



Understanding PTP

The Precision Time Protocol (PTP), as defined in the IEEE 1588 standard, synchronizes withnanosecond accuracy the real-time clocks of the devices in a network. The clocks in are organized into a server-client hierarchy. PTP identifies the port that is connected to a device with the most precise clock. This clock is referred to as the server clock. All the other devices on the network synchronize their clocks with the server clock and are referred to as members. Constantly-exchanged timing messages ensure continued synchronization.

Precision Time Protocol (PTP) is defined in IEEE 1588 as Precision Clock Synchronization for Networked Measurements and Control Systems, and was developed to synchronize the clocks in packet-based networks that include distributed device clocks of varying precision and stability. PTP is designed specifically for industrial, networked measurement and control systems, and is optimal for use in distributed systems because it requires minimal bandwidth and little processing overhead.

Table 1: Nodes within a PTP Network

Network Element	Description
Grandmaster (GM)	A network device physically attached to the primary time source. All clocks are synchronized to the grandmaster clock.
Ordinary Clock (OC)	An ordinary clock is a 1588 clock with a single PTP port that can operate in one of the following modes: <ul style="list-style-type: none">• Server mode—Distributes timing information over the network to one or more client clocks, thus allowing the client to synchronize its clock to the server clock.• Client mode—Synchronizes its clock to a server clock. You can enable the client mode on up to two interfaces simultaneously in order to connect to two different server clocks.

Network Element	Description
Boundary Clock (BC)	<p>The device participates in selecting the best server clock and can act as the server clock if no better clocks are detected.</p> <p>Boundary clock starts its own PTP session with a number of downstream clients. The boundary clock mitigates the number of network hops and results in packet delay variations in the packet network between the Grandmaster and client.</p>
Transparent Clock (TC)	A transparent clock is a device or a switch that calculates the time it requires to forward traffic and updates the PTP time correction field to account for the delay, making the device transparent in terms of time calculations.



Note In Cisco IOS XR Release 7.3.1, on the Cisco N540-FH-CSR-SYS router, PTP is not supported on ports 0-14.



Note In Cisco IOS XR Release 7.3.2, PTP is enabled by default on all Ethernet ports of the following variants of the Cisco NCS 540 router. This support facilitates interoperability with FPGA ports.

- N540-FH-CSR-SYS
- N540-FH-AGG-SYS

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Why PTP?

Smart grid power automation applications, such as peak-hour billing, virtual power generators, and outage monitoring and management, require extremely precise time accuracy and stability. Timing precision improves network monitoring accuracy and troubleshooting ability.

In addition to providing time accuracy and synchronization, the PTP message-based protocol can be implemented on packet-based networks, such as Ethernet networks. The benefits of using PTP in an Ethernet network include:

- Low cost and easy setup in existing Ethernet networks
- Limited bandwidth requirement for PTP data packets

Routers and Delays

In an IP network, routers provide a full-duplex communication path between network devices. Routers send data packets to packet destinations using IP address information contained in the packets. When the router attempts to send multiple packets simultaneously, the router buffers some packets so that they are not lost before they are sent. When the buffer is full, the router delays sending packets. This delay can cause device clocks on the network to lose synchronization with one another.

Additional delays can occur when packets entering a router are stored in its local memory while the router searches the address table to verify packet fields. This process causes variations in packet forwarding time latency, and these variations can result in asymmetrical packet delay times.

Adding PTP to a network can compensate for these latency and delay problems by correctly adjusting device clocks so that they stay synchronized with one another. PTP enables network routers to function as PTP devices, including boundary clocks (BCs) and transparent clocks (TCs).

For more information about PTP clock devices and their role in a PTP network, see the *PTP Clocks* section.

Message-Based Synchronization

To ensure clock synchronization, PTP requires an accurate measurement of the communication path delay between the time source (server) and the receiver (client). PTP sends messages between the server and client device to determine the delay measurement. Then, PTP measures the exact message transmit and receive times and uses these times to calculate the communication path delay.

PTP then adjusts current time information contained in network data for the calculated delay, resulting in more accurate time information.

This delay measurement principle determines path delay between devices on the network. The local clocks are adjusted for this delay using a series of messages sent between servers and clients. The one-way delay time is calculated by averaging the path delay of the transmit and receive messages. This calculation assumes a symmetrical communication path; however, routed networks do not necessarily have symmetrical communication paths, due to the various asymmetries in the network.

Using transparent clocks, PTP provides a method to measure and account for the delay in a time-interval field in network timing packets. This makes the routers temporarily transparent to the server and client nodes on

the network. An end-to-end transparent clock forwards all messages on the network in the same way that a router does.

To read a detailed description of synchronization messages, see the *PTP Event Message Sequences* section. To learn more about how transparent clocks calculate network delays, refer to [Transparent Clock, on page 7](#).

PTP Event Message Sequences

This section describes the PTP event message sequences that occur during synchronization.

Synchronizing with Boundary Clocks

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

- Sync
- Delay_Req
- Follow_Up
- Delay_Resp

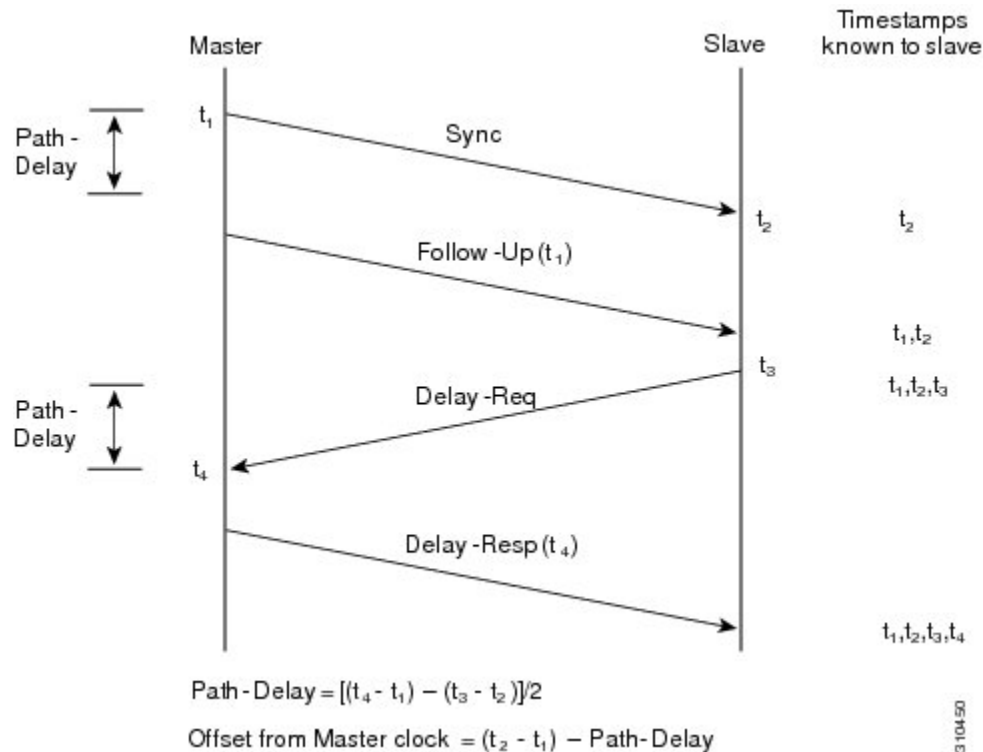
These messages are sent in the following sequence:

- The server sends a Sync message to the client and notes the time (t_1) at which it was sent.
- The client receives the Sync message and notes the time of reception (t_2).
- The server conveys to the client the timestamp t_1 by embedding the timestamp t_1 in a Follow_Up message.
- The client sends a Delay_Req message to the server and notes the time (t_3) at which it was sent.
- The server receives the Delay_Req message and notes the time of reception (t_4).
- The server conveys to the client the timestamp t_4 by embedding it in a Delay_Resp message.

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

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

Figure 1: Detailed Steps—Boundary Clock Synchronization



Synchronizing the Local Clock

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

PTP Clocks

A PTP network is made up of PTP-enabled devices and devices that are not using PTP. The PTP-enabled devices typically consist of the following clock types.

Grandmaster Clock

Within a PTP domain, the grandmaster clock is the primary source of time for clock synchronization using PTP. The grandmaster clock usually has a very precise time source, such as a GPS or atomic clock. When the network does not require any external time reference and only needs to be synchronized internally, the grandmaster clock can free run.

Ordinary Clock

An ordinary clock is a PTP clock with a single PTP port. It functions as a node in a PTP network and can be selected by the BMCA as a server or client within a subdomain. Ordinary clocks are the most common clock type on a PTP network because they are used as end nodes on a network that is connected to devices requiring synchronization. Ordinary clocks have various interfaces to external devices.

Boundary Clock

A boundary clock in a PTP network operates in place of a standard network router. Boundary clocks have more than one PTP port, and each port provides access to a separate PTP communication path. Boundary clocks provide an interface between PTP domains. They intercept and process all PTP messages, and pass all other network traffic. The boundary clock uses the BMCA to select the best clock seen by any port. The selected port is then set as a client. The server port synchronizes the clocks connected downstream, while the client port synchronizes with the upstream server clock.

Transparent Clock

The role of transparent clocks in a PTP network is to update the time-interval field that is part of the PTP event message. This update compensates for switch delay and has an accuracy of within one picosecond.

Restrictions for PTP

PTP over MPLS is not supported.

PTP Profiles

Table 2: Feature History Table

Feature Name	Release Information	Description
PTP Profiles Support for N540-6Z14S-SYS-D	Release 7.5.2	PTP Profiles are now supported on the following Cisco NCS 540 router variant: <ul style="list-style-type: none"> N540-6Z14S-SYS-D
PTP Profiles Support for N540-24Q8L2DD-SYS	Release 7.4.1	PTP Profiles are specific selections of PTP configurations that allow organizations to achieve a performance that meets the requirement of a particular application. You can configure different PTP profiles for different applications, such as audio and media. PTP profiles ensure the application components stay in sync across multiple devices. <p>PTP Profiles are now supported on the following Cisco NCS 540 router variant:</p> <ul style="list-style-type: none"> N540-24Q8L2DD-SYS

Feature Name	Release Information	Description
PTP Profiles Support for N540X-16Z4G8Q2C-A/D	Release 7.0.1	PTP Profiles are now supported on the following Cisco NCS 540 router variant: <ul style="list-style-type: none"> N540X-16Z4G8Q2C-A/D

ITU-T Telecom Profiles for PTP

Cisco IOS XR software supports ITU-T Telecom Profiles for PTP as defined in the ITU-T recommendation. A profile consists of PTP configuration options applicable only to a specific application.

Separate profiles can be defined to incorporate PTP in different scenarios based on the IEEE 1588-2008 standard. A telecom profile differs in several ways from the default behavior defined in the IEEE 1588-2008 standard and the key differences are mentioned in the subsequent sections.

The following sections describe the ITU-T Telecom Profiles that are supported for PTP.

G.8265.1

G.8265.1 profile fulfills specific frequency-distribution requirements in telecom networks. Features of G.8265.1 profile are:

- Clock advertisement: G.8265.1 profile specifies changes to values used in Announce messages for advertising PTP clocks. The clock class value is used to advertise the quality level of the clock, while the other values are not used.
- Clock Selection: G.8265.1 profile also defines an alternate BMCA to select port states and clocks is defined for the profile. This profile also requires to receive Sync messages (and optionally, Delay-Response messages) to qualify a clock for selection.
- Port State Decision: The ports are statically configured to be Server or Client instead of using FSM to dynamically set port states.
- Packet Rates: The packet rates higher than rates specified in the IEEE 1588-2008 standard are used. They are:
 - Sync/Follow-Up Packets: Rates from 128 packets-per-second to 16 seconds-per-packet.
 - Delay-Request/Delay-Response Packets: Rates from 128 packets-per-second to 16 seconds-per-packet.
 - Announce Packets: Rates from 8 packets-per-second to 64 packets-per-second.
- Transport Mechanism: G.8265.1 profile only supports IPv4 PTP transport mechanism.
- Mode: G.8265.1 profile supports transport of data packets only in unicast mode.
- Clock Type: G.8265.1 profile only supports Ordinary Clock-type (a clock with only one PTP port).
- Domain Numbers: The domain numbers that can be used in a G.8265.1 profile network ranges from 4 to 23. The default domain number is 4.
- Port Numbers: Multiple ports can be configured; however, all ports must be of the same type, either Server or Client.

G.8275.1

G.8275.1 profile fulfills the time-of-day and phase synchronization requirements in telecom networks with all network devices participating in the PTP protocol. G.8275.1 profile with SyncE provides better frequency stability for the time-of-day and phase synchronization.

Features of G.8275.1 profile are:

- Synchronization Model: G.8275.1 profile adopts hop-by-hop synchronization model. Each network device in the path from Server to Client clock synchronizes its local clock to upstream devices and provides synchronization to downstream devices.
- Clock Selection: G.8275.1 profile also defines an alternate BMCA that selects a clock for synchronization and port state for the local ports of all devices in the network is defined for the profile. The parameters defined as a part of the BMCA are:
 - Clock Class
 - Clock Accuracy
 - Offset Scaled Log Variance
 - Priority 2
 - Clock Identity
 - Steps Removed
 - Port Identity
 - notSlave flag
 - Local Priority
- Port State Decision: The port states are selected based on the alternate BMCA algorithm. A port is configured to a server-only port state to enforce the port to be a server for multicast transport mode.
- Packet Rates: The nominal packet rate for Announce packets is 8 packets-per-second and 16 packets-per-second for Sync/Follow-Up and Delay-Request/Delay-Response packets.
- Transport Mechanism: G.8275.1 profile only supports Ethernet PTP transport mechanism.
- Mode: G.8275.1 profile supports transport of data packets only in multicast mode. The forwarding is done based on forwardable or non-forwardable multicast MAC address.
- Clock Type: G.8275.1 profile supports the following clock types:
 - Telecom Grandmaster (T-GM)
 - Telecom Time subordinate/client Clock (T-TSC)
 - Telecom Boundary Clock (T-BC)
- Domain Numbers: The domain numbers that can be used in a G.8275.1 profile network ranges from 24 to 43. The default domain number is 24.

The G.8275.1 supports the following:

- T-GM: The telecom grandmaster (T-GM) provides timing to all other devices on the network. It does not synchronize its local clock with any other network element other than the Primary Reference Time Clock (PRTC).
- T-BC: The telecom boundary clock (T-BC) synchronizes its local clock to a T-GM or an upstream T-BC, and provides timing information to downstream T-BCs or T-TSCs. If at a given point in time there are no higher-quality clocks available, T-BC continues to provide its own timing information to its peers, although derived clock is not as accurate as the T-GM.
- T-TSC: The telecom time subordinate/client clock (T-TSC) synchronizes its local clock to another PTP clock (in most cases, the T-BC), and does not provide synchronization through PTP to any other device.

Performance Requirements

The router is compliant with Class B performance requirements for T-TSC and T-BC as documented in G.8273.2.

G.8275.2

The G.8275.2 is a PTP profile for use in telecom networks where phase or time-of-day synchronization is required. It differs from G.8275.1 in that it is not required that each device in the network participates in the PTP protocol. Also, G.8275.2 uses PTP over IPv4 in unicast mode.

The G.8275.2 profile is based on the partial timing support from the network. Hence nodes using G.8275.2 are not required to be directly connected.

The G.8275.2 profile is used in mobile cellular systems that require accurate synchronization of time and phase. For example, the fourth generation (4G) of mobile telecommunications technology.

Features of G.8275.2 profile are:

- Clock Selection: G.8275.2 profile also defines an alternate BMCA that selects a clock for synchronization and port state for the local ports of all devices in the network is defined for the profile. The parameters defined as a part of the BMCA are:
 - Clock Class
 - Clock Accuracy
 - Offset Scaled Log Variance
 - Priority 2
 - Clock Identity
 - Steps Removed
 - Port Identity
 - notSlave flag
 - Local Priority



Note See ITU-T G.8275.2 document to determine the valid values for Clock Class parameter.

- **Port State Decision:** The port states are selected based on the alternate BMCA algorithm. A port can be configured as "server-only", "client-only", or "any" mode.
- **Packet Rates:**
 - Synchronization/Follow-Up—minimum is one packet-per-second and maximum of 128 packets-per-second.
 - Packet rate for Announce packets—minimum of one packet-per-second and maximum of eight packets-per-second.
 - Delay-Request/Delay-Response packets—minimum is one packet-per-second and maximum of 128 packets-per-second.
- **Transport Mechanism:** G.8275.2 profile supports only IPv4 PTP transport mechanism.
- **Mode:** G.8275.2 profile supports transport of data packets only in unicast mode.
- **Clock Type:** G.8275.2 profile supports the following clock types:
 - **Telecom Grandmaster (T-GM):** Provides timing for other network devices and does not synchronize its local clock to other network devices. However, T-GM can be connected to a GPS or GNSS for deriving better clock information.
 - **Telecom Time Subordinate/Client Clock (T-TSC) and Partial-Support Telecom Time Subordinate/Client Clocks (T-TSC-P):** A client clock synchronizes its local clock to another PTP clock, but does not provide PTP synchronization to any other network devices.
 - **Telecom Boundary Clock (T-BC) and Partial-Support Telecom Boundary Clocks (T-BC-P):** Synchronizes its local clock to a T-GM or an upstream T-BC clock and provides timing information to downstream T-BC or T-TSC clocks.
- **Domain Numbers:** The domain numbers that can be used in a G.8275.2 profile network ranges from 44 to 63. The default domain number is 44.

PTP Virtual Port

Feature Name	Release Information	Feature Description
PTP Virtual Port Support for Cisco NCS 540 routers	Release 7.4.1	<p>You can now select the best available timing source for your routers by using the PTP Virtual Port feature.</p> <p>This feature allows you to compare, select, and advertise the best clock source between a PTP server and other local timing sources connected to the routers.</p> <p>Virtual Port is an external frequency, phase, and time input interface on a Telecom Boundary Clock (T-BC), and thus participates in the timing source selection.</p>

G.8275.1 introduces the concept of a virtual port on the T-BC. A virtual port is an external frequency, phase, and time input interface on a T-BC, which can participate in the source selection.

Limitations

- Assisted Partial Timing Support (APTS) is supported only for the G8275.2 non hybrid mode.
- Virtual port is supported for G8275.1 and G8275.2 in hybrid and non-hybrid modes.
- Virtual port configuration is not allowed under Ordinary Clocks.
- Virtual port cannot be configured if the time of day (ToD) priority is not set under the global PTP configuration mode. Use the **time-of-day priority** command to set the ToD.

Assisted Partial Timing Support

In a network having GNSS or GPS reference, all nodes (or secondary clocks) at the edge of the network follow the GNSS primary clock that runs at the core. When GNSS or GPS reference fails at the core, the secondary clocks running at the edge no longer receive accurate time stamps from the primary clock.

With the use of APTS, the nodes at the edge of the network identify GNSS or GPS as primary clock source, and PTP as the secondary source. So even if the GNSS reference is lost, the nodes fall back to the backup PTP session running between the primary clock at core and the nodes at the edge, and are thereby able to maintain an accurate time stamp.

Configuring the G.8265.1 Profile

Configuring the Client Global Configuration: Example

Master Node

```
ptp
 clock
 domain 4
 profile g.8265.1 clock-type master
 profile master
 transport ipv4
 sync frequency 16
 announce interval 1
 delay-request frequency 16
 interface gi 0/1/0/0
 ptp
 profile master
 transport ipv4
 port state master-only
 ipv4 address 18.1.1.1/24
```

Slave Node

```
ptp
 clock
 domain 4
 profile g.8265.1 clock-type slave

 profile slave
 transport ipv4
 sync frequency 16
 announce interval 1
 delay-request frequency 16
 interface gi 0/1/0/0
 ptp
```


Configuring the G.8275.2 Profile

Global configuration for the telecom profile for Server clock:

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

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

Global configuration for the telecom profile for Client clock:

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

interface GigabitEthernet0/0/0/12
  ptp
  profile slave
  master ipv4 10.10.10.1
  !
  !
  ipv4 address 10.10.10.2 255.255.255.0
  !
```

Global configuration with clock type as T-Boundary Clock (T-BC) for the telecom profile:

```
ptp
clock
  domain 44
  profile g.8275.2 clock-type T-BC
  !
profile slave
  transport ipv4
  port state slave-only
  sync frequency 64
```

```

announce frequency 8
unicast-grant invalid-request deny
delay-request frequency 64
!
profile master
transport ipv4
sync frequency 64
announce frequency 8
unicast-grant invalid-request deny
delay-request frequency 64
!
log
servo events
best-master-clock changes
!
!

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

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

```

Example: Configuring G.8275.2 in Hybrid Mode

1. Configuring Sync2

```

clock-interface sync 2 location 0/RP0/CPU0
port-parameters
gps-input tod-format cisco pps-input ttl <depending on the tod format incoming :
cisco/ntp4>
!
frequency synchronization
selection input
priority 1
wait-to-restore 0
quality receive exact itu-t option 1 PRC

```

2. Configuring the T-GM with GNSS as source



Note If the server clock receives front panel inputs, skip to step b.

a. Enabling GNSS

```

gnss-receiver 0 location 0/RP1/CPU0
no shut
constellation auto
frequency synchronization
selection input

```

```
wait-to-restore 0
quality receive exact itu-t option 1 PRC
```



Note In Cisco IOS XR Release 7.0.1, GNSS is *not* supported on N540-28Z4C-SYS-A/D and N540-12Z20G-SYS-A/D variants.



Note In Cisco IOS XR Release 7.3.1, GNSS is *not* supported on N540X-6Z18G-SYS-A/D and N540X-8Z16G-SYS-AD variants.



Note In Cisco IOS XR Release 7.4.1, GNSS is *not* supported on the N540X-4Z14G2Q-SYS-A/D variants.

b. Configuring global PTP

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

c. Configuring global frequency

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

d. Enabling GPS for phase and frequency input

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

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

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

```
frequency synchronization
!
```

3. Configuring G.8275.2 on T-BC

a. Configuring global SyncE

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

b. Configuring global PTP

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

c. Configuring Client port on Hybrid BC

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

d. Configuring Server port on Hybrid BC

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

4. Configuring G8275.2 on T-TSC

a. Configuring global SyncE

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

b. Configuring global PTP

```
ptp
clock
```



```

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

```

c. Configuring Client port on Hybrid BC

```

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

```

Example: Configuring G.8275.2 in Non-Hybrid Mode

1. Configuring Sync2

```

clock-interface sync 2 location 0/RP0/CPU0
port-parameters
gps-input tod-format cisco pps-input ttl <depending on the tod format incoming :
cisco/ntp4>
!
frequency synchronization
selection input
priority 1
wait-to-restore 0
quality receive exact itu-t option 1 PRC

```

2. Configuring the T-GM with GNSS as source



Note If the server clock receives front panel inputs, skip to step b.

a. Enabling GNSS

```

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

```



Note In Cisco IOS XR Release 7.0.1, GNSS is *not* supported on N540-28Z4C-SYS-A/D and N540-12Z20G-SYS-A/D variants.



Note In Cisco IOS XR Release 7.3.1, GNSS is also *not* supported on N540X-6Z18G-SYS-A/D and N540X-8Z16G-SYS-AD variants.



Note In Cisco IOS XR Release 7.4.1, GNSS is *not* supported on the N540X-4Z14G2Q-SYS-A/D variants.

b. Configuring global PTP

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

c. Enabling GPS for phase and frequency input

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

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

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

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

3. Configuring G.8275.2 on T-BC

a. Configuring global PTP

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

```

    delay-request frequency 64
    !

```

b. Configuring Client port on Hybrid BC

```

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

```

c. Configuring Server port on Hybrid BC

```

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

```

4. Configuring G8275.2 on T-TSC

a. Configuring global PTP

```

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

```

b. Configuring Client port on Hybrid BC

```

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

```

Configuring Virtual Port

Effective Cisco IOS XR Release 7.4.1, you can configure virtual port on the G8275.1 and G8275.2 profiles in hybrid and non-hybrid modes.

For virtual port configuration to work, GNSS or Sync2 must be configured.

```

ptp
 clock
 domain 44

```

```

profile g.8275.2 clock-type T-BC
!
profile profile1
transport ipv4
sync frequency 64
clock operation one-step
announce frequency 8
delay-request frequency 64
!
virtual-port
offset-scaled-log-variance 20061
priority2 128
clock-class 6
clock-accuracy 33
local-priority 127
!
frequency priority 254
time-of-day priority 90    <<--time-of-day priority is a required parameter if you want
to configure virtual port-->>
log

```

Configuring APTS

Effective Cisco IOS XR Release 7.4.1, you can configure APTS on the G8275.2 profile in non-hybrid mode.

```

ptp
aps
clock
domain 44
profile g.8275.2 clock-type T-BC
!
profile profile1
transport ipv4
sync frequency 64
clock operation one-step
announce frequency 8
delay-request frequency 64
!
virtual-port
  offset-scaled-log-variance 20061
  priority2 128
  clock-class 6
  clock-accuracy 33
  local-priority 127
!
frequency priority 254
time-of-day priority 90
log

```

PTP Over Bundled Virtual Interface

Table 3: Feature History

Feature Name	Release Information	Description
PTP over BVI	Release 7.2.2	<p>This feature allows PTP traffic to flow over a bridged virtual interface.</p> <p>You can now configure PTP over BVI on the following variants:</p> <ul style="list-style-type: none"> • N540-24Z8Q2C-SYS • N540X-ACC-SYS • N540-ACC-SYS • N540-28Z4C-SYS • N540-28Z4C-SYS-A • N540-28Z4C-SYS-D • N540X-16Z4G8Q2C-A • N540X-16Z4G8Q2C-D • N540X-16Z8Q2C-D • N540-12Z20G-SYS-A • N540-12Z20G-SYS-D • N540X-12Z16G-SYS-A • N540X-12Z16G-SYS-D

Limitations

- PTP over BVI is supported only for PTP IPv4 sessions on BVI.
- PTP over BVI is supported only on the server interfaces of T-GM and T-BC.
- For PTP over BVI to work seamlessly, SyncE must be configured on a physical interface.
- PTP over BVI is not supported on subinterfaces.
- PTP over BVI does not support bundle interfaces within BVI.

Configuring PTP Over BVI

Consider the following topology:



Note Host routers A and B have the standard PTP client configuration.

Verifying PTP Over BVI

To check for the packet counters at BVI interface on the server, use the **show ptp packet-counters bvi *bvi-name*** command.

To check the state of PTP on the BVI interface on the server, use the **show ptp interface brief** command.

Slow Tracking

Under normal configured conditions, any change in offset triggers an immediate reaction in the servo. With the Slow Tracking feature enabled, the servo corrects the phase offset based on the configured value. If the phase offset exceeds the acceptable range, servo goes into Holdover state. In such a condition, the Slow Tracking feature becomes inactive and the servo corrects itself to the latest offset and goes into Phase locked state. Slow Tracking becomes active again.



-
- Note**
- The supported slow tracking rate range is from 8-894 nanoseconds per second and must be in multiples of 8.
 - This feature is active only when servo is in Phase locked mode.
-

```
Router:# config
ptp
clock
domain 24
profile g.8275.1 clock-type T-BC
!
profile profile1
multicast target-address ethernet 01-1B-19-00-00-00
transport ethernet
sync frequency 16
clock operation one-step
announce frequency 8
delay-request frequency 16
!
physical-layer-frequency
servo-slow-tracking 16
!
```

PTP Holdover Traceability Suppression

Table 4: Feature History Table

Feature Name	Release Information	Feature Description
PTP Holdover Traceability Suppression	Release 7.4.1	When a device which is configured as a Boundary clock (T-BC) loses synchronization with a quality Primary clock, to ensure that the downstream nodes continue to receive the configured clock class for a specified duration, and it's traceable you can configure this feature.

When the device loses synchronization with a quality Primary clock, to ensure that the downstream nodes continue to receive the configured clock class, and it's traceable you can configure this feature.

This feature enables the device which is configured as a boundary clock (T-BC) with PTP Profiles G.8275.1 or G.8275.2 to send out the configured clock-class as holdover clock-class and the time traceability flag to be set as TRUE for the specified duration. This is to ensure the down-stream nodes do not have an impact as this is a deviation from prescribed G.8275.1 ITU-T standards.



Note

- There are PTP flaps during switchovers or ISSU as the PTP holdover timer is running on the active RSP.
- Once the configured holdover override duration has lapsed and the device is unable to receive a quality Primary clock within this duration, the device sends the prescribed default clock class of 165, and the traceability flag will be set as FALSE to advertise loss of clock to downstream nodes.

Configuring PTP Holdover traceability suppression

This section describes how to configure the PTP holdover traceability suppression feature:

```
Router# config
Router(config)# ptp
Router(config-ptp)# holdover-spec-duration 1000
Router(config-ptp)# holdover-spec-clock-class 135
Router(config-ptp)# uncalibrated-traceable-override
Router(config-ptp)# holdover-spec-traceable-override
```

IEEE Default Profile

The IEEE 1588 standard defines one profile, the default profile A telecom profile defines:

- Restrictions on network technology
- Required PTP options

- Allowed PTP options
- Forbidden PTP options

The IEEE 1588 Default Profile can be configured only over IP and MPLS networks.

The Default Profile requires the following PTP options:

- The standard BMCA, with both priority fields set to 128.
- All management messages implemented
- Domain number zero

Example: Hybrid Default Profile

Global PTP Configuration:

```
ptp
 clock
  domain 0
 exit
 profile slave
  transport ipv4
  sync frequency 32
  announce frequency 2
  delay-request frequency 32
 exit
 profile master
  transport ipv4
 exit
 uncalibrated-clock-class 255 unless-from-holdover
 freerun-clock-class 255
 startup-clock-class 255
 physical-layer-frequency <-- This is a mandatory command -->
 exit
```

PTP Hybrid Mode

Your router allows the ability to select separate sources for frequency and time-of-day (ToD). Frequency selection can be between any source of frequency available to the router, such as: GPS, SyncE or IEEE 1588 PTP. The ToD selection is between the source selected for frequency and PTP, if available (ToD selection is from GPS or PTP). This is known as hybrid mode, where a physical frequency source (SyncE) is used to provide frequency synchronization, while PTP is used to provide ToD synchronization.

Frequency selection uses the algorithm described in ITU-T recommendation G.781, and is described in the Configuring Frequency Synchronization module in this document. The ToD selection is controlled using the time-of-day priority configuration. This configuration is found under the source interface frequency synchronization configuration mode and under the global PTP configuration mode. It controls the order for which sources are selected for ToD. Values in the range of 1 to 254 are allowed, with lower numbers.

Configuring PTP Hybrid Mode



Note You must configure the PTP hybrid mode when using the G.8275.1 PTP profile.

Configure hybrid mode by selecting PTP for the time-of-day (ToD) and another source for the frequency. This task summarizes the hybrid configuration. See the other PTP configuration modules for more detailed information regarding the PTP configurations. For more information on SyncE configurations, see the *Configuring Ethernet Interfaces* section in the *Interface and Hardware Component Configuration Guide for Cisco NCS 540 Series Routers*.

To configure PTP Hybrid mode:

1. Configure Global Frequency Synchronization

```
RP/0/RP0/CPU0:router(config)# frequency synchronization
RP/0/RP0/CPU0:router(config)# commit
RP/0/RP0/CPU0:router(config)# quality itu-t option [1 | 2]
```

2. Configure Frequency Synchronization in Interface.

```
RP/0/RP0/CPU0:router(config)# interface GigabitEthernet 0/0/0/0
RP/0/RP0/CPU0:router(config-if)# frequency synchronization
RP/0/RP0/CPU0:router(config-if-freqsync)# selection input
RP/0/RP0/CPU0:router(config-if-freqsync)# time-of-day-priority 100
RP/0/RP0/CPU0:router(config-if-freqsync)# commit
```

3. Configure Global PTP

```
RP/0/RP0/CPU0:router(config)# ptp
RP/0/RP0/CPU0:router(config-ptp)# time-of-day priority 1
RP/0/RP0/CPU0:router(config)# commit
```

4. Configure Client Port

```
RP/0/RP0/CPU0:router(config)# interface GigabitEthernet0/0/0/2
RP/0/RP0/CPU0:router(config-if)# ptp
RP/0/RP0/CPU0:router(config-if)# profile slave
RP/0/RP0/CPU0:router(config-if)# multicast target-address ethernet 01-1B-19-00-00-00
RP/0/RP0/CPU0:router(config-if)# transport ethernet sync frequency 16
RP/0/RP0/CPU0:router(config-if)# announce frequency 8
RP/0/RP0/CPU0:router(config-if)# delay-request frequency 16
RP/0/RP0/CPU0:router(config-if)# frequency synchronization
RP/0/RP0/CPU0:router(config-if-freqsync)# selection input
RP/0/RP0/CPU0:router(config-if-freqsync)# priority 1
RP/0/RP0/CPU0:router(config-if-freqsync)# wait-to-restore 0
```

5. Configure Server Port

```
RP/0/RP0/CPU0:router(config)# interface GigabitEthernet0/0/0/3
RP/0/RP0/CPU0:router(config)# ptp
RP/0/RP0/CPU0:router(config)# profile master
RP/0/RP0/CPU0:router(config)# multicast target-address ethernet 01-1B-19-00-00-00
RP/0/RP0/CPU0:router(config)# port state master-only
RP/0/RP0/CPU0:router(config)# transport ethernet
RP/0/RP0/CPU0:router(config)# sync frequency 16
RP/0/RP0/CPU0:router(config)# announce frequency 8
RP/0/RP0/CPU0:router(config)# delay-request frequency 16
RP/0/RP0/CPU0:router(config)# frequency synchronization
RP/0/RP0/CPU0:router(config-if-freqsync)# exit
```

Verifying the PTP Hybrid Mode Configurations

Use the following show commands to verify the configurations:

- **show ptp platform servo**

```
RP/0/RP0/CPU0:ios# show ptp platform servo
Tue Mar  5 07:08:00.134 UTC
Servo status: Running
Servo stat_index: 2
Device status: PHASE_LOCKED
Servo Mode: Hybrid
Servo log level: 0
Phase Alignment Accuracy: 0 ns
Sync timestamp updated: 8631
Sync timestamp discarded: 0
Delay timestamp updated: 8631
Delay timestamp discarded: 0
Previous Received Timestamp T1: 22521.011765183 T2: 22521.011766745 T3: 22521.018061685
T4: 22521.018063247
Last Received Timestamp T1: 22521.073747183 T2: 22521.073748745 T3: 22521.080054957
T4: 22521.080056515
Offset from master:  0 secs, 2 nsecs
Mean path delay   :  0 secs, 1560 nsecs
setTime():1 stepTime():1 adjustFreq():0
Last setTime: 21984.000000000 flag:0 Last stepTime:-276573300 Last adjustFreq:0
RP/0/RP1/CPU0:ios#
```

- **show running-config ptp**

```
RP/0/RP0/CPU0:router# show running-config ptp
ptp
clock
domain 24
profile g.8275.1 clock-type T-BC
!
profile slave
transport ethernet
sync frequency 16
announce frequency 8
delay-request frequency 16
!
profile master
transport ethernet
sync frequency 16
announce frequency 8
delay-request frequency 16
!
!
physical-layer frequency
!
```

- **show running-config frequency synchronization**

```
RP/0/RP0/CPU0:router# show running-config frequency synchronization
Tue Feb  6 06:36:26.472 UTC
frequency synchronization
quality itu-t option 1
clock-interface timing-mode system
!
```

- **show frequency synchronization interface brief**

```
RP/0/RP0/CPU0:P3# show frequency synchronization interface brief
```

```
Tue Feb 6 06:37:49.234 UTC
```

```
Flags: > - Up D - Down S - Assigned for selection
```

```
d - SSM Disabled x - Peer timed out i - Init state
```

```
s - Output squelched
```

```
F1 Interface QLrcv QLuse Pri QLsnd Output driven by
```

```
==== =====
```

```
>S GigabitEthernet0/0/0/2 PRC PRC 1 DNU GigabitEthernet0/0/0/2
```

```
>x GigabitEthernet0/0/0/3 Fail n/a 100 PRC GigabitEthernet0/0/0/2
```

```
>x GigabitEthernet0/0/0/4 Fail n/a 100 PRC GigabitEthernet0/0/0/2
```

```
RP/0/RP0/CPU0:P3#
```

PTP Profile Interoperation

Table 5: Feature History Table

Feature Name	Release Information	Description
PTP Profile Interoperation	Release 7.2.1	PTP profile interoperation enables users to deploy newer profiles in a network containing older devices that do not support these profiles. This support allows for a gradual upgrade path. For this release, interoperation is supported only between the G.8275.1 and G.8275.2 profiles.
PTP Profile Interoperation	Release 7.5.1	Support for this feature is now extended on the following Cisco NCS 540 router variants: <ul style="list-style-type: none"> • N540-FH-CSR-SYS • N540-FH-AGG-SYS • N540X-6Z18G-SYS-A/D • N540X-8Z16G-SYS-A/D • N540X-4Z14G2Q-A/D For this release, interoperation is extended between default, G.8275.1, and G.8275.2 profiles.

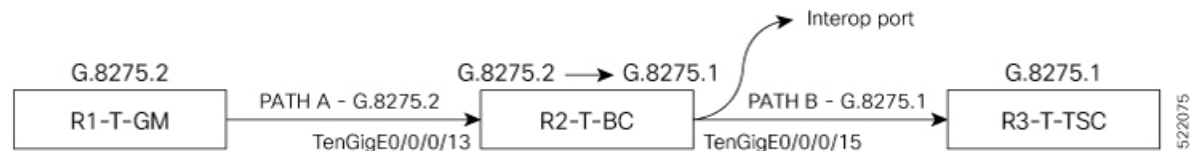
PTP profile interoperation occurs when a device that is running a particular profile is also configured to interoperate with one or more peer clocks that are running different profiles. To enable this behavior, use the `ptp interop profile profile` command to configure the interfaces that are connected to such peer clocks to interoperate.

For each such interface, the following configuration are available:

- Profile of the peer clock. If the profile is not specified, the profile of the local clock is used.
- Domain Number of the peer clock. If not specified, the domain number of the local clock is used. Incoming PTP messages with a different domain number are dropped.
- The Ingress-Conversion behavior. This behavior allows you to specify how to convert the clock properties received in incoming Announce messages.
 - The Priority1 and Priority2 values. If not specified, the default mapping is applied.
 - The ClockAccuracy value. If not specified, the default mapping is applied.
 - The OffsetScaledLogVariance value. If not specified, the default mapping is applied.
 - Any number of Clock-Class-Mappings. These mappings override the default mappings whenever present.
 - The Clock-Class-Default value. If present, this value is used for all clock class values for which a more specific mapping is not configured.
- The Egress-Conversion behavior: This behavior allows you to specify how to convert the clock properties sent in outgoing Announce messages. The options are the same as for Ingress-Conversion.

Consider the following example:

Figure 4: Simple Illustration of PTP Profile Interoperation



Router R1 (acting as grandmaster clock) is running the profile G.8275.2 through Path A towards router R2. R2 acts as a boundary clock and is running profile G.8275.1. The egress interface of R2 is an interop port that converts profile G.8275.2 to G.8275.1.

The profile G.8275.1 is carried over Path B toward the ordinary clock or router R3.

Configure the following on the interop port of Boundary Clock 'B':

```
interface TenGigE0/0/0/15
  ptp
  interop
  profile g.8275.1
  domain 24
  !
  multicast target-address ethernet 01-1B-19-00-00-00
  transport ethernet
  port state master-only
  sync frequency 64
  clock operation one-step
  announce interval 1
  delay-request frequency 32
  !
  frequency synchronization
```

Verifying PTP Interoperation

Run the following show commands on the interop port of R2 (see the figure above):

```
RP/0/RP0/CPU0:R2# show ptp platform servo
Sat Jul  3 17:28:50.107 UTC
Servo status: Running
Servo stat_index: 2
Device status: PHASE_LOCKED
Servo Mode: Hybrid
Servo log level: 0
Phase Alignment Accuracy: 1 ns
Sync timestamp updated: 24668
Sync timestamp discarded: 0
Delay timestamp updated: 24668
Delay timestamp discarded: 0
Previous Received Timestamp T1: 1625246930.271485001  T2: 1625246930.271485039  T3:
1625246930.280721326  T4: 1625246930.280
Last Received Timestamp T1: 1625246930.333474633  T2: 1625246930.333474671  T3:
1625246930.344744853  T4: 1625246930.3447448
Offset from master: -0 secs, 1 nsecs
Mean path delay   : 0 secs, 25 nsecs
setTime():1  stepTime():2  adjustFreq():12246
Last setTime: 1625245327.000000000 flag:0  Last stepTime:141500000  Last adjustFreq:5
```

```
RP/0/RP0/CPU0:JAGUAR# show ptp interop
Sat Jul  3 17:28:53.477 UTC
Interface TenGigE0/0/0/15
```

Egress Conversions:

```
Profile:          G.8275.2 -> G.8275.1
Domain:           44 -> 24
Priority1:        128 -> 128
Priority2:        128 -> 128
ClockClass:      6 -> 6
ClockAccuracy:   0x21 -> 0x21
OffsetScaledLogVariance: 0x4e5d -> 0x4e5d
```

Ingress Conversions:

This port is not receiving Announce messages

```
RP/0/RP0/CPU0:R2# show ptp interfaces brief
```

```
Sat Jul  3 17:37:09.018 UTC
Intf      Port      Port      Line
Name      Number   State     Encap    State     Mechanism
-----
Te0/0/0/13  1        Slave    IPv4     up        1-step DRRM
Te0/0/0/15  2        Master   Ethernet up        1-step DRRM
```

```
RP/0/RP0/CPU0:R2# show ptp advertised-clock
```

```
Sat Jul  3 17:48:28.691 UTC
Clock ID: 8a96ffef6a0d8
Clock properties:
  Domain: 44, Priority1: 128, Priority2: 128, Class: 6
  Accuracy: 0x21, Offset scaled log variance: 0x4e5d
  Time Source: GPS
  Timescale: PTP
  Frequency-traceable, Time-traceable
  Current UTC offset: 37 seconds (valid)
```