command to enable PTP on the interface.

Example:

```
Router(config)# interface gi0/1/1
```

Step 3 Use the **no ptp enable** command to disable the PTP on the interface.

Example:

```
Router(config-if)# no ptp enable
```

PTP multi-domain

The Cisco IR8340 Rugged Series Router supports the configuration of up to four distinct clock domains, each with different profiles and roles. While it allows multiple Boundary Clock (BC) or Ordinary Clock (OC) domains, it supports only one Transparent Clock (TC) domain at a time.

Use the **show run | sec ptp** command to view the PTP multi-domain configuration.

```
Router# show run | sec ptp
ptp clock boundary domain 1  profile default
 clock-port 1
  transport ipv4 multicast interface Gi0/1/0
ptp clock boundary domain 2  profile power
 clock-port mas
  transport ethernet multicast interface Gi0/1/1
ptp clock ordinary domain 3  profile default
 clock-port sl slave
  transport ipv4 multicast interface Gi0/1/2
ptp clock transparent domain 4  profile power
```

GMC-BC time source

You can configure GMC-BC time source in three ways:

- Source selection
- Source from NTP domain
- Source from PTP domain

Note

- GMC-BC source selection priority <0-2>.
- GMC-default takes time source only from NTP, IRIG-B, handset, or internal oscillator.

Configure GMC-BC time source selection

Use this procedure to configure Boundary time source selection in GMC.

Before you begin

Note The **gmc-default**/**gmc-bc** configs are not allowed if the device is in PRTC/Telecom mode.

Procedure

Step 1 Use the **configure** command to enter into configuration mode.

Example:

```
Router# configure
```

Step 2 Use the **ptp clock boundary domain** *domain-number* **profile default** command to enable the default profile boundary mode.

Example:

```
Router(config)# ptp clock boundary domain 0 profile default
```

Step 3 Use the **gmc-default** command to enable the Grandmaster Clock (GMC) boundary clock.

Example:

```
Router(config-ptp-clk)# gmc-default
```

Configure GMC-BC time source from NTP domain

Use this procedure to configure GMC-Boundary time source from NTP domain.

Before you begin

For configuring PTP as source for NTP reference, see NTP Timing Based on PTP Clock.

Procedure

Step 1 Use the **configure** command toenter into configuration mode.

Example:

```
Router# configure
```

Step 2 Use the **ptp clock boundary domain** *domain-number* **profile default** command to enable the default profile boundary mode.

Example:

```
Router(config)# ptp clock boundary domain 0 profile default
```

Step 3 Use the **gmc-bc source** command to force PTP-BC clock to get time source from NTP.

Example:

```
Router(config-ptp-clk)# gmc-bc source 1 ntp
```

Configure GMC-BC time source from PTP domain

Use this procedure to configure GMC-BC time source from PTP domain.

Procedure

Step 1 Use the **configure** command toenter into configuration mode.

Example:

```
Router# configure
```

Step 2 Use the **ptp clock boundary domain** *domain-number* **profile default** command to enable the default profile boundary mode.

Example:

```
Router(config)# ptp clock boundary domain 0 profile default
```

Step 3 Use the **gmc-bc source** command to force PTP-BC clock to get time source from PTP domain 1.

Example:

```
Router(config-ptp-clk)# Gmc-bc source 0 ptp domain 1
```

GNSS as a reference to PTP

GNSS serves as a reference source for PTP when it operates in PRTC mode, is locked, and the Telecom profile is not configured.

Configure the GNSS status

This task configures the Ethernet Synchronization Messaging Channel (ESMC), network-clock synchronization, and Precision Time Protocol (PTP) settings required for GNSS operation, and provides show commands to verify the GNSS status.

To configure the GNSS status, follow these steps:

Procedure

Step 1 Use the **configure terminal** command to enter the global configuration mode.

Example:

```
Router# configure terminal
```

Step 2 Use the **esmc process** command to enable the Ethernet Synchronization Messaging Channel (ESMC) process.

Example:

```
Router(config)# esmc process
```

Step 3 Use the network clock commands as given:

a) Use the **network-clock synchronization automatic** command to enable automatic network-clock synchronization.

Example:

```
Router(config)# network-clock synchronization automatic
```

b) Use the **network-clock synchronization mode QL-enabled** command to set the network-clock synchronization mode to quality-level (QL) enabled.

Example:

```
Router(config)# network-clock synchronization mode QL-enabled
```

c) Use the **network-clock quality-level rx** *quality-level* **External** *slot-identifier frequency-type* command to set the received quality level to QL-PRC for the external R0 1 Hz source.

Example:

```
Router(config)# network-clock quality-level rx QL-PRC External R0 1hz
```

d) Use the **network-clock input-source** *priority* **External** *slot-identifier frequency-type* command to set the network input source.

Example:

```
Router(config)# network-clock input-source 1 External R0 1hz
```

Step 4 Use the **ptp clock boundary domain** *domain-number* **profile default** command to set the boundary clock domain and profile.

Example:

```
Router(config)# ptp clock boundary domain 0 profile default
```

Step 5 Use the **clock-port master** command to set the clock port as primary.

Example:

```
Router(config-ptp-clk)# clock-port master
```

Step 6 Use the **transport ipv4 multicast interface** *interface* command to set the IPv4 multicast interface for transport traffic.

Example:

```
Router(config-ptp-port)# transport ipv4 multicast interface GigabitEthernet 0/1/6
```

Step 7 (Optional) Use the **show ptp clock dataset default** command to verify the dataset.

Example:

```
Router# show ptp clock dataset default
            CLOCK [Boundary Clock, domain 0]
            Profile: default
            Two Step Flag: Yes
            Clock Identity: 0xB8:A3:77:FF:FE:1E:5F:E3
            Number Of Ports: 1
            Priority1: 128
            Priority2: 128
            Domain Number: 0
            Slave Only: No
            Clock Quality:
            Class: 6
            Accuracy: Within 100ns
            Offset (log variance): 20061
```

Step 8 (Optional) Use the **show gnss status** command to verify the GNSS status.

Example:

```
Router# show gnss status
            GNSS status:
            GNSS status: Enable
            Clock Progress: Locked
            GNSS Fix Type: time only fix
            Cable-delay: 50
            Constellation: AUTO
            Satellite count: 27
            PDOP: 99.989998  TDOP: 0.210000
            HDOP: 99.989998  VDOP: 99.989998
            Major Alarm: False
            Minor Alarm: Low Current Detected
```

Step 9 (Optional) Use the **show ptp clock dataset time-properties** command to verify the time properties.

Example:

```
Router# show ptp clock dataset time-properties
            CLOCK [Boundary Clock, domain 0]
            Current UTC Offset Valid: FALSE
            Current UTC Offset: 0
            Leap 59: FALSE
            Leap 61: FALSE
            Time Traceable: TRUE
            Frequency Traceable: TRUE
            PTP Timescale: TRUE
            Time Source: GPS
```

PTP profile configuration on WAN and LAN ports

The Cisco Catalyst IR8340 Rugged Series Router includes:

- Two WAN ports, Gig0/0/0 and Gig0/0/1, which support telecom profiles such as G.8265.1 and G.8275.1.
- Twelve LAN ports that support default, power, or dot1as PTP profiles.

When the telecom profile is configured on the Cisco Catalyst IR8340 Rugged Series Router:

- All LAN profiles act as primary clocks.
- LAN profiles derive their timing from the telecom profile.

Note The **no ptp enable** command under the interface does not work for G.8265.1 profile and has no effect on it.

PTP commands

show ptp clock

You can use these commands to verify the PTP clock configuration:

- **show ptp clock dataset parent**
- **show ptp clock dataset current**
- **show ptp clock dataset time-properties**
- **show ptp clock dataset default**
- **show ptp clock running**

This example shows the Default profile configuration:

```
Router# show ptp lan clock running
                     PTP Boundary Clock [Domain 0]  [Profile: default]
         State          Ports          Pkts sent      Pkts rcvd      Redundancy Mode
         PHASE_ALIGNED  1              7340           13877          Hot standby
```

```
                              PORT SUMMARY
                                                                    PTP Master
Name  Tx Mode      Role         Transport    State        Sessions     Port Addr
1     mcast       negotiated   Gi0/1/0     Slave        1            UNKNOWN
DUT1#
```

This example shows the Power profile configuration:

```
Router# show ptp clock running
                     PTP Boundary Clock [Domain 0]  [Profile: power]
         State          Ports          Pkts sent      Pkts rcvd      Redundancy Mode
         PHASE_ALIGNED  1              193            46             Hot standby
                              PORT SUMMARY
                                                                      PTP Master
Name  Tx Mode      Role         Transport    State        Sessions     Port Addr
1     mcast       negotiated   Ethernet     Slave        1            UNKNOWN
DUT1#
```

This example shows the 802.1AS profile configuration:

```
Router# show ptp clock running
                     PTP Boundary Clock [Domain 0]  [Profile: dot1as]
         State          Ports          Pkts sent      Pkts rcvd      Redundancy Mode
         PHASE_ALIGNED  1              1193            1146             Hot standby
                              PORT SUMMARY
                                                                      PTP Master
Name  Tx Mode      Role         Transport    State        Sessions     Port Addr
1     mcast       negotiated   Ethernet     Slave        1            UNKNOWN
DUT1#
```

show ptp

You can use these commands to verify the PTP port configuration:

- **show ptp port dataset port**
- **show ptp lan port**
- **show ptp lan port counters messages**
- **show ptp lan port counters errors**

show ptp lan

You can use these commands to verify the PTP LAN configuration:

- **show ptp lan clock**
- **show ptp lan clk-id-domain-map**
- **show ptp lan foreign-master-record**
- **show ptp lan rogue-master-record**
- **show ptp lan histogram**

  delay—Show PTP histogram of mean path delay

  offset—Show PTP histogram of offset

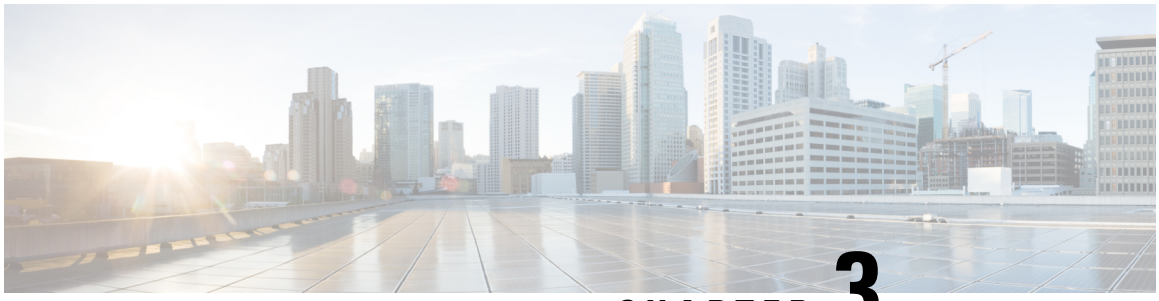
  time-error—Show PTP history of time error (last 15 days)

- show ptp lan history ?

delay—Show PTP history of mean path delay (last 15 days)

offset—Show PTP history of offset (last 15 days)

time-error—Show PTP history of time error (last 15 days)



CHAPTER 3

Network Time Protocol

Network Time Protocol (NTP) synchronizes time in a network and provides:

- synchronization of time across a network of machines, and
- UDP over IP.

NTP version 3 is defined in RFC 1305. By default, NTP services are disabled on all interfaces.

- NTP time synchronization, on page 49
- Configure NTP, on page 55
- Additional references for NTP, on page 60
- Release information for NTP, on page 61

NTP time synchronization

When multiple time sources are available, such as Virtual Integrated Network System (VINES), hardware clock, or manual configuration, NTP is considered the most authoritative and overrides time set by other methods.

An NTP network receives time from sources like a radio or atomic clock and distributes it to machines in the network.

NTP efficiently synchronizes two machines within a millisecond using just one packet per minute.

NTP time accuracy mechanisms

NTP avoids syncing with machines whose time is inaccurate in two ways.

- It ignores machines that are not synchronized.
- It compares the time that it received from multiple machines and skips any machine whose time significantly differs from others, even if it has a lower stratum. This method creats a self-organizing tree of NTP servers.

NTP stratum levels

To maintain hierarchical accuracy, NTP uses stratum levels to define the distance of a device from an authoritative time source, ensuring precise synchronization across the network. For example:

- A stratum 1 server has a direct source like a radio, atomic clock, or Global Positioning System (GPS).

- A stratum 2 server gets time from a stratum 1 server.

NTP software

Some manufacturers provide NTP software for host systems and a public version for UNIX. This software lets UNIX-based servers get time from an atomic clock and share it with our routers.

NTP features

The router does not support stratum 1 connections, such as radio or atomic clock. However, it supports GPS time sources. For network time, we recommend using public NTP servers on the internet.

If the network is isolated from the internet, the router allows a machine to act as synchronized via NTP, even if its time is set using other methods. Other machines in the network can then synchronize with it via NTP.

NTP associations

NTP communications, known as associations, are statically configured using the IP addresses of peers. Accurate timekeeping is achieved through the exchange of NTP messages between associated machines.

In a LAN, NTP can use IP broadcast messages to reduce configuration complexity. Machines send or receive broadcasts, but timekeeping is less accurate due to one-way communication.

NTP security

We recommend you to use NTP security features to prevent incorrect time settings. Two options are available to secure NTP.

- Access list restrictions.
- Encrypted authentication.

NTP access group

NTP access groups define and restrict access to NTP services using access control lists (ACLs). They:

- control which systems can communicate with the NTP server or peer by specifying access types and associating them with ACLs,
- grant or deny access to an entire network, a subnet, or a specific host within a subnet, and
- are configured using the `ntp access-group` command in global configuration mode.

Access group options and behavior

The access group options are processed from least restrictive to most restrictive:

1. ipv4—configures IPv4 access lists.
2. ipv6—configures IPv6 access lists.
3. peer—allows:
    - time requests,
    - NTP control queries, and

- the system to synchronize itself to a system whose address passes the access list criteria.

4. serve—It:
   - allows time requests and NTP control queries.
   - does not allow the system to synchronize itself to a system whose address passes the access list criteria.
5. serve-only—allows only time requests from a system whose address passes the access list criteria.
6. query-only—allows only NTP control queries from a system whose address passes the access list criteria.

If a source IP matches multiple access lists, access is granted based on the first match.

If access groups are not configured, all access types are allowed.

If access groups are configured, only specified types are allowed.

For details on NTP control queries, refer to RFC 1305 (NTP Version 3).

Encrypted NTP authentication

You can use NTP authentication for access control by verifying trusted NTP packets with authentication keys, instead of relying on IP-based access lists. The authentication process:

- Create an NTP packet with an embedded MD5-generated cryptographic checksum key and send it to the receving client.
- The client verifies the checksum against trusted keys.
- The system accepts packets that have a matching authentication key and valid timestamp information, ignoring all others.

In large networks, the Range of Trusted Key Configuration feature simplifies the configuration of multiple trusted keys.

Source IP address for NTP packets

The sending interface determines the source IP of an NTP packet. Use the **ntp source interface** command in the global configuration mode to specify the source interface.

This interface serves as the source address for all packets. Use the **source** keyword within the **ntp peer** or **ntp server** command for a specific association.

Poll-based NTP associations

Network devices with NTP operate in different association modes to synchronize time with reference sources, either by polling host servers or listening to NTP broadcasts. Poll-based association modes provide high time accuracy and reliability through regular polling of time sources.

Poll-based association modes

The poll-based association uses modes to provide a high level of time accuracy and reliability. It supports two modes.

- client, and
- symmetric active

The choice of mode depends on:

- The role of the device as a timekeeping server or client.
- The proximity of the device to a Stratum 1 timekeeping server.

The table compares NTP client mode and symmetric active mode.

Table 7: Comparison of NTP client and symmetric active modes

Feature	Client mode	Symmetric active mode
Function	The device polls its assigned time-serving hosts for the current time and synchronizes with one of them.	The device polls its assigned time-serving hosts and also responds to polls from those hosts.
Type of relationship	Client-host relationship: The host does not capture or use time information from the client.	Peer-to-peer relationship: The peers retain time-related information from the client.
Use case	Best suited for file servers and workstation clients that do not provide time synchronization to other clients.	Recommended for setups with mutually redundant servers interconnected via diverse network paths.
Typical deployment	Used by devices that require time synchronization but do not provide time services to others.	Commonly used by stratum 1 and stratum 2 servers on the internet.
Command to configure	Use the **ntp server** command to specify the time server and set the device to operate in client mode.	Use the **ntp peer** command to specify the time-serving hosts and set the device to operate in symmetric active mode.

Polling considerations

Devices engage in polling when operating as a:

- client or a host in client mode, or
- peer in symmetric active mode.

Usually, polling has minimal impact on memory, CPU, and bandwidth resources. However, excessive simultaneous polling can degrade system or network performance.

To avoid performance issues:

- limit the number of direct peer-to-peer or client-to-server associations, and
- use NTP broadcasts to propagate time information within a localized network.

Broadcast-based NTP association

Broadcast-based NTP association lets you passively receive time updates from NTP servers. This is efficient for localized networks and it is:

- suitable for networks with modest time-accuracy and reliability requirements,
- preferable with more than 20 clients in a network, and
- recommended for networks with limited bandwidth, system memory, or CPU resources.

Broadcast-based NTP functionality

In broadcast client mode:

- A device listens for NTP broadcast packets sent by broadcast time servers and does not poll servers.
- Time accuracy may be slightly reduced, as time information flows only one way.

Broadcast-based NTP configuration

Broadcast-based NTP requires these considerations:

- Use the **ntp broadcast client** command to configure a router to listen for NTP broadcast packets.
- For broadcast client mode to work:
  - The broadcast server and its clients must be on the same subnet.
  - Enable the time server to transmit NTP broadcast packets on the device interface using the **ntp broadcast** command.

NTP services on a specific interface

By default, the NTP services are disabled on all interfaces and enabled globally when any NTP command is entered.

Use the **ntp disable** command in interface configuration mode to prevent NTP packets on specific interfaces.

System as an authoritative NTP server

Use the **ntp** command in global configuration mode to configure authoritative NTP server, even without synchronization to an external time source.



Note Use the **ntp primary** command with caution, as it can easily override valid time sources, especially when configured with a low stratum number. Configuring multiple machines with the **ntp primary** command in the same network may cause timekeeping instability if they do not agree on the time.

Recommendations for NTP

NTP configuration guidelines and restrictions ensure secure, accurate, and reliable implementation in your network, providing consistency and preventing vulnerabilities.

Configuration guidelines

These guidelines explain how to configure the feature for proper operation and security.

- Use the **ntp allow mode private** command to process NTP mode 7 packets, which are disabled by default.
- Use the **show running-config | include ntp** command to check if a device is configured with NTP or not. If the output contains any of these commands, then that device is vulnerable:
  - **ntp broadcast client**
  - **ntp primary**
  - **ntp multicast client**
  - **ntp peer**
  - **ntp server**

Usage guidelines

These guidelines provide recommendations for using the feature effectively in different scenarios.

- For more information on understanding Cisco software releases, see the White Paper: Cisco IOS and NX-OS Software Reference Guide.
- The **ntp refclock gps** command is supported only in the Primary Reference Time Clock (PRTC) mode.
- To mitigate the vulnerability, disable NTP as a workaround. Only configured IP packets can exploit the vulnerability. Transit traffic is not affected.

Restrictions

NTP authentication comes with certain considerations for efficient usage. These are the performance and synchronization considerations.

- Encryption and decryption in NTP authentication are CPU-intensive and may reduce time accuracy.
- Use access lists for less resource-intensive access control, if your network allows it.
- Once NTP authentication is configured, the router synchronizes and provides time only to trusted sources.

To reduce security risks and ensure reliable operation, by default:

- NTP services are disabled on all interfaces.
- The `Line Aux 0` option is disabled.

To reduce security vulnerabilities and minimize risks:

- Cisco software supporting NTPv4 is unaffected; earlier versions are vulnerable.

- NTP versions 4.2.4p7 and earlier are vulnerable to unauthenticated remote attacks that may cause a Denial of Service (DoS) condition.
- NTP peer authentication is not a workaround and remains a vulnerable configuration.
- When NTP debugging is enabled, the message "`NTP: Receive: dropping message: Received NTP private mode 7 packet`" may appear, indicating the issue.

Configure NTP

NTP configuration includes:

- Configure poll-based NTP associations
- Configure broadcast-based NTP associations
- Configure an external reference clock
- Configure NTP authentication

Configure poll-based NTP associations

Use this procedure to configure poll-based NTP associations.

Procedure

Step 1 Use the **enable** command to enable the privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ntp peer** command to form a peer association with another system.

Example:

```
Router(config)# ntp peer 192.168.10.1 normal-sync version 2 prefer
```

The syntax of the command is: **ntp peer***ip-address* [**normal-sync**] [**version** *number*] [**key** *key-id*] [**prefer**]

Table 8: syntax description

ntp peer	Creates a symmetric NTP association with a peer.
ip-address	IPv4 or IPv6 address of the NTP peer.

normal-sync	Uses standard NTP sync behavior (no fast or accelerated sync modes).
version *number*	NTP protocol version (1–4). Default value is 4.
key *key-id*	Authentication key ID to use (must be preconfigured).
prefer	Marks this peer as preferred during clock selection.

Step 4 Use the **ntp server** command to form a server association with another system.

Example:

```
Router(config)# ntp server 192.168.10.1 version 2 prefer
```

The syntax of the command is: **ntp server** *ip-address* [**version** *number*] [**key** *key-id*] [**prefer**]

Table 9: Syntax description

Keyword	description
ntp server	Adds an NTP server for time synchronization.
ip-address	IPv4 or IPv6 address of the NTP server.
version *number*	NTP protocol version to use (1–4). Default value is 4.
key *key-id*	Uses the specified authentication key ID (must be preconfigured).
prefer	Marks this server as the preferred source during clock selection.

Step 5 Use the **end** command to exit global configuration mode and returns to privileged EXEC mode.

Example:

```
Router(config)# end
```

Configure broadcast-based NTP associations

Use this procedure to configure broadcast-based NTP associations.

Procedure

Step 1 Use the **enable** command to enable privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **interface** command to configure an interface and enter interface configuration mode.

Example:

```
Router(config)# interface GigabitEthernet 0/0/0
```

Step 4 Use the **ntp broadcast version** command to configure the specified interface to send NTP broadcast packets.

Example:

```
Router(config-if)# ntp broadcast version 2
```

Step 5 Use the **ntp broadcast client** command to configure the specified interface to receive NTP broadcast packets.

Example:

```
Router(config-if)# ntp broadcast client
```

Step 6 Use the **ntp broadcastdelay** command to adjust the estimated round-trip delay for NTP broadcasts.

Example:

```
Router(config-if)# ntp broadcastdelay 100
```

Step 7 Use the **end** command to exit the interface configuration mode and return to privileged EXEC mode.

Example:

```
Router(config)# end
```

Configure an external reference clock

Use this procedure to configure an external reference clock for synchronization.

Procedure

Step 1 Use the **enable** command to enable the privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **line aux** command to enter line configuration mode for the auxiliary port 0.

Example:

```
Router(config)# line aux 0
```

Step 4 Use the **end** command to exit line configuration mode and returns to privileged EXEC mode.

Example:

```
Router(config-line)# end
```

Step 5 (Optional) Use the **show ntp associations** command to view the status of NTP associations, including the status of the GPS reference clock.

Example:

```
Router# show ntp associations
```

Step 6 (Optional) Use the **show ntp status** command to view the status of NTP.

Example:

```
Router# show ntp status
```

Step 7 (Optional) Use the **debug ntp refclock** command to check the reference clock activities.

Example:

```
Router# debug ntp refclock
```

Configure NTP authentication

Use this procedure to configure NTP authentication.

Procedure

Step 1 Use the **enable** command to enable privileged EXEC mode.

Example:

```
Router> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ntp authenticate** command to enable the NTP authentication.

Example:

```
Router(config)# ntp authenticate
```

Step 4 Use the **ntp authentication-key** command to define authentication keys.

Example:

```
Router(config)# ntp authentication-key 1 md5 key1
```

Each key is defined by a key number, a type, and a value.

Step 5 Use the **ntp trusted-key** command to define trusted authentication keys.]

Example:

```
Router(config)# ntp trusted-key 1 - 3
```

If a key is trusted, this device can synchronize with a system that uses this key in its NTP packets.

Step 6 Use the **ntp server** command to synchronize the software clock with an NTP time server.

Example:

```
Router(config)# ntp server 172.16.22.44 key 2
```

Step 7 Use the **end** command to exit global configuration mode and returns to privileged EXEC mode.

Example:

```
Router(config)# end
```

Additional references for NTP

This table lists the NTP reference documents.

Table 10: NTP reference documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases Guide
Basic System Management commands	Basic System Management Command Reference
NTPv4 in IPv6	*Cisco IOS Basic System Management Guide*
IP extended access lists	*Cisco IOS IP Addressing Configuration Guide*
IPX extended access lists	*Novell IPX Configuration Guide*
NTP package vulnerability	*Network Time Protocol Package Remote Message Loop Denial of Service Vulnerability (DoS)*
Cisco IOS and NX-OS software releases	*'White Paper: Cisco IOS and NX-OS Software Reference Guide*

Standards and RFCs

Standard/RFCs	Title
RFC 1305	*Network Time Protocol (Version 3) Specification, Implementation and Analysis*

Technical assistance

Description	Link
The Cisco technical documentation website provides online resources for downloading documentation, software, and tools. Use these resources to install and configure the software. Troubleshoot and resolve technical issues with Cisco products and technologies using these resources. Access to most tools on the Cisco technical documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Additional references for NTP

This table lists the NTP reference documents.

Table 11: NTP reference documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases Guide
Basic System Management commands	Basic System Management Command Reference
NTPv4 in IPv6	*Cisco IOS Basic System Management Guide*
IP extended access lists	*Cisco IOS IP Addressing Configuration Guide*
IPX extended access lists	*Novell IPX Configuration Guide*
NTP package vulnerability	*Network Time Protocol Package Remote Message Loop Denial of Service Vulnerability (DoS)*
Cisco IOS and NX-OS software releases	*'White Paper: Cisco IOS and NX-OS Software Reference Guide*

Standards and RFCs

Standard/RFCs	Title
RFC 1305	*Network Time Protocol (Version 3) Specification, Implementation and Analysis*

Technical assistance

Description	Link
The Cisco technical documentation website provides online resources for downloading documentation, software, and tools. Use these resources to install and configure the software. Troubleshoot and resolve technical issues with Cisco products and technologies using these resources. Access to most tools on the Cisco technical documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

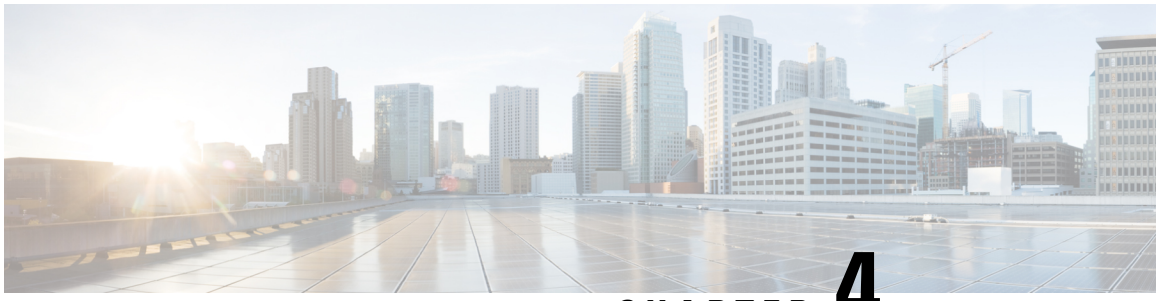
Release information for NTP

This table shows the software release that introduced each feature and lists later releases in the same train supporting the feature unless stated otherwise.

Table 12: Feature information

Feature Name	Feature Information
Network Time Protocol	NTP is a protocol designed to time-synchronize a network of machines. NTP runs on UDP, which in turn runs on IP. NTP is documented in RFC 1305.

You can use Cisco Feature Navigator to find platform and software image support information at www.cisco.com/go/cfn. A Cisco.com account is not required.



CHAPTER 4

NTP time synchronization with PTP clock

Network Time Protocol (NTP) time synchronization with a Precision Time Protocol (PTP) clock provides:

- Precise time distribution across network devices.
- High accuracy using PTP as a stratum 0 reference clock.

- PTP as NTP reference clock, on page 63
- Timing Card as NTP reference clock, on page 65
- GPS as NTP reference clock, on page 67

PTP as NTP reference clock

Starting from Cisco IOS-XE Release 17.9.1, Cisco Catalyst IR8340 Rugged Series Routers support NTP time synchronization with PTP clock. A Network Advantage license is required for this support.

PTP time serves as a stratum 0 source, while the Cisco IOS NTP server functions as a stratum 1 device. The server provides clock information to its NTP clients at stratum 2 and 3.

Configure PTP reference clock

The PTP as a reference clock to NTP is disabled by default. Cisco Catalyst IR8340 Rugged Series Routers support this feature with PTP Default, Power, and 802.AS profiles. Telecom profiles (8265.1 or 8275.1) as sources are not supported. NTP can use only one reference at a time either GNSS or PTP.

Before you begin

Configure the PTP and verify that it is in client mode.

Procedure

Step 1 Use the **configure terminal** command to enter into the configuration mode.

Example:

```
Router# configure terminal
```

Step 2 Use the **ntp master** command to configure the master clock as NTP.

Example:

```
Router(config)# ntp master
```

Step 3 Use the **ntp refclock ptp** command to configure PTP as a reference clock.

Example:

```
Router(config)# ntp refclock ptp
```

You can use the **no** form of the command to disable this feature.

```
Router(config)# no ntp refclock ptp
```

Step 4 (Optional) Use the **show run** command to monitor the PTP reference clock configuration.

Example:

```
Router# show run | sec ptp|ntp
ntp refclock ptp
ptp clock boundary domain 0  profile power
 clock-port 1
  transport ethernet multicast interface Gi0/1/4
```

Step 5 (Optional) Use the **show ptp clock running** command to monitor the PTP mode status.

Example:

```
Router# show ptp clock running
                    PTP Boundary Clock [Domain 0]  [Profile: power]
         State          Ports          Pkts sent      Pkts rcvd      Redundancy Mode
         PHASE_ALIGNED  1              629978         633            Hot standby
                              PORT SUMMARY
                                                                        PTP Master
Name  Tx Mode      Role         Transport    State         Sessions     Port Addr
1     mcast        negotiated   Ethernet     Slave         1            UNKNOWN
```

Step 6 (Optional) Use the **show ntp status** command to monitor the NTP status.

Example:

```
Router# show ntp status
Clock is synchronized, stratum 1, reference is .PTP.
nominal freq is 250.0000 Hz, actual freq is 249.9998 Hz, precision is 2**10
ntp uptime is 28233900 (1/100 of seconds), resolution is 4016
reference time is E6161FA8.FFBE7988 (08:26:16.999 UTC Fri Apr 29 2022)
clock offset is 0.9998 msec, root delay is 0.00 msec
root dispersion is 3940.49 msec, peer dispersion is 3938.47 msec
loopfilter state is 'CTRL' (Normal Controlled Loop), drift is 0.000000856 s/s
system poll interval is 64, last update was 4 sec ago.
```

Step 7 (Optional) Use the **show ptp lan clock** command to monitor PTP and NTP synchronization status.

Example:

```
Router# show ptp lan clock | inc time
Local clock time: 2022-4-29 8:48:39 UTC
```

Step 8 (Optional) Use the **show clock detail** command to monitor the clock information.

Example:

```
Router# show clock detail
08:48:39.278 UTC Fri Apr 29 2022
Time source is NTP
```

Step 9 (Optional) Use the command to check the amount of time the platform takes to switch to the next available timing source after the initial timing source goes down.

Example:

```
Router# show ntp association detail
127.127.6.1 configured, ipv4, our_master, sane, valid, stratum 0
ref ID .PTP., time E61622E9.00000000 (08:40:09.000 UTC Fri Apr 29 2022)
our mode active, peer mode passive, our poll intvl 256, peer poll intvl 1024
root delay 0.00 msec, root disp 0.00, reach 377, sync dist 4.62
delay 0.00 msec, offset 0.9998 msec, dispersion 2.81, jitter 0.97 msec
precision 2**10, version 4
assoc id 63756, assoc name 127.127.6.1
assoc in packets 11, assoc out packets 17652, assoc error packets 0
org time E61622E8.FFBE7988 (08:40:08.999 UTC Fri Apr 29 2022)
rec time 00000000.00000000 (00:00:00.000 UTC Mon Jan 1 1900)
xmt time E61622E8.FFBE7988 (08:40:08.999 UTC Fri Apr 29 2022)
filtdelay = 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
filtoffset = 0.99 1.99 0.99 0.99 0.99 0.99 1.99 0.99
filterror = 0.97 2.89 4.81 6.73 8.65 10.57 11.53 12.49
minpoll = 4, maxpoll = 10
```

In this example, the NTP waits 8x256 seconds to switch over to the next source.

PTP as NTP reference clock commands

These are the PTP commands to use when PTP acts as an NTP reference clock.

Table 13: PTP debug commands

Command	Description
ntp logging	Enables syslogs from NTP.
debug ntp all	Provides the complete debugging logs for NTP processes.
debug platform software pd-ptp all	Provides debugging logs on the switch relating to PTP as a reference clock.
show ntp status	Shows detailed NTP status, including whether NTP is using PTP as its reference clock.
show ntp association detail	Shows detailed information about NTP peering.
show ptp clock running	Verify PTP's secondary mode by checking its phase-aligned state and its lock to a primary clock.

Timing Card as NTP reference clock

Timing Card as NTP reference clock provides:

- enhanced precision compared to the system oscillator, and

- a seamless fallback to the Timing Card's time when Global Navigation Satellite System (GNSS) is unlocked or disabled.

NTP polls the Timing Card for time at predefined intervals. If GNSS becomes unavailable or is disabled, the router automatically switches to the Timing Card for time synchronization.

Configure Timing Card reference clock

You can configure the Timing Card as a reference clock for NTP.

Procedure

Step 1 Use the **configure terminal** command to enter configuration mode.

Example:

```
Router# configure terminal
```

Step 2 Use the **ntp master** command to configure the master clock for NTP.

Example:

```
Router(config)# ntp master
```

Step 3 Use the **ntp refclock timing-card** command to configure the Timing Card as a reference clock.

Example:

```
Router(config)# ntp refclock timing-card
```

Step 4 (Optional) Use the **show ntp status** command to monitor the NTP status.

Example:

```
Router# show ntp status
 Clock is synchronized, stratum 4, reference is 127.127.7.1
 nominal freq is 250.0000 Hz, actual freq is 249.9997 Hz, precision is 2**10
 ntp uptime is 6200 (1/100 of seconds), resolution is 4016
 reference time is E8DB7E3A.DC6A8158 (15:36:50.861 IST Thu Oct 19 2023)
 clock offset is 1.0000 msec, root delay is 0.00 msec
 root dispersion is 3940.44 msec, peer dispersion is 3938.29 msec
 loopfilter state is 'CTRL' (Normal Controlled Loop), drift is 0.000001064 s/s
 system poll interval is 16, last update was 11 sec ago.
```

Step 5 (Optional) Use the **show ntp associations** command to monitor the NTP associations.

Example:

```
Router# show ntp associations
address ref clock st when poll reach delay offset disp
~192.2.1.1 .LOCL. 7 14 16 7 0.000 0.000 1938.4
*~127.127.7.1 .TCLO. 3 15 16 3 0.000 1.000 3938.2
* sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```

GPS as NTP reference clock

GPS as NTP reference clock ensures that it:

- Receives time from GNSS, where GNSS acts as a Stratum 0 reference clock and provides the time as a Stratum 1 server through NTP.
- Provides continuous synchronization from GNSS when it is locked and stable, even if other Stratum 1 servers are available through NTP peers.
- Automatically falls back to a reachable NTP server using NTP peers when GNSS is not available.

Configure NTP using GPS time

You can configure the GPS time as the reference clock for NTP.

The GPS time serves as a Stratum 0 source, while the Cisco IOS NTP server functions as a Stratum 1 device, distributing clock information to its NTP clients at Stratum 2 and Stratum 3.

Procedure

Step 1 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Router# configure terminal
```

Step 2 Use the **ntp refclock gps** command to configure the NTP reference clock as GPS.

Example:

```
Router(config)#ntp refclock gps
```

Step 3 (Optional) Use the **show ntp status** command to monitor the NTP status.

Example:

```
Router# show ntp status
Clock is synchronized, stratum 1, reference is .GPS.
nominal freq is 250.0000 Hz, actual freq is 249.9970 Hz, precision is 2**10
ntp uptime is 94000 (1/100 of seconds), resolution is 4016
reference time is E31778F3.0B851ED8 (19:58:43.045 GMT Thu Sep 24 2020)
clock offset is 11.0000 msec, root delay is 0.00 msec
root dispersion is 3950.55 msec, peer dispersion is 3938.47 msec
loopfilter state is 'CTRL' (Normal Controlled Loop), drift is 0.000011995 s/s
system poll interval is 64, last update was 7 sec ago.
```

Step 4 (Optional) Use the **show ntp associations** command to monitor the NTP status.

Example:

```
Router# show ntp associations
address ref clock st when poll reach delay offset disp
*~127.127.5.1 .GPS. 0 38 64 7 0.000 11.000 1938.8
* sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```

Step 5 (Optional) Use the **show clock** command to view the clock information.

Example:

```
Router# show clock
20:00:43.660 GMT Thu Sep 24 2020
```

Step 6 (Optional) Use the **debug ntp refclock** command to check the NTP reference clock configuration messages in the log.

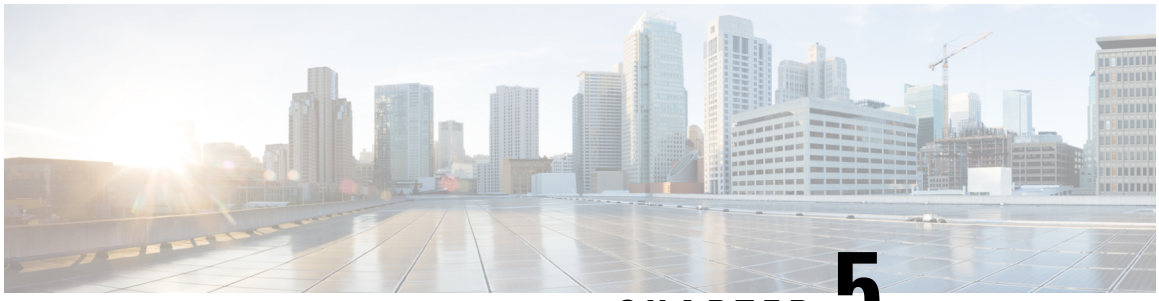
Example:

```
Router# debug ntp refclock
*Sep 24 19:58:43.045 GMT: GPS: Poll Requested
*Sep 24 19:58:43.045 GMT: GPS (19:58:43.056 GMT Thu Sep 24 2020)
*Sep 24 19:58:43.045 GMT: Valid time rcvd from GPS: 2020/09/24 19:58:43.056 (frac = 0x0E560440)
*Sep 24 19:58:43.045 GMT: RTS poll timestamp (local clock) was 0xE31778F3.0B851ED8
*Sep 24 19:58:43.045 GMT: GPS timestamp is 0xE31778F3.0E560440
*Sep 24 19:58:43.045 GMT: NTP Core(NOTICE): ntpd PPM
*Sep 24 19:58:43.046 GMT: NTP Core(NOTICE): trans state : 5
*Sep 24 19:58:43.046 GMT: NTP Core(NOTICE): Clock is synchronized.
```

The syntax of the command: **debug ntp {adjust | all | core | events | packet | refclock}**

Table 14: Syntax description

Keyword of the command	Description
adjust	NTP clock adjustments information
all	All levels of debugging for NTP
core	Core messages of NTP
events	Events of NTP
packet	NTP packets
refclock	Reference Clock messages



CHAPTER 5

G.8265.1 profile

The G.8265.1 is a frequency distribution profile that:

- ensures accurate clock quality level (QL) representation through clock advertisement,
- uses an alternate BMCA for precise clock and port state selection,
- statically assigns primary or secondary roles for reliable operation,
- supports higher packet rates for improved performance compared to IEEE 1588-2008,
- enhances scalability and reliability by using IPv4 unicast communication, and
- restricts clock types and domain numbers for streamlined network operation.

- G.8265.1 profile features, on page 69
- Configure G.8265.1 server and client Ordinary Clock, on page 71

G.8265.1 profile features

G.8265.1 specifies PTP deployment in telecom networks to provide precise and dependable time synchronization through:

- clock functions
- Port configuration and behavior
- network and transmission requirements.

Clock functions

G.8265.1 clock functions are:

- Clock advertisement: G.8265.1 updates Announce messages for PTP clocks. It uses the clock class value to advertise clock QL and ignores other values.
- Clock selection: G.8265.1 defines an alternate Best Master Clock Algorithm (BMCA) to select port states and clocks. It requires Sync messages (and optionally Delay-Response messages) to qualify a clock for selection.

- Clock types: G.8265.1 supports only ordinary clocks, each with a single PTP port. For a G.8265.1 secondary, all PTP ports on a device operate independently, with clock selection functioning separately for each Ordinary Clock.

Port configuration and behavior

G.8265.1 port configurations are:

- Port state decision: Ports are statically configured as primary or secondary and bypass the FSM for dynamic port state selection.
- Port numbers: G.8265.1 requires that all PTP port numbers be set to 1, since all clocks in the network are ordinary clocks as per G.8265.1.

Network and transmission requirements

G.8265.1 network and transmission requirements are:

- Packet rates: Packet rates exceed those specified in the IEEE 1588-2008 standard include:
  - Sync or Follow-Up packets: Average packet rates range from 128 packets per second to 16 seconds per packet.
  - Delay-Req or Delay-Resp packets: Average packet rates range from 128 packets per second to 16 seconds per packet.
  - Average packets: Average packet rates range from eight packets per second to 64 seconds per packet.
- Transport mechanism: G.8265.1 limits the PTP transport mechanism to IPv4 and mandates unicast transmission for all packets instead of multicast.
- Domain numbers: G.8265.1 limits domain numbers to the range from 4 to 23, with a default of 4.
- Supported clocks: G.8265.1 supports only primary and secondary clocks, excluding boundary and transparent clocks.

G.8265.1 profile map

This table maps Synchronization Status Messaging (SSM) Quality Levels (QL) codes to ITU-T G.781 synchronization quality levels and their corresponding clock classes for G.8265.1-compliant networks.

Table 15: G.8265.1 Profile Mapping

SSM QL	ITU-T G.781			Clock Class
—	Option I	Option II	Option III	—
0001	—	QL-PRS	—	80
0000	—	QL-STU	QL-UNK	82
0010	QL-PRC	—	—	84

SSM QL	ITU-T G.781			Clock Class
0111	—	QL-ST2	—	86
0011	—	—	—	88
0100	QL-SSU-A	QL-TNC	—	90
0101	—	—	—	92
0110	—	—	—	94
1000	QL-SSU-B	—	—	96
1001	—	—	—	98
1101	—	QL-ST3E	—	100
1010	—	QL-ST3 or QL-EEC2	—	102
1011	QL-SEC/QL-EEC1	—	QL-SEC	104
1100	—	QL-SMC	—	106
1110	—	QL-PROV	—	108
1111	—	QL-DUS	—	110

Restrictions for G.8265.1 profile

G.8265.1 doesn't support on

- sub-interface
- vrf interface
- port-channel interface

Configure G.8265.1 server and client Ordinary Clock

G.8265.1 server configuration includes:

- Server configuration to operate as an Ordinary clock
- Client configuration to operate as an Ordinary clock
- PTP commands

Configure a server to operate as an ordinary clock

Perform these steps to configure a server as an ordinary clock within a network setup to ensure correct time synchronization among devices.

Procedure

Step 1 Use the**enable** command to enter into EXEC mode.

Example:

```
Router# enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter into configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ptp clock ordinary domain** command to configure the PTP ordinary clock.

Example:

```
Router(config)# ptp clock ordinary domain 4 profile g8265.1
```

Configures the PTP ordinary clock. The **profile** keyword configures the clock to use the G.8265.1 profile. Using a telecom profile requires that the clock have a domain number of 4–23.

Step 4 Use the **priority1** command to set the preference-level for the server clock.

Example:

```
Router(config-ptp-clk)# priority1 priorityvalue
```

Sets the preference level for a clock. Client devices use the priority1 value when selecting a server clock: a lower priority1 value indicates a preferred clock. The priority1 value is considered above all other clock attributes.

Valid values are from 0-255. The default value is 128.

Step 5 Use the **priority2** command to set a secondary preference level for a clock when router is unable to use **priority1** value.

Example:

```
Router(config-ptp-clk)# priority1 priorityvalue
```

Sets a secondary preference level for a clock. Subordinate devices use the priority2 value when selecting a server clock: a lower priority2 value indicates a preferred clock. The priority2 value is considered only when the router cannot use priority1 and other clock attributes to select a clock.

Valid values are from 0-255. The default value is 128.

Step 6 Use the **clock-port** command to set the clock port to PTP server mode.

Example:

```
Router(config-ptp-clk)# clock-port master master
```

Step 7 Use the **transport ipv4 unicast interface** command to specify the transport mechanism for clocking traffic.

Example:

```
Router(config-ptp-port)# transport ipv4 unicast interface GigabitEthernet 0/0/0 negotiation
```

A Loopback interface can be used as well as the WAN ports.

The client router IP address should be reachable via the WAN interface (GigabitEthernet 0/0/0 or GigabitEthernet 0/0/1) so that PTP packets can be sent or received on the WAN ports.

The **negotiation** keyword configures the router to discover a PTP server clock from all available PTP clock sources.

Step 8 Use the **sync interval** command to specify the interval used to send PTP synchronization messages.

Example:

```
Router(config-ptp-port)# sync interval -4
```

The intervals are set using log base 2 values, and they are:

- 1: one packet every 2 seconds
- 0: one packet every second
- -1: one packet every 1/2 second, or 2 packets per second
- -2: one packet every 1/4 second, or 4 packets per second
- -3: one packet every 1/8 second, or 8 packets per second
- -4: one packet every 1/16 seconds, or 16 packets per second.
- -5: one packet every 1/32 seconds, or 32 packets per second.
- -6: one packet every 1/64 seconds, or 64 packets per second.
- -7: one packet every 1/128 seconds, or 128 packets per second.

Step 9 Use the **announce interval** command to specify the interval for PTP announce message.

Example:

```
Router(config-ptp-port)# announce interval 2
```

The intervals are set using log base 2 values, and they are:

- 3: one packet every 8 seconds
- 2: one packet every 4 seconds
- 1: one packet every 2 seconds
- 0: one packet every second
- -1: one packet every 1/2 second, or 2 packets per second
- -2: one packet every 1/4 second, or 4 packets per second
- -3—1 packet every 1/8 second, or 8 packets per second

Step 10 Use the **end** command to exit the configuration mode.

Example:

```
Router(config-ptp-port)# end
```

Configure a client to operate as an Ordinary Clock

Perform these steps to configure a client as an ordinary clock within a network setup to ensure correct time synchronization among devices.

Procedure

Step 1 Use the**enable** command to enter into EXEC mode.

Example:

```
Router# enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter into configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **ptp clock ordinary domain** command to configure the PTP ordinary clock.

Example:

```
Router(config)# ptp clock ordinary domain 4 profile g8265.1
```

The **profile** keyword configures the clock to use the G.8265.1 profile. Using a telecom profile requires that the clock have a domain number from 4 to 23.

Step 4 Use the **clock-port** command to set the clock port to PTP client mode.

Example:

```
Router(config-ptp-clk)# clock-port client slave
```

Step 5 Use the **transport ipv4 unicast interface** command to specify the transport mechanism to clock rate.

Example:

```
Router(config-ptp-port)# transport ipv4 unicast interface GigabitEthernet 0/0/0 negotiation
```

A loopback interface can be used as well as the WAN ports.

The IP address of the server router should be reachable via the WAN interface (GigabitEthernet 0/0/0 or GigabitEthernet 0/0/1) so that PTP packets can be sent or received on the WAN ports.

The **negotiation** keyword configures the router to discover a PTP server clock from all available PTP clock sources.

Step 6 Use the **delay-req interval** command to configure the minimum interval allowed between PTP Delay-Req messages.

Example:

```
Router(config-ptp-port)# delay-req interval -4
```

The intervals are set using log base 2 values. They are:

- 3: one packet every 8 seconds
- 2: one packet every 4 seconds
- 1: one packet every 2 seconds

- 0: one packet every second
- -1: one packet every 1/2 second, or 2 packets per second
- -2: one packet every 1/4 second, or 4 packets per second
- -3: one packet every 1/8 second, or 8 packets per second
- -4: one packet every 1/16 seconds, or 16 packets per second.
- -5: one packet every 1/32 seconds, or 32 packets per second.
- -6: onepacket every 1/64 seconds, or 64 packets per second.
- -7: one packet every 1/128 seconds, or 128 packets per second.

Step 7 Use the **announce timeout** command to specify the number of PTP announcement intervals before the session times out.

Example:

```
Router(config-ptp-port)# announce timeout 8
```

Valid values are from 1 to 10.

Step 8 Use the **clock source** command to specify the address of a PTP server clock.

Example:

```
Router(config-ptp-port)# clock-source 8.8.8.1
```

Step 9 Use the **end** command to exit the configuration mode.

Example:

```
Router(config-ptp-port)# end
```

Verify the configuration

You can use these commands to verify a clocking configuration:

- show ptp clock running domain <domain no>
- show ptp clock dataset default
- show ptp clock dataset parent
- show ptp port <name of virtual port>
- show ptp wan stat stream <stream id>
- show network-clock synchronization
- show ptp port dataset port
- show ptp wan tod
- show gnss time
- show gnss status

Examples

```
Router#  show ptp clock running domain 4
                    PTP Ordinary Clock [Domain 4]  [Profile: g8265.1]
         State          Ports          Pkts sent      Pkts rcvd      Redundancy Mode
         ACQUIRING      1              1543           4680           Hot standby
                              PORT SUMMARY
                                                                      PTP Master
Name  Tx Mode      Role         Transport    State        Sessions     Port Addr
slave unicast      slave        Gi0/0/1      Slave        1            2.3.1.1
                            SESSION INFORMATION
slave [Gi0/0/1] [Sessions 1]
 Peer addr          Pkts in    Pkts out   In Errs    Out Errs
 2.3.1.1            4680       1543       0          0

Router#  show ptp clock running domain 4
                    PTP Ordinary Clock [Domain 4]  [Profile: g8265.1]
         State          Ports          Pkts sent      Pkts rcvd      Redundancy Mode
         PHASE_ALIGNED  1              44752          135639         Hot standby
                              PORT SUMMARY
                                                                       PTP Master
Name  Tx Mode      Role         Transport    State        Sessions     Port Addr
slave unicast      slave        Gi0/0/1      Slave        1            2.3.1.1
                            SESSION INFORMATION
slave [Gi0/0/1] [Sessions 1]
 Peer addr          Pkts in    Pkts out   In Errs    Out Errs
 2.3.1.1            135639     44752      0          0

Router#  show ptp clock dataset default
CLOCK [Ordinary Clock, domain 4]
  Profile: g8265.1
  Two Step Flag: No
  Clock Identity: 0x6C:03:09:FF:FE:18:5F:03
  Number Of Ports: 1
  Priority1: 128
  Priority2: 128
  Domain Number: 4
  Slave Only: Yes
  Clock Quality:
    Class: 255
    Accuracy: Unknown
    Offset (log variance): 0

Router#  show ptp clock dataset parent
CLOCK [Ordinary Clock, domain 4]
  Profile: g8265.1
  Parent Clock Identity: 0x44:B6:BE:FF:FE:42:EF:13
  Parent Port Number: 0
  Parent Stats: No
  Observed Parent Offset (log variance): 0
  Observed Parent Clock Phase Change Rate: 0
  Grandmaster Clock:
    Identity: 0x44:B6:BE:FF:FE:42:EF:13
    Priority1: 128
    Priority2: 128
    Clock Quality:
      Class: 104
      Accuracy: Unknown
      Offset (log variance): 52592

Router#  show ptp clock dataset time-properties
CLOCK [Ordinary Clock, domain 4]

  Current UTC Offset Valid: FALSE
  Current UTC Offset: 37
  Leap 59: FALSE
```

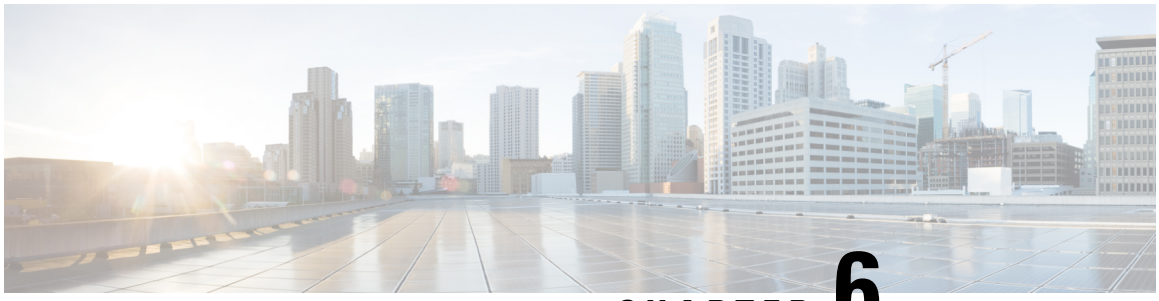
```
  Leap 61: FALSE
  Time Traceable: FALSE
  Frequency Traceable: TRUE
  PTP Timescale: TRUE
  Time Source: Internal Oscillator

Router#  show ptp port dataset port
PORT [slave]
  Clock Identity: 0x6C:03:09:FF:FE:18:5F:03
  Clock Profile: g8265.1
  Transport Interface: GigabitEthernet0/0/1
  Port Number: 1
  Port State: Slave
  Min Delay Req Interval (log base 2): -4
  Peer Mean Path Delay: 0
  Announce interval (log base 2): 1
  Announce Receipt Timeout: 3
  Sync Interval (log base 2): -5
  Delay Mechanism: End to End
  Peer Delay Request Interval (log base 2): -4
  PTP version: 2

Router#  show ptp wan stat stream 0
LOCK STATUS : PHASE LOCKED
SYNC Packet Stats
  Time elapsed since last packet: 0.0
  Configured Interval : -5, Acting Interval -5
  Tx packets : 0,  Rx Packets : 96215
  Last Seq Number : 30678,  Error Packets : 0
Delay Req Packet Stats
  Time elapsed since last packet: 0.0
  Configured Interval : -4, Acting Interval : -4
  Tx packets : 48107, Rx Packets : 0
  Last Seq Number : 0, Error Packets : 0
Delay Response Packet Stats
  Time elapsed since last packet: 0.0
  Configured Interval : -4, Acting Interval : -4
  Tx packets : 0, Rx Packets : 48107
  Last Seq Number : 48106, Error Packets : 0
Announce Packet Stats
  Time elapsed since last packet: 0.0
  Configured Interval : 1, Acting Interval : 1
  Tx packets : 0, Rx Packets :  1509
  Last Seq Number 1508 Error Packets 0
Signalling Packet Stats
  Time elapsed since last packet: 0.0
  Configured Interval : 0, Acting Interval : 0
  Tx packets : 12, Rx Packets : 12
  Last Seq Number : 0, Error Packets : 0
Current Data Set                            Units     Within tolerance?
  Offset from master :  +0.000000000       seconds          Yes
  Mean Path Delay    :  +0.000000027       seconds          Yes
  Forward Path Delay :  +0.000000027       seconds          Yes
  Reverse Path Delay :  +0.000000028       seconds          Yes
  Steps Removed 1

Router#  show ptp wan tod
PTPd ToD information:

Time: 01/05/22 11:35:21
```



CHAPTER 6

G.8275.1 Profile

G.8275.1 is a Precision Time Protocol (PTP) profile that:

- is defined for use in telecom networks,
- provides phase or time-of-day synchronization where each network device is required to participate in the PTP protocol, and
- provides PHY-layer frequency support.

PTP is defined in the IEEE 1588-2008 standard.

- Synchronization, on page 79
- Configure the G.8275.1 profile, on page 84

Synchronization

The G.8275.1 model uses hop-by-hop synchronization. Each network element on the path from primary to secondary synchronizes its local clock to upstream devices and provides synchronization to downstream devices.

G.8275.1 clock types

G.8275.1 defines three types of clocks.

- Telecom Grandmaster (T-GM)
- Telecom Time Slave Clock (T-TSC)
- Telecom Boundary Clock (T-BC)

This table compares the roles of telecom clocks.

Table 16: Role and functionality of telecom clocks

Action	Telecom Grandmaster (T-GM)	Telecom Time Slave Clock (T-TSC)	Telecom Boundary Clock (T-BC)
Timing source to other devices in the network	Acts as a primary clock	Acts as a secondary clock	Acts as a grandmaster when no higher-quality clocks are available.
Synchronization	Does not synchronize its local clock with any other network elements.	• Synchronizes its local clock to another PTP clock. • Does not provide synchronization via PTP to any other devices.	Synchronizes its local clock to a T-GM or upstream T-BC and distributes timing information to downstream T-BCs or T-TSCs
Virtual port[1]	Not supported	Not supported	Supported

[1]: A virtual port is an external frequency, phase and time input interface, which can participate in the source selection.

Virtual ports

G.8275.1 specifies virtual ports for enhanced synchronization capabilities in hybrid mode. A hybrid mode combines PTP for phase synchronization and synchronous Ethernet (SyncE) for frequency stability in telecom networks.

A virtual port is an external frequency, phase, and time input interface on a T-BC that:

- participates in source selection.
- can be configured under G.8275.1 T-BC only in hybrid mode, and
- allows the system to check the Priority2 value set in the configuration and default to 128 if none is specified.

Note Virtual port configuration is not supported for ordinary clocks or T-BCs in non-hybrid mode.

When you configure a virtual port, the router first checks for the Priority2 value in that configuration. If Priority2 is not set, it uses the default priority value of 128 from the parent dataset. If a virtual port is configured, the Priority2 setting under the higher-level clock mode is ignored.

Note Devices with a Global Navigation Satellite System (GNSS) module on the Timing Card can configure the T-BC to use a virtual port. When the GNSS locks, the virtual port provides time, phase, and frequency from the GNSS.

G.8275.1 topology for frequency and time synchronization

Summary

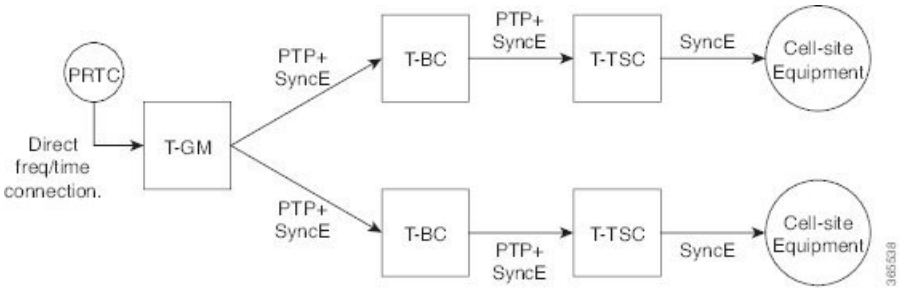
The G.8275.1 topology describes a network architecture for distributing precise frequency and time synchronization from a primary source down to cell-site equipment using PTP and SyncE.

The key components involved in the G.8275.1 topology process are:

- Primary Reference Time Clock (PRTC): Provides the primary frequency and time reference signal.
- T-GM: Receives timing from the PRTC and distributes synchronization signals using PTP and SyncE.
- T-BC: Synchronizes to an upstream clock (T-GM or another T-BC) using PTP and SyncE, and provides synchronization to downstream clocks (T-BC or Telecom Slave Clock (T-TSC)).
- T-TSC: Synchronizes to an upstream clock (T-BC) using PTP and SyncE, and provides frequency synchronization.
- Cell-site Equipment: Receives frequency synchronization from the T-TSC.

Workflow

Figure 7: G.8275.1 topology



The ITU-T G.8275.1 standard defines this topology, a PTP profile for telecom networks for precise time and frequency synchronization in mobile operations.

The process involves these stages:

1. The PRTC provides a direct frequency and time connection to the T-GM.
2. The T-GM distributes PTP and SyncE synchronization signals downstream to T-BCs.
3. T-BCs receive PTP and SyncE signals from an upstream clock (either the T-GM or another T-BC).
4. T-BCs synchronize their internal clocks based on the received signals and distribute PTP and SyncE signals further downstream to other T-BCs or T-TSCs.
5. T-TSCs synchronize their internal clocks based on the received signals.
6. T-TSCs provide SyncE frequency synchronization to the cell-site Equipment.
7. The Cell-site Equipment uses the received SyncE signal for frequency synchronization.

Result

This process ensures accurate delivery of precise frequency and time synchronization from a highly stable PRTC through the network to the end cell-site equipment.

PTP domains

G.8275.1 sets specific PTP domains to manage timing across the network once the synchronization model is in place.

A PTP domain is a network protocol management technique used in synchronized communication that:

- provides phase synchronization and time-of-day alignment across network devices,
- enables precise timing in various industrial and communication environments, and
- supports configurations such as ITU-T G.8275.1 to use in telecom networks.

G.8275.1 networks:

- do not allow devices that only forward PTP packets, such as non-participant devices and PTP transparent clocks.
- support PTP domain numbers ranging from 24 to 43, with 24 being the default.
- SyncE, though not mandatory, is commonly used to improve frequency stability for phase and time-of-day synchronization, a setup known as hybrid mode.

PTP messages and transport

To enable efficient timing synchronization, G.8275.1 specifies PTP message types and transport requirements.

G.8275.1 defines these PTP transport parameters:

- Multicast PTP over Ethernet is required. You can use either the forwardable multicast MAC address (01-1B-19-00-00-00) or the non-forwardable multicast MAC address (01-80-C2-00-00-0E). The MAC address is selected per port through configuration.
- You can use either one-step or two-step clock mode.
- Two-way PTP operation is mandatory to deliver phase and time-of-day. The Delay-Request-Response mechanism measures propagation delay, while the peer-delay mechanism is not used.
- The minimum packet rate is 8 packets-per-second for Announce messages and 16 packets per second for `Sync, Follow-Up, Delay-Req` and `Delay-Resp` messages.
- Signaling and management messages are not used.

Note G8275.1 is not supported on sub-interface, dot1q, or port-channel.

Best Master Clock Algorithm parameters and functions

G.8275.1 defines an alternate Best Master Clock Algorithm (BMCA) that each device uses to select a clock for synchronization and to determine the states of its local ports.

G.8275.1's alternate BMCA parameters are:

1. `notSlave` flag: The `notSlave` flag is a configurable boolean value for each port. It indicates whether a port can operate in secondary mode. When enabled on a port, the clock does not synchronize to any clock received on that port.
2. `Local priority`: The `Local priority` is a per-port configuration. It resolves ties when a PTP clock chooses between clocks from different ports within a single network element. The network element's local clock also has a configurable local priority.

The G.8275.1 BMCA's parameters are:

Clock characteristics and classification:

- `Clock Class`: The profile defines clock classes for compliant clocks. The clock class depends on the clock type, its traceability, and its holdover status.
- `Clock Accuracy`:

  0x21: Used by a T-GM locked to a PRTC.

  0xFE: Used by a T-GM in holdover or a T-BC.
- `Offset Scaled Log Variance`:

  0x4E5D: Used by a T-GM locked to a PRTC.

  0xFFFF: Used by a T-GM in holdover or a T-BC.

Priority and tie-breaking parameters:

1. `Priority2`: Used as in the original 1588v2 BMCA. `Priority1` is not used.
2. `Local Priority`: It is a per-port configuration. It resolves ties when a PTP clock chooses between clocks from different ports within a single network element. The network element's local clock also has a configurable local priority.
3. `Clock Identity`: It acts as a tiebreaker between clocks, as in the original 1588v2 BMCA.
4. `Steps Removed`: This value helps select between ports receiving the same clock, as in the original 1588v2 BMCA.
5. `Port Identity`: The port identity acts as a tiebreaker between ports on the same clock.

A G.8275.1 clock ignores these values in received `Announce` messages:

- alternate master, unicast, and the profile-specific members of the flag field,
- control field, and
- priority1

Configure the G.8275.1 profile

The G.8275.1 profile configuration includes:

- T-GM configuration
- T-TSC configuration
- T-BC configuration
- PTP clock commands

Configure the T-GM

You can configure the router as a Telecom Grandmaster (T-GM), distributing timing to downstream devices using GNSS as the timing source.

A PTP Ordinary Clock (PTP-OC-T-GM) can synchronize itself with an upstream Grandmaster using frequency and 1PPS inputs. It typically uses these frequencies:

- 10 MHz: Provides a stable frequency reference for clock synchronization.
- 1PPS: Provides precise timing alignment to ensure accurate phase synchronization.

Procedure

Step 1 Use the **configure** command to enter into global configuration mode.

Example:

```
Router# configure
```

Step 2 Use the **ptp clock ordinary domain 24 profile G.8275.1** command to enable PTP clock as an ordinary clock.

Example:

```
Router# ptp clock ordinary domain 24 profile telecom-g8275.1
```

- `domain 24`: Sets the PTP domain number to `24`. This ensures the router participates in the correct PTP instance, as multiple domains can coexist in a network.
- `profile telecom-g8275.1`: Applies the G.8275.1 telecom profile, which is specifically designed for phase and time synchronization in telecom networks.

Step 3 Use the **tod R0 ubx** command to configure the Time of Day (ToD) source.

Example:

```
Router(config)# tod R0 ubx
```

Step 4 Use the **input 1pps R0** command to configure the router to accept the **1PPS (Pulse Per Second)** signal from the GNSS module connected to the R0 interface.

Example:

```
Router(config)# input 1pps R0
```

Step 5 Use the **clock-port master-port master** command to configure the PTP clock port as a primary port.

Example:

```
Router(config)# clock-port master-port master
```

Step 6 Use the **transport ethernet multicast interface GigabitEthernet0/0/1** command to configure the PTP clock to use Ethernet for transport and specifies the physical interface.

Example:

```
Router(config)# transport ethernet multicast interface GigabitEthernet0/0/1
```

Step 7 Use the **end** command to exit the configuration mode and returns to the operational (privileged EXEC) mode.

Example:

```
Router(config)# end
```

Configure T-TSC

You can configure the router as a Telecom Time Slave Clock (T-TSC), distributing timing to downstream devices using GPS as the timing source.

Procedure

Step 1 Use the **configure** command to enter into global configuration mode.

Example:

```
Router# configure
```

Step 2 Use the **ptp clock ordinary domain 24 profile G.8275.1** command to enable the PTP clock as an ordinary clock.

Example:

```
Router# ptp clock ordinary domain 24 profile telecom-g8275.1
```

- `domain 24`: Sets the PTP domain number to `24`. This setting ensures the router participates in the correct PTP instance, as multiple domains can coexist in a network.
- `profile telecom-g8275.1`: Applies the G.8275.1 telecom profile, which is specifically designed for phase and time synchronization in telecom networks.

Step 3 Use the **tod R0 ubx** command to configure the Time of Day (ToD) source.

Example:

```
Router(config)# tod R0 ubx
```

Step 4 Use the **output 1pps R0** command to configure the router to generate and provide a 1PPS (Pulse Per Second) signal on the R0 interface.

Example:

```
Router(config)# output 1pps R0
```

Step 5 Use the **clock-port slave-port slave** command to configure the PTP clock port as a secondary port.

Example:

```
Router(config)# clock-port slave-port slave
```

Step 6 Use the **transport ethernet multicast interface GigabitEthernet0/0/1** command to configure the PTP clock to use Ethernet for transport and specifies the physical interface.

Example:

```
Router(config)# transport ethernet multicast interface GigabitEthernet0/0/1
```

Step 7 Use the **end** command to exit the configuration mode and return to the operational (privileged EXEC) mode.

Example:

```
Router(config)# end
```

Configure T-BC

You can configure the router as a Boundary Clock (BC) to receive time from an upstream clock and distribute it to downstream devices while maintaining precise synchronization.

Procedure

Step 1 Use the **configure** command to enter into global configuration mode.

Example:

```
Router# configure
```

Step 2 Use the **ptp clock boundary domain 24 profile G.8275.1** command to enable the PTP clock as an Boundary Clock.

Example:

```
Router# ptp clock boundary domain 24 profile telecom-g8275.1
```

- `domain 24`: Sets the PTP domain number to `24`. This ensures that the router participates in the correct PTP instance, as multiple domains can coexist in a network.
- `profile telecom-g8275.1`: Applies the G.8275.1 telecom profile, which is specifically designed for phase and time synchronization in telecom networks.

Step 3 Use the **tod R0 cisco** command to configure the Time of Day (ToD) source.

Example:

```
Router(config)# tod R0 ubx
```

Step 4 Use the **output 1pps R0** command to configure the router to generate and provide a 1PPS (Pulse Per Second) signal on the R0 interface.

Example:

```
Router(config)# output 1pps R0
```

Step 5 Use the **clock-port bc-port-1** command to function as part of the BC.

Example:

```
Router(config)# clock-port bc-port-1
```

Step 6 Use the **transport ethernet multicast interface GigabitEthernet0/0/0** command to configure the PTP clock to use Ethernet for transport and specifies the physical interface.

Example:

```
Router(config)# transport ethernet multicast interface GigabitEthernet0/0/0
```

Step 7 Use the **clock-port bc-port-2** command to function as part of the BC.

Example:

```
Router(config)# clock-port bc-port-2
```

Step 8 Use the **transport ethernet multicast interface GigabitEthernet0/0/1** command to configure the PTP clock to use Ethernet for transport and specifies the physical interface.

Example:

```
Router(config)# transport ethernet multicast interface GigabitEthernet0/0/1
```

Step 9 Use the **end** command to exit the configuration mode and return to the operational (privileged EXEC) mode.

Example:

```
Router(config)# end
```

PTP clock commands

Use these commands to verify the G.8275.1 profile configuration.

Procedure

Step 1 Use the **show ptp clock running** command to view the PTP clock configuration.

Example:

```
Router# show ptp clock running
                    PTP Ordinary Clock [Domain 24] [Hybrid] [Profile: g8275.1]
        State          Ports          Pkts sent      Pkts rcvd      Redundancy Mode
        PHASE_ALIGNED  1              1176           2946           Hot standby
                              PORT SUMMARY
                                                                  PTP Master
Name  Tx Mode      Role         Transport    State        Sessions     Port Addr
slave mcast        slave        Ethernet     Slave        1            UNKNOWN
```

Step 2 Use the **show ptp clock dataset default** command to view the default PTP clock dataset.

Example:

```
Router# show ptp clock dataset default
CLOCK [Ordinary Clock, domain 24]
  Profile: g8275.1
  Two Step Flag: No
  Clock Identity: 0x6C:03:09:FF:FE:18:5F:03
  Number Of Ports: 1
  Priority1: 128
```

```
  Priority2: 128
  Local Priority: 128
  Domain Number: 24
  Slave Only: Yes
  Clock Quality:
    Class: 255
    Accuracy: Unknown
    Offset (log variance): 65535
```

Step 3 Use the **show ptp clock dataset parent** command to view the parent PTP clock dataset.

Example:

```
Router# show ptp clock dataset parent
CLOCK [Ordinary Clock, domain 24]
  Profile: g8275.1
  Parent Clock Identity: 0x44:B6:BE:FF:FE:42:EF:13
  Parent Port Number: 0
  Parent Stats: No
  Observed Parent Offset (log variance): 0
  Observed Parent Clock Phase Change Rate: 0

  Grandmaster Clock:
    Identity: 0x44:B6:BE:FF:FE:42:EF:13
    Priority1: 128
    Priority2: 128
    Clock Quality:
      Class: 248
      Accuracy: Unknown
      Offset (log variance): 65535
```

Step 4 Use the **show ptp port dataset port** command to view the PTP port data set information.

Example:

```
Router# show ptp port dataset port
PORT [slave]
  Clock Identity: 0x6C:03:09:FF:FE:18:5F:03
  Clock Profile: g8275.1
  Transport Interface: GigabitEthernet0/0/1
  Port Number: 1
  Port State: Slave
  Min Delay Req Interval (log base 2): -4
  Peer Mean Path Delay: 0
  Announce interval (log base 2): -3
  Announce Receipt Timeout: 3
  Sync Interval (log base 2): -4
  Delay Mechanism: End to End
  Peer Delay Request Interval (log base 2): -4
  PTP version: 2
  Local Priority: 128
  Not-slave: False
```

Step 5 Use the **show ptp wan stat stream 0** command to view the PTP WAN statistics.

Example:

```
Router# show ptp wan stat stream 0
LOCK STATUS : PHASE LOCKED
SYNC Packet Stats
  Time elapsed since last packet: 0.0
  Configured Interval : -5, Acting Interval -5
  Tx packets : 0,  Rx Packets : 96215
  Last Seq Number : 30678,  Error Packets : 0
Delay Req Packet Stats
  Time elapsed since last packet: 0.0
```

```
  Configured Interval : -4, Acting Interval : -4
  Tx packets : 48107, Rx Packets : 0
  Last Seq Number : 0, Error Packets : 0
Delay Response Packet Stats
  Time elapsed since last packet: 0.0
  Configured Interval : -4, Acting Interval : -4
  Tx packets : 0, Rx Packets : 48107
  Last Seq Number : 48106, Error Packets : 0
Announce Packet Stats
  Time elapsed since last packet: 0.0
  Configured Interval : 1, Acting Interval : 1
  Tx packets : 0, Rx Packets :  1509
  Last Seq Number 1508 Error Packets 0
Signalling Packet Stats
  Time elapsed since last packet: 0.0
  Configured Interval : 0, Acting Interval : 0
  Tx packets : 12, Rx Packets : 12
  Last Seq Number : 0, Error Packets : 0
Current Data Set                            Units     Within tolerance?
  Offset from master :  +0.000000000       seconds          Yes
  Mean Path Delay    :  +0.000000027       seconds          Yes
  Forward Path Delay :  +0.000000027       seconds          Yes
  Reverse Path Delay :  +0.000000028       seconds          Yes
  Steps Removed 1
```

Step 6 Use the **show ptp wan tod** command to view the PTP WAN time of the day.

Example:

```
Router# show ptp wan tod
PTPd ToD information:

Time: 01/05/22 11:35:21
```

Step 7 Use the **show network-clocks synchronization detail** command to view the synchronization details of the network clocks.

Example:

```
Router# show network-clocks synchronization detail
Automatic selection process : Enable
Equipment Clock : 2048 (EEC-Option1)
Clock State : Frequency Locked
Clock Mode : QL-Enable
ESMC : Enabled
SSM Option : 1
T0 : GigabitEthernet0/0/1
Hold-off (global) : 300 ms
Wait-to-restore (global) : 10 sec
Tsm Delay : 180 ms
Revertive : No
Force Switch: FALSE
Manual Switch: FALSE
Number of synchronization sources: 1
Squelch Threshold: QL-SEC
sm(netsync NETCLK_QL_ENABLE), running yes, state 1A
Last transition recorded: (begin)-> 2A (ql_mode_enable)-> 1A (src_added)-> 1A (sf_change)-> 1A
(ql_change)-> 1A
Nominated Interfaces
 Interface            SigType     Mode/QL      Prio  QL_IN  ESMC Tx  ESMC Rx
 Internal             NA          NA/Dis       251   QL-SEC    NA        NA
*Gi0/0/1              NA          Sync/En      1     QL-PRC    -         -
```

Step 8 Use the **show esmc detail** command to view the Ethernet Synchronization Messaging Channel details.

Example:

```
Router# show esmc detail
Interface: GigabitEthernet0/0/0
  Administrative configurations:
    Mode: Asynchronous
    ESMC TX: Disable
    ESMC RX: Disable
    QL TX: -
    QL RX: -
  Operational status:
    Port status: UP
    QL Receive: QL-DNU
    QL Transmit: -
    QL rx overrided: -
    ESMC Information rate: 1 packet/second
    ESMC Expiry: 5 second
    ESMC Tx Timer: Stopped
    ESMC Rx Timer: Stopped
    ESMC Tx interval count: 1
    ESMC INFO pkts in: 777
    ESMC INFO pkts out: 1068
    ESMC EVENT pkts in: 0
    ESMC EVENT pkts out: 2
```

Step 9 Use the **show platform hardware network-clocks** command to view the chassis network clock details.

Example:

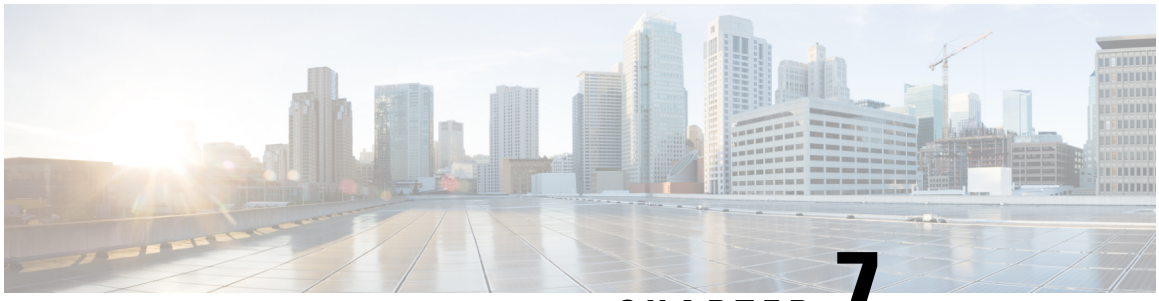
```
Router# show platform hardware network-clocks
Chassis Manager Netclk Status
----------------
DPLL1 Status:
-------------
Bandwidth: 1.7 Hz
Phase Slope Limit: 7500 ns/s
Current PLL1 Mode: MANUAL NORMAL
Current Input Selected: REF7 (CLK_REC_25M_WAN2)
Current PLL1 Holdover Status: OFF
Current PLL1 Lock Status: ON

Router# show platform hardware network-clocks
DPLL2 Status:
-------------
Bandwidth: 0.029 Hz
Phase Slope Limit: 750 ns/s
Current PLL2 Mode: TOP CLIENT (NCO)
Current Input Selected: none
Current PLL2 Holdover Status: OFF
Current PLL2 Lock Status: OFF

Router# show platform hardware network-clocks
Current Input Status:
  REF0 (CLK_LOOPBACK1)   : OK
  REF1 (CLK_LOOPBACK2)   : OK
  REF2 ((TDM_SYNC_MB_PLL) : FAIL (SCM, CFM, GST, PFM failed)
  REF3 (RSV_2_M_PLL)      : FAIL (SCM, CFM, GST, PFM failed)
  REF4 (CLK_PPS_GPS_PLL)  : FAIL (SCM, CFM, GST, PFM failed)
  REF5 (CLK_PPS_MB_PLL)   : FAIL (SCM, CFM, GST, PFM failed)
  REF6 (CLK_REC_25M_WAN1) : FAIL (SCM, CFM, GST, PFM failed)
  REF7 (CLK_REC_25M_WAN2) : OK
  REF8 (CLK20M_OCXO)      : OK
  REF9 (RSV_1_MB_PLL)     : FAIL (SCM, CFM, GST, PFM failed)

Router# show platform hardware network-clocks
```

```
REF0 Freq Configured   : 25 Mhz
REF1 Freq Configured   : 25 Mhz
REF2 Freq Configured   : 8 Khz
REF3 Freq Configured   : 10 Mhz
REF4 Freq Configured   : 1 Hz
REF5 Freq Configured   : 1 Hz
REF6 Freq Configured   : 25 Mhz
REF7 Freq Configured   : 25 Mhz
REF8 Freq Configured   : 20 Mhz
REF9 Freq Configured   : 25 Mhz
```



CHAPTER 7

G.8275.2 Profile

- G.8275.2 profile, on page 93
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- PTP domain, on page 94
- Alternate best timetransmitter clock algorithm, on page 94
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- Configure G.8275.2 profile, on page 97
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G.8275.2 profile

The G.8275.2 telecom profile is a Precision Time Protocol (PTP) profile that:

- Provides phase and time-of-day synchronization in telecommunication networks
- Operates with partial timing support from the network
- Supports an optional hybrid full timing support mode
- Uses PTP over IPv4 in unicast mode to achieve precise time synchronization

The G.8275.2 profile does not require every device in the network to participate in the PTP protocol. This profile is intended for use in carefully planned network environments where network behavior and performance, including static asymmetry, can be maintained within defined limits.

G.8275.2 clock types

The G.8275.2 profile supports partial timing, hybrid full timing, and three specific clock roles. It does not include assisted partial clock types.

G.8275.2 clock roles

The G.8275.2 profile supports these clock roles:

- **Telecom grandmaster (T-GM):** A T-GM is a clock type that provides timing information to other devices in the network. The T-GM typically connects to a primary reference time source, such as a Global

Navigation Satellite System (GNSS) receiver, and does not synchronize its local clock using other network elements.

- **Partial support telecom boundary clock (T-BC-P):** A T-BC-P is a boundary clock that can act as a grandmaster, synchronize from another PTP clock, or provide time to a secondary clock.
- **Partial support telecom time slave clock (T-TSC-P):** A T-TSC-P is a secondary clock that synchronizes its local clock to another PTP clock, such as a T-GM or T-BC-P. This clock does not provide synchronization to other devices.

PTP domain

Permitted PTP domain numbers for the G.8275.2 profile range from 44 to 63.

PTP messages and transport

The G.8275.2 profile requires PTP over IPv4 in unicast mode. The profile supports only one-step clock operation and unicast message negotiation.

The profile supports these modes:

- **Hybrid mode:** Provides holdover with assistance from Synchronous Ethernet (SyncE) for T-TSC, T-BC, or T-GM devices. Enable hybrid mode on a T-GM that uses a virtual port GNSS as input.
- **Non-hybrid mode:** Provides holdover without SyncE for T-TSC or T-BC devices. Enable non-hybrid mode on a T-GM that uses a virtual port (GNSS) as input.

The G.8275.2 profile uses these PTP messages.

- sync
- delay_req
- announce
- follow_up
- delay_resp
- signaling

Alternate best timetransmitter clock algorithm

This section explains the Alternate Best TimeTransmitter Clock Algorithm (BTCA) selection process and the role of its attributes in G.8275.2 PTP domains.

The G.8275.2 profile uses the BTCA, a modified version of the IEEE 1588 standard model. BTCA selects the primary time-transmitting clock, the Grandmaster, in a PTP domain. It enables each device to select its synchronization source and determine the operational state of its local ports.

Alternate BTCA attributes

The alternate BTCA evaluates these attributes in the order of selection priority:

clockClass: Indicates the traceability and accuracy of a PTP clock. A lower clockClass value indicates higher quality and traceability. For example, these values can mean the clock is traceable to a primary reference time source such as GNSS.

- 6: T-GM traceable to the primary reference clock provided by the GNSS.
- 7: T-GM previously traceable to the primary reference clock, currently in holdover within specification.
- 135: T-BC previously traceable to the primary reference clock, currently in holdover within specification.
- 160: T-GM previously traceable to the primary reference clock, currently in holdover out of specification and traceable to a Category 3 frequency source (OCXO in timing module).
- 165: T-BC currently in holdover out of specification.

clockAccuracy: Specifies the accuracy of the clock time relative to a reference time. The value is expressed as a range, for example within 25 nanoseconds or within 100 nanoseconds (ns).

offsetScaledLogVariance: Provides a statistical measure of the clock's stability. This attribute is a logarithmic representation of the variance of the clock offset, which indicates the stability of the time output.

priority2: Specifies a configurable numeric attribute used as a secondary tiebreaker if all other attribute values are equal. A lower value indicates higher priority.

Localpriority: Specifies a configurable numeric attribute used to determine clock priority. A lower value indicates higher priority. This attribute is the primary tiebreaker in the BTCA, is locally significant, and is defined in the router PTP configuration.

Virtual port support in G.8275.2 profile

A virtual PTP port enables T-GM and T-BC devices to receive frequency and phase inputs from electrical sources. T-GM and T-BC devices receive frequency inputs such as SyncE, GNSS 1PPS, and Time of Day (ToD). These devices support virtual ports in both hybrid and non-hybrid modes.

Note SyncE is not supported in non-hybrid mode.

Virtual port operation

When configured to derive time and frequency from a GNSS source, T-GM and T-BC devices use the virtual port as the reference input.

Virtual ports participate in the alternate BTCA for T-BCs. In T-GM mode, specifically for primary only configurations, the device does not evaluate BTCA from G.8275.2 peers. Instead, the device uses local priority to select from multiple inputs, such as a virtual port or a G.8275.2 peer.

Virtual port selection

Virtual port selection uses these criteria:

- **T-GM:** The virtual port is available for selection when GNSS is locked and the external SyncE reference source is in the QL-PRC state.

- **T-BC:** The virtual port participates in the BTCA only when GNSS is locked and SyncE is in the QL-PRC state. If the system selects the virtual port as the primary clock, electrical inputs drive the PTP clock. The T-BC primary can be a virtual port or a WAN port, based on the alternate BTCA priority.

Virtual port attributes

Virtual ports locked to GNSS use these attributes:

- **clock class**: 6
- **clock accuracy**: 0x21, which is within 100 nanoseconds
- **offset scaled log variance**: 0x4E5D.

Guidelines and limitations

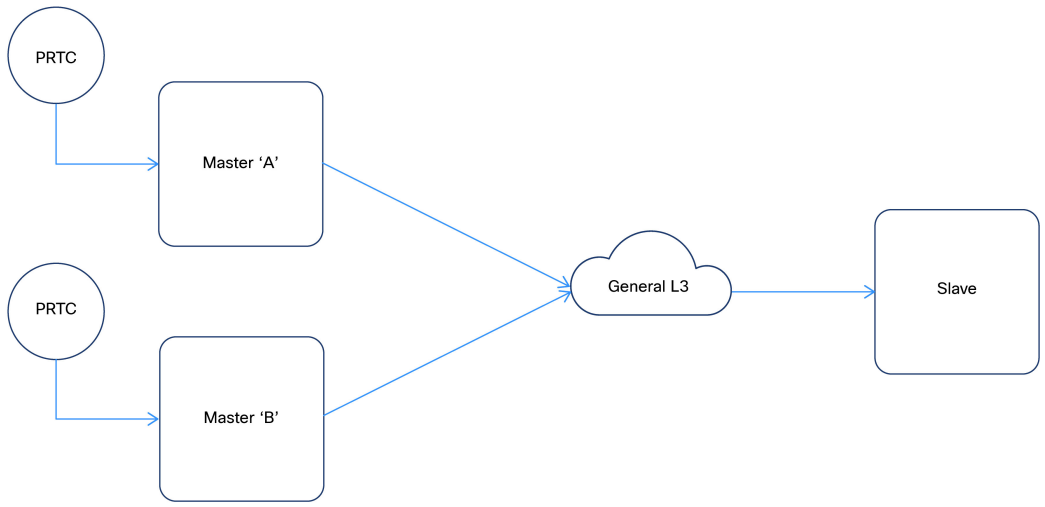
The G.8275.2 PTP profile has these requirements and constraints.

- Does not support Virtual Routing and Forwarding (VRF) or subinterfaces
- Supports only the loopback interface and the Gigabit interfaces GigabitEthernet0/0/0 and GigabitEthernet0/0/1 as transport interfaces on the IR8340 platform
- Excludes Pdelay_Req, Pdelay_Resp, Pdelay_Resp_Follow_Up and management messages.
- Does not support virtual port configuration for ordinary clocks
- Requires boundary clocks to implement configuration examples
- Can cause temporary frequency and phase inaccuracies in non-hybrid mode or partial timing support when switching between sources

G.8275.2 deployment scenario

The figure illustrates a typical G.8275.2 network configuration. This network contains two primary clocks, one boundary clock and one secondary clock. Server A operates as the ordinary clock and Server B acts as the backup server clock and includes a virtual port.

Figure 8: Hybrid full timing support configuration topology



Configure G.8275.2 profile

The G.8275.2 Profile can be configured for partial timing support or for hybrid full timing support.

- Configure G.8275.2 profile for partial timing support
- Configure G.8275.2 profile for hybrid full timing support

Configure G.8275.2 profile for partial timing support

Configuring G.8275.2 profile for partial timing support includes these configurations:

- Configure T-GM
- Configure T-TSC-P

Configure T-GM

Perform this task to configure the T-GM for partial timing support and hybrid full timing support.

Procedure

Step 1 Configure global Sync-E, on page 99

Step 2 Configure Sync-E, on page 101 on the border interface that connects to T-TSC-P.

Step 3 Configure loopback interface.

Step 4 Configure GNSS.

Step 5 Configure G.8275.2 PTP as a hybrid boundary clock.

a) Use the **ptp clock boundary domain** *domain-number* **hybrid profile g8275.2** command to enable the hybrid PTP boundary clock.

Example:

```
Device(config)#ptp clock boundary domain 44 hybrid profile g8275.2
```

b) Use the **priority2** *priority-value* command to set the Priority2 field (default for holdover).

Example:

```
Device(config-ptp-clk)#priority2 25
```

c) Use the **virtual-port** *port-id* **profile g8275.2** command to create a virtual port for GNSS input.

Example:

```
Device(config-ptp-clk)#virtual-port vp1 profile g8275.2
```

d) Use the **input 1pps R0** command to configure the virtual port for 1PPS timing input.

Example:

```
Device(config-ptp-virtual-port)#input 1pps R0
```

e) Use the **input tod R0 ubx** command to configure the virtual port for ToD input.

Example:

```
Device(config-ptp-virtual-port)#input tod R0 ubx
```

f) Use the **priority2** *priority-value* command to define the priority for the virtual port.

Example:

```
Device(config-ptp-virtual-port)#priority2 25
```

g) Use the **clock-port** *port-name* **master profile g8275.2** command to define a primary port for connection to a T-TSC-P or a T-BC-P.

Example:

```
Device(config-ptp-clk)#clock-port primary1 master profile g8275.2
```

Note
The **master** keyword prevents any T-BC or T-TSC from becoming the primary clock. This T-GM can only function as the GMC.

h) Use the **transport ipv4 unicast interface** *loopback-interface***negotiation** command to configure the primary port to use the loopback interface for unicast transport.

Example:

```
Device(config-ptp-port)#transport ipv4 unicast interface Lo0 negotiation
```

i) (Optional) Use the **clock-port** *port-name* **profile g8275.2** command to define a regular primary port without master keyword, for alternate BTCA rules.

Example:

```
Device(config-ptp-clk)#clock-port primary1 profile g8275.2
```

j) Use the **transport ipv4 unicast interface** *loopback-interface* **negotiation** command to configure the regular primary port to use the loopback interface.

Example:

```
Device(config-ptp-port)#transport ipv4 unicast interface Lo0 negotiation
```

k) (Optional) Use the **clock source** *secondary-ip-address* command to configure primary port to accept connections from specified secondary clocks.

Example:

```
Device(config-ptp-port)#clock source 2.2.2.4
```

Replace *secondary-ip-address* with the actual IP address of the T-TSC-P loopback interface.

Configure global Sync-E

Perform this task to configure global Sync-E.

Procedure

Step 1 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Use the **esmc process** command to enable the Ethernet Synchronization Messaging Channel (ESMC) process.

Example:

```
Device(config)#esmc process
```

Note
This step is not applicable for configuring backup source.

Step 3 Use the **network-clock revertive** command to enable revertive mode.

Example:

```
Device(config)#network-clock revertive
```

Note
This step is not required in T-TSC configuration.

Step 4 Use the **network-clock synchronization automatic** command to enable automatic synchronization.

Example:

```
Device(config)#network-clock synchronization automatic
```

Step 5 Use the **network-clock synchronization mode ql-enabled** command to enable QL mode.

Example:

```
Device(config)#network-clock synchronization mode ql-enabled
```

Step 6 Use the **network-clock quality-level rx** *quality-level* **external** *slot frequency* command to set the quality level for the external GNSS source.

Example:

Note
This step applies only to T-GM configuration.

```
Device(config)#network-clock quality-level rx QL-PRC External R0 1hz
```

Step 7 Set the input source. Choose the configuration according to your topology setup.

Configuration	Description
T-GM	Use the **network-clock input-source** *priority* **External R0** *slot-frequency* command to set the input source to GNSS. `Device(config)#network-clock input-source 2 External R0 1hz` **Note** QL-PRC is assigned to the input GNSS source.
T-BC/T-TSC	Use the **network-clock input-source** *priority* **interface** *interface-name* command to set the input source. `Device(config)# network-clock input-source 3 interface GigabitEthernet0/0/0` **Note** If you have multiple sources, repeat this command with the appropriate priority and interface.
GNSS as backup source	Use the **network-clock input-source** *priority* **interface** *interface-name* command to configure GNSS as an input source. `Device(config)#network-clock input-source 2 interface GigabitEthernet0/0/1` **Note** GNSS priority (2) is superior to WAN priority (3) in this example.
WAN as backup source	Use the **network-clock input-source** *priority* **interface** *interface-name* command to configure WAN as an input source. `Device(config)#network-clock input-source 3 interface GigabitEthernet0/0/0` **Note** Set priority values according to your network design.

Step 8 Use the **copy running-config startup-config** command in privileged EXEC mode to save the running configuration to the startup configuration.

Example:

Note
This step applies to T-GM, T-BC and T-TSC configurations.

```
Device(config)#end
            Device#copy running-config startup-config
```

Configure Sync-E

Perform this task to configure Sync-E on border interfaces that face hybrid T-GM, T-TSC, or T-TSC-P.

Procedure

Step 1 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Device#configure terminal
```

Step 2 Use the **interface** *interface-name* command to enter configuration mode for the border interface.

Example:

```
Device(config)#interface GigabitEthernet0/0/0
```

Step 3 Use the **ip address***ip-address subnet-mask* command to assign the IP address and subnet mask to the interface.

Example:

```
Device(config-if)#ip address 1.1.1.1 255.255.255.252
```

Note
Assign the IP address and subnet mask that correspond to the interface.

interface	IP address	subnet-mask
T-GM	1.1.1.1	255.255.255.252
T-TSC-P	2.2.2.4	255.255.255.255
T-BC	1.1.1.2	255.255.255.252
T-TSC	1.1.1.6	255.255.255.252

Step 4 Use the **synchronous mode** command to enable synchronous operation on the interface.

Example:

```
Device(config-if)#synchronous mode
```

Step 5 Use the **exit** command to go back to global configuration mode.

Example:

```
Device(config-if)#exit
```

Configure loopback interface

Perform this task to configure the loopback interface to use the G.8275.2 profile.

Procedure

Step 1 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Device#configure terminal
```

Step 2 Use the **interface Loopback** *interface number* command to enter the loopback interface configuration mode.

Example:

```
Device(config)#interface Loopback0
```

Step 3 Use the **ip address** *ip-address subnet-mask* command to assign the loopback IP address and subnet mask.

Example:

```
Device(config-if)#ip address 2.2.2.2 255.255.255.255
```

- The example shows the IP address and subnet mask for T-GM configuration.
- Use 2.2.2.3 255.255.255.255 for T-BC configuration.

Configure GNSS

Perform this task to configure GNSS interface.

Procedure

Step 1 Use the **gnss** command to enter GNSS configuration mode.

Example:

```
Device(config)#gnss
```

Step 2 Use the **no shutdown** command to enable GNSS operation.

Example:

```
Device(config-gnss)#no shutdown
```

Configure T-TSC-P

Perform this task to configure T-TSC-P for partial timing support.

Procedure

Step 1 Configure the loopback interface to support PTP.

a) Use the **configure terminal** command to enter global configuration mode.

Example:

```
Device#configure terminal
```

b) Use the **interface Loopback***interface-number* command to create and enter the configuration mode for the loopback interface.

Example:

```
Device(config)#interface Loopback0
```

c) Use the **ip address** *ip-address subnet-mask* command to assign the loopback IP address and subnet mask.

Example:

```
Device(config)#ip address 2.2.2.4 255.255.255.255
```

Step 2 Configure G.8275.2 PTP profile.

a) Use the **ptp clock boundary domain** *domain-number* **profile g8275.2** command to enable the PTP boundary clock for the G.8275.2 profile.

Example:

```
Device(config)#ptp clock boundary domain 44 profile g8275.2
```

b) Use the **priority2** *priority-value* command to set the Priority2 field (default for holdover).

Example:

```
Device(config-ptp-clk)#priority2 25
```

c) Use the **clock-port** *port-name* **profile g8275.2** command to configure the secondary port for the G.8275.2 profile.

Example:

```
Device(config-ptp-clk)#clock-port secondary1 profile g8275.2
```

d) Use the **transport ipv4 unicast interface** *loopback-interface* **negotiation** command to set the interface for PTP unicast transport.

Example:

```
Device(config-ptp-port)#transport ipv4 unicast interface Lo0 negotiation
```

e) Use the **clock source** *gmc-ip-address* command to set the GMC source IP address.

Example:

```
Device(config-ptp-port)#clock source 2.2.2.2
```

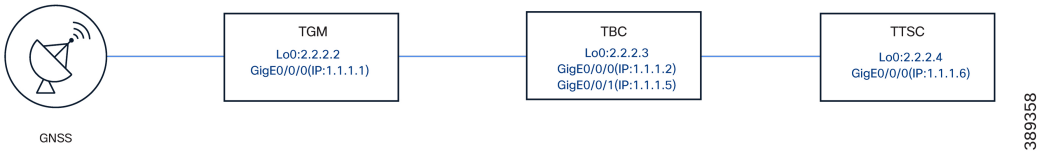
G.8275.2 profile for hybrid full timing support

Summary

This summary outlines the components and their roles in the G.8275.2 timing process.

Workflow

Figure 9: Topology: G.8275.2 profile for hybrid full timing support



Components

The key components involved in the G.8275.2 hybrid full timing supoprt process are:

- **T-GM:** Telecom grandmaster that acts as the GNSS source. It uses the GigabitEthernet0/0/0 interface with IP address 1.1.1.1/30
- **T-BC:** Telecom boundary clock that manages timing across multiple interfaces.

  Interfaces:

  - GigabitEthernet0/0/0 (connected to T-GM), IP 1.1.1.2/30
  - GigabitEthernet0/0/1 (connected to T-TSC), IP 1.1.1.5/30

- **T-TSC:** The telecom time slave clock that receives timing from the T-BC. It uses interface GigabitEthernet0/0/0, connected to TBC IP 1.1.1.6/30.
- **Loopback Interfaces:** Provides stable endpoints for G.8275.2 addressing and PTP communication.

Verify PTP status

To verify the status of PTP, Sync-E, and GNSS, you can run these commands. These commands are optional and can be executed as per the requirement.

Procedure

Step 1 Use the **show ptp clock running** command to display the current PTP clock configuration.

Example:

```
Device#show ptp clock running


PTP Boundary Clock [Domain 44] [Hybrid] [Profile: g8275.2]
State          Ports   Pkts sent   Pkts rcvd   Redundancy Mode
PHASE_ALIGNED  2       338098      1032563     Hot standby
PORT SUMMARY
Name   Tx Mode      Role      Transport    State   Sessions   Port Addr
slave1 unicast      negotiated Lo0          Slave   1          2.2.2.3
vp1    -            unknown    -            -       0          -
```

The output displays the number of packets sent and received. This information confirms that the secondary clock transmits packets and the primary clock responds. Ensure that these values increment. The **Role** and **State** fields provide the status of the clock as a secondary or primary.

Step 2 Use the **show ptp clock dataset default** command to view the default dataset.

Example:

```
Device#show ptp clock dataset default


CLOCK [Boundary Clock, domain 44]
  Profile: g8275.2
  Two Step Flag: No
  Clock Identity: 0x38:FD:F8:FF:FE:5B:DC:43
  Number Of Ports: 2
  Priority1: 128
  Priority2: 45
  Local Priority: 128
  Domain Number: 44
  Slave Only: No
  Signal Fail: No   Clock Quality:
    Class: 135
    Accuracy: Unknown
    Offset (log variance): 65535
```

This information includes default clock attributes and the default class based on the synchronization state.

Step 3 Use the **show ptp clock dataset parent** command to display parent clock information.

Example:

```
Device#show ptp clock dataset parent


CLOCK [Boundary Clock, domain 44]
  Profile: g8275.2

  Parent Clock Identity: 0x38:FD:F8:FF:FE:5B:D0:73
  Parent Port Number: 2
  Parent Stats: No
  Observed Parent Offset (log variance): 65535
  Observed Parent Clock Phase Change Rate: 2147483647

  Grandmaster Clock:
    Identity: 0x44:B6:BE:FF:FE:42:E7:C3
    Priority1: 128     Priority2: 25
    Clock Quality:
      Class: 6
      Accuracy: Within 100ns       Offset (log variance): 20061
```

This output shows the master (T-BC) and grandmaster (T-GM). The **class** attribute confirms if the time is traceable to the GNSS source (class 6).

Step 4 Use the **show ptp port dataset port** command to get detailed information of each PTP port.

Example:

```
Device#show ptp port dataset port


PORT [slave1]
  Clock Identity: 0x38:FD:F8:FF:FE:5B:DC:43
  Clock Profile: g8275.2
  Transport Interface: Loopback0
```

```
  Port Number: 1
  Port State: Slave
  Min Delay Req Interval (log base 2): -4
  Peer Mean Path Delay: 0
  Announce interval (log base 2): 1
  Announce Receipt Timeout: 3
  Sync Interval (log base 2): -5
  Delay Mechanism: End to End
  Peer Delay Request Interval (log base 2): -4
  PTP version: 2
  Local Priority: 128
  Master-only: False   Signal-fail: False
```

Step 5 Use the **show ptp wan stat stream 0** command to display PTP WAN statistics.

Example:

```
Device#show ptp wan stat stream 0


LOCK STATUS : PHASE LOCKED
SYNC Packet Stats
  Time elapsed since last packet: 0.0
  Configured Interval : -5, Acting Interval -5
  Tx packets : 0,  Rx Packets : 682718
  Last Seq Number : 64011,  Error Packets : 0
Delay Req Packet Stats
  ...
Current Data Set                            Units     Within tolerance?
  Offset from master :  +0.000000010        seconds          Yes
  Mean Path Delay    :  +0.000000598        seconds          Yes   ...
```

Note
Lock Status indicates the current synchronization state. The value can be:

- Acquiring
- Phase Locked (the Offset from master shows the sync accuracy) or
- Holdover

Step 6 Use the **show ptp wan tod** command to display the current PTP ToD information.

Example:

```
Device#show ptp wan tod


PTPd ToD information:
Time: 01/05/22 11:35:21
```

Step 7 Use the **show network-clocks synchronization** command to view network clock synchronization status.

Example:

```
Device#show network-clocks synchronization


Symbols:     En - Enable, Dis - Disable, Adis - Admin Disable
             NA - Not Applicable
             *  - Synchronization source selected
             #  - Synchronization source force selected
             &  - Synchronization source manually switched
Automatic selection process : Enable ...
*Gi0/0/0              NA          Sync/En      3     QL-PRC    -   -
```

```
External R0           1HZ         NA/Dis       4     QL-PRC    NA
NA
```

This output displays the Sync-E lock status and shows the available clocks (for example, **Internal**, **External R0**, and **Gi 0/0/0**), and which source is currently selected. For hybrid full timing support, QL-PRC should be present if PTP class is 6.

Step 8 Use the **show esmc detail** command to view ESMC details, including administrative configurations, port status, QL values, and packet counts.

Example:

```
Device#show esmc detail

Interface: GigabitEthernet0/0/0   Administrative configurations:
    Mode: Asynchronous
    ESMC TX: Disable
    ESMC RX: Disable     ...
  Operational status:
    Port status: UP     QL Receive: QL-DNU
    ...
    ESMC INFO pkts in: 777
    ESMC INFO pkts out: 1068
```

Step 9 Use the **show platform hardware network-clocks** command to view chassis-level network clock and PLL status.

Example:

```
Device#show platform hardware network-clocks

DPLL0 Status:
-------------
Bandwidth: 14 HZ
Phase Slope Limit: UNLIMITED

Current PLL0 Mode: MANUAL FREERUN

Current Input Selected: none

Current PLL0 Holdover Status: OFF

Current PLL0 Lock Status: OFF
System CPLD Holdover Status:

System CPLD Lock Status:

DPLL1 Status:
-------------
Bandwidth: 1.7 Hz

Phase Slope Limit: 7500 ns/s

Current PLL1 Mode: MANUAL NORMAL

Current Input Selected: REF6 (CLK_REC_25M_WAN1)

Current PLL1 Holdover Status: OFF

Current PLL1 Lock Status: ON

DPLL2 Status:
-------------
```

```
Bandwidth: 0.010 Hz

Phase Slope Limit: 885 ns/s

Current PLL2 Mode: TOP CLIENT (NCO)

Current Input Selected: none

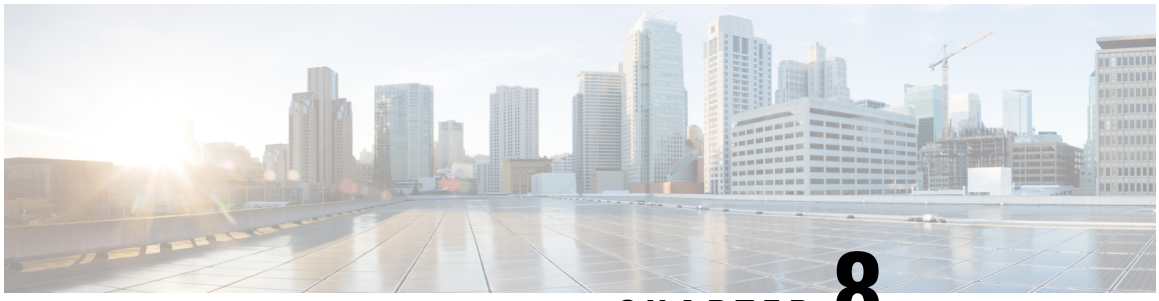
Current PLL2 Holdover Status: OFF

Current PLL2 Lock Status: OFF

Current Input Status:
  REF0 (CLK_LOOPBACK1)   : OK
  REF1 (CLK_LOOPBACK2)   : OK
  REF2 ((TDM_SYNC_MB_PLL) : FAIL (SCM, CFM, GST, PFM failed)
  REF3 (RSV_2_M_PLL)      : FAIL (SCM, CFM, GST, PFM failed)
  REF4 (CLK_PPS_GPS_PLL)  : OK
  REF5 (CLK_PPS_MB_PLL)   : FAIL (SCM, CFM, GST, PFM failed)   REF6 (CLK_REC_25M_WAN1) : OK
  REF7 (CLK_REC_25M_WAN2) : FAIL (SCM, CFM, GST, PFM failed)   REF8 (CLK20M_OCXO)      : OK
  REF9 (RSV_1_MB_PLL)     : FAIL (SCM, CFM, GST, PFM failed)
  REF0 Freq Configured   : 25 Mhz
  REF1 Freq Configured   : 25 Mhz   REF2 Freq Configured   : 8 Khz
  REF3 Freq Configured   : 10 Mhz
  REF4 Freq Configured   : 1 Hz
  REF5 Freq Configured   : 1 Hz
  REF6 Freq Configured   : 25 Mhz
  REF7 Freq Configured   : 25 Mhz
  REF8 Freq Configured   : 20 Mhz
  REF9 Freq Configured   : 25 Mhz

DCO Frequency:
  Current_DCO_Freq_Offset: -0.044384
```

Sync-E uses PLL1 and PTP uses PLL2.



CHAPTER 8

Synchronous Ethernet ESMC and SSMs

Synchronous Ethernet (SyncE) is a network synchronization technology that ensures:

- Ethernet synchronization via physical layer timing.
- High-quality clocking for telecom and data transport, similar to Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH).

- Synchronous Ethernet and clock selection in routers, on page 109
- Clock selection modes, on page 110
- Configure synchronous Ethernet ESMC and SSM, on page 110

Synchronous Ethernet and clock selection in routers

SyncE, defined in ITU G.781, aligns Ethernet link bit clocks to high-quality, stratum-1-traceable signals, similar to SONET and SDH.

SyncE provides clock synchronization to Ethernet, ensuring the reliability of SONET, SDH, and T1/E1 networks. It uses Synchronization Status Message (SSM) and Ethernet Synchronization Message Channel (ESMC) for clock synchronization.

Ethernet synchronization message channel

ESMC uses the SSM from SONET or SDH networks. Unlike SONET and SDH, which use fixed frame locations, ESMC transmits SSM via IEEE 802.3 Organization-Specific Slow Protocol (OSSP).

ESMC quality level

ESMC carries a Quality Level (QL) to indicate clock quality, helping nodes select reliable sources and prevent timing loops.

Clock synchronization in routers

When SyncE configured on the router, it synchronizes to the best available clock source. If no better clock source is available, the router stays synchronizes to the current source.

Clock selection modes

The router supports two clock selection modes for selecting the best clock source.

- QL-enabled
- QL-disabled

This table describes the clock selection modes.

Table 17: Clock modes

Mode	Description
QL-enabled Mode	It uses these QL values to select the best clock source: • clock quality level (QL), • clock availability, and • priority
QL-disabled mode	It uses these alternative criteria to select the clock source: • clock availability, or • Priority

Configure synchronous Ethernet ESMC and SSM

Perform these steps to configure Synchronous Ethernet ESMC and SSM on the router.

Procedure

Step 1 Use the **enable** coammand to enable the privileged EXEC mode.

Example:

```
Router# enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Router# configure terminal
```

Step 3 Use the **network-clock synchronization automatic** command to enable the network clock selection algorithm for automatic configuration and proceed to step 6; otherwise, proceed with step 4.

Example:

```
Router(config)# network-clock synchronization automatic
```

This command disables the Cisco-specific network clock process and turns on the G.781-based automatic clock selection process.

Note
This command must be configured before any input source.

Step 4 Use the **network-clock eec** command to specify the Ethernet Equipment Clock (EEC) type as a network clock.

Example:

```
Router(config)# network-clock eec 1
```

The Ethernet Equipment Clock (EEC) types are:

- 1—ITU-T G.8262 option 1 (2048)
- 2—ITU-T G.8262 option 2 and Telcordia GR-1244 (1544)

Step 5 Use the **network-clock synchronization ssm option** command to configure the G.781 synchronization option.

Example:

```
Router(config)# network-clock synchronization ssm option 2 GEN1
```

The G.781 synchronization option guidelines to send synchronization messages.

- Option 1 refers to G.781 synchronization option 1, which is designed for Europe. This is the default value.
- Option 2 refers to G.781 synchronization option 2, which is designed for the United States.
- GEN1 specifies option 2 Generation 1 synchronization.
- GEN2 specifies option 2 Generation 2 synchronization.

Step 6 Use the **network-clock input-source** command to provide the input clock source in the network.

Example:

```
Router(config)# network-clock input-source 1 interface GigabitEthernet 0/0/0
Router(config)# network-clock input-source 1 external R0 1hz
Router(config)# network-clock input-source 2 controller t1 0/2/0
Router(config)# network-clock input-source 3 ptp domain 4
```

Enables you to select an interface as an input clock for the router. You can select WAN interfaces (Gigabit Ethernet 0/0/0, Gigabit Ethernet 0/0/1), T1/E1 controllers, or an external interface. Selection priority for the clock source (1 is the highest priority). When the higher-priority clock source fails, the next-higher-priority clock source is selected.

Note
Before configuring Ethernet interface as clock source, you should configure synchronous mode under interface configuration.

SyncE is not supported on LAN interfaces.

Step 7 Use the **network-clock synchronization mode ql-enabled** command to enable automatic selection of a clock source based on quality level.

Example:

```
Router(config)# network-clock synchronization mode ql-enabled
```

Step 8 Use the **network-clock wait-to-restore** command to configure a global wait-to-restore timer for synchronous Ethernet clock sources in seconds.

Example:

```
Router(config)# network-clock wait-to-restore 70 global
```

(Optional) The timer specifies how long the router waits before including a restored clock source in the clock selection process.

Valid values are 0 to 86,400 seconds. The default value is 300 seconds.

It is recommended not to configure a very low wait-to-restore value. A momentarily unstable clock source may trigger frequent and disruptive timing shifts, degrading network performance. By introducing an adequate delay, the router ensures that the restored clock source is stable before it is reselected.

Step 9 Use the **esmc process** command to enable ESMC process globally.

Example:

```
Router(config)# esmc process
```

Step 10 Use the **network-clock quality-level** command to specify a quality level for a line or external clock source.

Example:

For Tx QL:

```
Router(config)# network-clock quality-level tx QL-SSU-A interface GigabitEthernet 0/0/0
```

For Rx QL as SSU:

```
Router(config)# network-clock quality-level rx QL-SSU-A  interface GigabitEthernet 0/0/0
```

For Rx QL as PRC:

```
Router(config)# network-clock quality-level rx ql-prc external r0 1hz
```

The available quality values depend on the G.781 synchronization settings specified by the **network-clock synchronization ssm option** command:

The syntax of the command: **network-clock quality-level**{**tx** | **rx**} *value* {**interface** *interface-id* | **controller** [**E1** | BITS] slot/card/port | **external** [2m | 10m] }

Table 18: Syntax description

Keyword	Description
tx	Sets the tx quality level for the source.
rx	Sets the rx quality level for the source.
value	The quality indicator to apply. The supported values include QL-PRC, QL-SSU-A, QL-SSU-B, QL-SEC, QL-DNU (actual list depends on hardware/software).
interface-id	Provides an Ethernet interface used for SyncE.
E1	An E1 controller port carrying SSM over TDM.
BITS	A Building Integrated Timing Supply port.

Keyword	Description
external	Provides an external frequency reference input and specifies its frequency (2 MHz or 10 MHz).

- Option 1—Available values are QL-PRC, QL-SSU-A, QL-SSU-B, QL-SEC, and QL-DNU.
- Option 2, GEN1—Available values are QL-PRS, QL-STU, QL-ST2, QL-SMC, QL-ST4, and QL-DUS.
- Option 2, GEN 2—Available values are QL-PRS, QL-STU, QL-ST2, QL-TNC, QL-ST3, QL-SMC, QL-ST4, and QL-DUS.

Step 11 Use the **interface** command to specify a trunk interface and to enter into a interface configuration mode.*interface-id*

Example:

```
Router(config)# interface gigabitethernet 0/0/0
```

Step 12 (Optional) Use the **network-clock source quality-level** command to provide the forced QL value to the local clock selection process.

Example:

```
Router(config-if)# network-clock source quality-level QL-PRS tx
```

Step 13 Use the **synchronous mode** command to configure the Ethernet interface to synchronous mode and enable the ESMC and QL process on the interface.

Example:

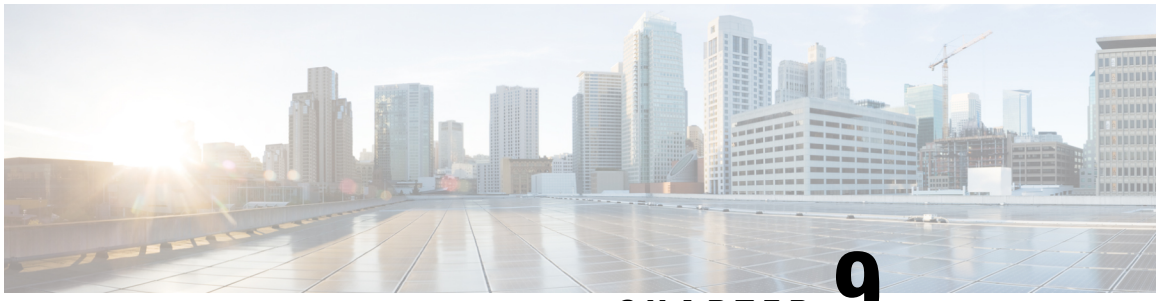
```
Router(config-if)# synchronous mode
```

Step 14 Use the **end** command to exit interface configuration mode and returns to the privileged EXEC mode.

Example:

```
Router(config-if)# end
```

Exits interface configuration mode and returns to privileged EXEC mode.



CHAPTER 9

Global Navigation Satellite Systems

The Global Navigation Satellite System (GNSS) is a positioning, navigation, and timing (PNT) service. It facilitates:

- network synchronization planning,
- enhances flexibility, and
- strengthens resilience in managing synchronization challenges within hierarchical networks.

- Global Navigation Satellite Systems for network synchronization, on page 115
- Restrictions for GNSS timing source, on page 116
- GNSS receiver functionality , on page 117
- Primary Reference Time Clock mode with GNSS, on page 119
- Configure the satellite constellation for GNSS, on page 120

Global Navigation Satellite Systems for network synchronization

Time synchronization with GNSS in industrial networks

The router timing module has a built-in GNSS receiver that enables the router to:

- determine its own location, and
- obtain an accurate time from a satellite constellation.

Industrial automation and control systems, utility networks, and military networks require a large number of devices to maintain an accurate and synchronized sense of time.

GNSS signaling

The GNSS receiver acquires satellites and provides timing signals to the host system in two ways.

- Self-survey mode
- Overdetermined clock mode

Summary

GNSS signaling calculates and stores position data to establish a stable reference and then delivers precise timing signals for reliable network synchronization. This is achieved through the Self-Survey and Overdetermined clock modes.

Workflow

Table 19: GNSS receiver modes

Mode	Description
Self-survey	This mode automates position calculation, result storage, and faster transitions to operational modes: • After a reset, the GNSS receiver enters self-survey mode. • It calculates a 3D position after locking onto at least four satellites. • Around 2,000 positions are calculated over 35 minutes. • Once complete, it generates timing signals and switches to the Normal (Locked to GPS) mode. • The Self-survey mode results are saved to the receiver's flash memory, enabling quicker transitions to Overdetermined clock mode. • Each new self-survey overwrites the previous results in flash memory. • You can manually restart the self-survey using the **gnss self-survey restart** command.
Overdetermined clock	The device enters Overdetermined clock mode after completing the self-survey and storing position data in non-volatile memory. In this mode, the GNSS receiver provides timing information based on the satellite positions stored during the self-survey Cisco IOS collects PPS signals only in Overdetermined clock mode, as timing signals during self-survey mode can have an error of up to 20 seconds. The GNSS receiver stays in Overdetermined clock mode and can restart the self-survey in these scenarios: • automatically, if the antenna is moved more than 100m, and • manually, using the **gnss self-survey restart** command.

After locking onto a satellite system, the GNSS receiver sends a 10-ms-wide PPS (Pulse Per Second) pulse and the current time and date to the Cisco IOS time service.

Restrictions for GNSS timing source

Use these guidelines when employing GNSS as a timing source and monitoring related events.

- GNSS is available as a timing source only for the default PTP and power profiles.

- GNSS can be used as a PTP timing source only in GMC-BC mode.
- The supported syslog messages for GNSS events are:
  - entering self-survey mode,
  - reaching the OD mode, and
  - firmware upgrade status—start, complete, or fail.
- When the router loses the antenna signal while acting as the PTP GMC:
  - clock quality degrades and
  - a GMC switchover occurs.
- GPS antenna alarms do not trigger external relay alarms.
- To configure GNSS Auto, verify that a minimum of eight satellites are tracked for each enabled major GNSS, such as GPS, or Global Navigation Satellite System (GLONASS).
- The Antenna Open alarm may activate without a hardware issue. In such situations, configure the constellation AUTO to GPS or another available constellation.

GNSS receiver functionality

The router uses a GNSS receiver to deliver precise frequency and phase output for the host system. When connected to an external GNSS antenna, the receiver automatically:

- delivers an accurate one pulse-per-second (PPS) signal.
- offers a stable 10 MHz frequency output.
- acquires GNSS satellite signals.
- tracks up to 32 satellites.
- calculates location, speed, heading, and time.

For more information on the GNSS receiver and its timing signals, see GNSS signaling.

Note It is recommended to use the GPS LRM-400 cable for GNSS to verify that you can monitor all GNSS alarms. For details on supported antennas and cables, see the *Cisco Catalyst IR8340 Rugged Series Router Hardware Installation Guide*.

The GNSS supports these frequency bands:

- AUTO—GPS, QZSS, and GLONASS (default)
- GPS
- GLONASS
- BeiDou
- Galileo

GNSS features

This table lists the GNSS features of the router.

Table 20: GNSS features of Cisco Catalyst IR8340 Rugged Series Router

Feature	Description
Time mode	A receiver mode where the position of receiver is fixed, and only the time is calculated using all available satellites.
survey-in	A procedure performed before enabling time mode. It determines the position of a stationary receiver by averaging all valid 3D position solutions over time. The receiver: • computes the average position over time until it achieves a predefined standard deviation, • ensures the minimum observation time has passed, • switches to fixed mode, and • activates the timing features automatically.
survey-in and fixed-position navigation	• reduces timing jitter, even at low signal levels, and • maintains synchronization with a single satellite in view
Time pulse accuracy	• clear sky—20 ns • indoor—500 ns.

Feature	Description
Per second activity	Once the receiver locks onto the signal, the router performs these tasks every second: • reads the updated time and date. • retrieves the PPS timestamp from the hardware. • sends the time, date, and PPS timestamp to the GNSS virtual clock or servo. The GNSS virtual clock then drives the PTP output.

Use the **constellation** command to select between these constellations (Global Positioning System (GPS) and Global Navigation Satellite System (GLONASS)). Changing the constellation restarts the survey-in process to lock onto the new constellation. For more details, see Configure the satellite constellation for GNSS, on page 120.

Default time of day format for GNSS

The default Time of Day (TOD) format is UBX, and a one PPS output is available when GNSS is locked (Example: PRTC mode).

To achieve a lock at a one-Hertz frequency, you can configure these commands.

- **network-clock synchronization automatic**
- **network-clock synchronization mode QL-enabled**
- **network-clock quality-level rx QL-PRC External R0 1hz**
- **network-clock input-source 1 External R0 1hz**
- **network-clock wait-to-restore 10 global**

GNSS LED

The GNSS LED (labeled 'GPS' on both the cable side and power supply side) shows the GNSS status. This table shows LED colors and their meaning.

Table 21: GNSS LED

Color	Status
Blinking green	Attempt to acquire satellite fix.
Solid green	GNSS has valid signal or fix.
Blinking amber	Antenna fault.
Off	GNSS not configured.

Primary Reference Time Clock mode with GNSS

Primary Reference Time Clock (PRTC) mode with GNSS provides a precise and reliable timing source for synchronization in high-precision networks like telecommunications and industrial systems.

The router operates in Primary Reference Time Clock (PRTC) mode with these characteristics:

- It functions in PRTC mode when GNSS is locked, and telecom profiles are not configured.
- In this mode, it outputs Time of Day (TOD) in UBX format along with a one PPS signal.
- Ordinary clocks and transparent clocks under LAN profiles are not supported while in PRTC mode.
- All boundary clocks in LAN profiles operate exclusively in Grandmaster Clock-Boundary Clock mode (GMC-BC mode) using GNSS input for timestamps and grandmaster clock details.
- In GMC-BC mode, the clock quality values:

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

- PRTC mode is supported on default PTP profile and power profile. The conversion to this mode takes place automatically when GNSS moves to a locked state.
- GNSS cannot be configured if any of these modes or options are configured:
  - 802.1AS (Time-Sensitive Networking Standard)
  - PTP Transparent Clock (TC) mode
  - GMC-BC options

Configure the satellite constellation for GNSS

Perform these steps to configure the satellite constellation for Global Navigation Satellite System (GNSS).

Procedure

Step 1 Use the **configure terminal** to enter the configuration mode.

Example:

```
Router# configure terminal
```

Enter global configuration mode.

Step 2 Use the **gnss** command to enable GNSS.

Example:

```
Router(config)# gnss
```

When GNSS is enabled, it collects PPS timestamp information.

When GNSS is disabled: The chip functions normally, but no software process collects timestamp or PPS information.

Step 3 Use the **constellation** command to configure the GNSS constellation.

Example:

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

(Optional) Configure the GNSS constellation. The default is auto (GPS+GLONASS+QZSS). Only one constellation is active at any given time.

The syntax of the command: **[no] constellation** { **auto** | **galileo** | **gps** | **glonass** | **beidou**}

Table 22: Syntax description

Keyword	Description
no	Clears the configuration.
constellation	sets the active GNSS constellation policy.
auto	Automatically selects the best available constellation.
galileo	Uses the European Union's global navigation satellite system constellation.
gps	Uses the GPS constellation.
glonass	Uses the Russian Federation's global navigation satellite system constellation.
beidou	Uses the China's global navigation satellite system constellation.

Step 4 Use the **exit** command to exit the GNSS configuration mode.

Example:

```
Router(config-gnss)# exit
```

Step 5 (Optional) Use the **show gnss status** command to view the GNSS status. This action is possible after the GNSS receiver has completed self-survey mode and is providing timing information from the satellite system.

Example:

```
Router# show gnss status
  GNSS status:
  GNSS status: Enable
  Clock Progress: Locked (GnssFixOK)
  GNSS Fix Type: time only fix
  Constellation: GLONASS
  Satellite count: 9
  PDOP: 99.989998  TDOP: 0.350000
  HDOP: 99.989998  VDOP: 99.989998
  Major Alarm: False
  Minor Alarm: False
```

This table shows the possible values for the GNSS and its receiver status.

Table 23: The possible values

Status values	Receiver values	
• Enable • Disable	Receiver Status	• auto—Auto mode for 2D/3D • 1SV—Single satellite • 2SV—Horizontal (2D) • 3SV—Full position (3D) • OD—Overdetermined
	Alarm	• Antenna open • Antenna shorted • Not tracking satellites • Survey-in progress • No stored position • Leap second pending
	Survey progress	This field shows the progress of the survey as a percentage of fixes collected so far. The self-survey is complete when the self-survey progress reaches one hundred percent.
	Positioning	• PDOP—Position Dilution of Precision • HDOP—Horizontal Dilution of Precision • VDOP—Vertical Dilution of Precision • TDOP—Time Dilution of Precision

Note
If any GNSS alarm conditions are present, the switch may not be providing timing information from the satellite system.

The alarm clears automatically.

Step 6 (Optional) Use the **show gnss satellite** command to view the GNSS-tracked satellite status.

Example:

```
Router# show gnss satellite all
All Satellites Info:

SV ID  Channel  Eph Flag  SV Used  CNR  Azimuth  Elevation  Health  Quality

--------------------------------------------------------------------------------
   19        6         1        -   24      260          1       1        4
   18        6         1        -   31      219          2       1        7
   15        6         1     Used   46      223         42       1        7
   14        6         1     Used   44      340         73       1        7
   13        6         1     Used   36       22         20       1        7
    4        6         1     Used   48      349         27       1        7
```

```
    3        6         1     Used   48       53         51       1        7
    2        6         1     Used   45      114         24       1        7
```

The syntax of the command: **show gnss satellite { all | satellite-number }**

Carrier-to-Noise Density, abbreviated as (C/N0) displays signal strength. The signal strength unit is dB-Hz and refers to the ratio of the carrier power and the noise power (dB) *per unit bandwidth* (Hz). Received satellite signal power varies with user antenna gain, satellite elevation angle, and satellite age. Typical C/N0 range is from 35 dB-H to 55 dB-Hz.

Step 7 (Optional) Use the **show gnss time** command to monitor the GNSS time.

Example:

```
Router## show gnss time
  Current GNSS Time:
  Time: 2021/12/09  07:11:59 UTC
```

Step 8 (Optional) Use the **show gnss location** command to view the GNSS location.

Example:

```
Router## show gnss location
  Current GNSS Location:
  LOC: 12:56.187572 N  77:41.742096 E  832.44 m
```

Step 9 (Optional) Use the **show gnss device** command to monitor the GNSS device information.

Example:

```
Router# show gnss device
  GNSS device:
  Model: NEO-M8T-0
  Software version: EXT CORE 3.01 (111141)
  Hardware version: 00080000
  Protocol version: 22.00
  Firmware version: TIM 1.10
  Unique Chip ID: 311652325097
  Major GNSS Satellites supported: GPS;GLO;GAL;BDS
```

Step 10 (Optional) Use the **show network-clocks synchronization** command to view the network clock synchronization status.

Example:

```
Router# show network-clocks synchronization
Symbols:     En - Enable, Dis - Disable, Adis - Admin Disable
             NA - Not Applicable
             *  - Synchronization source selected
             #  - Synchronization source force selected
             &  - Synchronization source manually switched
Automatic selection process : Enable
Equipment Clock : 2048 (EEC-Option1)
Clock Mode : QL-Enable
ESMC : Enabled
SSM Option : 1
T0 : External R0 1hz
Hold-off (global) : 300 ms
Wait-to-restore (global) : 10 sec
Tsm Delay : 180 ms
Revertive : No
Nominated Interfaces
 Interface            SigType     Mode/QL      Prio  QL_IN  ESMC Tx  ESMC Rx
 Internal             NA          NA/Dis       251   QL-SEC    NA        NA
```

```
*External R0          1HZ         NA/Dis       1     QL-PRC    NA        NA
```

Step 11 (Optional) Use the **show platform hardware network-clocks** command to view the available network clocks in the hardware.

Example:

```
Router# show platform hardware network-clocks
DPLL1 Status:
-------------
Bandwidth: 0.001 Hz
Phase Slope Limit: 885 ns/s
Current PLL1 Mode: MANUAL NORMAL
Current Input Selected: REF4 (CLK_PPS_GPS_PLL)
Current PLL1 Holdover Status: OFF
Current PLL1 Lock Status: ON
DPLL2 Status:
-------------
Bandwidth: 0.001 Hz
Phase Slope Limit: 885 ns/s
Current PLL2 Mode: MANUAL NORMAL
Current Input Selected: REF4 (CLK_PPS_GPS_PLL)
Current PLL2 Holdover Status: OFF
Current PLL2 Lock Status: ON

Router# show platform hardware network-clocks
  Current Input Status:
  REF0 (CLK_LOOPBACK1)   : OK
  REF1 (CLK_LOOPBACK2)   : OK
  REF2 ((TDM_SYNC_MB_PLL) : FAIL (SCM, CFM, GST, PFM failed)
  REF3 (RSV_2_M_PLL)      : FAIL (SCM, CFM, GST, PFM failed)
  REF4 (CLK_PPS_GPS_PLL)  : OK
  REF5 (CLK_PPS_MB_PLL)   : FAIL (SCM, CFM, GST, PFM failed)
  REF6 (CLK_REC_25M_WAN1) : FAIL (SCM, CFM, GST, PFM failed)
  REF7 (CLK_REC_25M_WAN2) : FAIL (SCM, CFM, GST, PFM failed)
  REF8 (CLK20M_OCXO)      : OK
  REF9 (RSV_1_MB_PLL)     : FAIL (SCM, CFM, GST, PFM failed)

DCO Frequency:
  Current_DCO_Freq_Offset: -0.033687
```