



Network Synchronization Configuration Guide for Cisco NCS 540 Series Routers, IOS XR Release 7.4.x

First Published: 2021-07-30

Last Modified: 2020-01-22

Americas Headquarters

Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
<http://www.cisco.com>
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

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CONTENTS

CHAPTER 1

Synchronous Ethernet ESMC and SSM 1

- Frequency Synchronization Timing Concepts 2
 - Sources 2
 - Selection Points 2
 - Restrictions 3
- Configuring Frequency Synchronization 3
 - Enabling Frequency Synchronization on the Router 3
 - Configuring Frequency Synchronization on an Interface 3
 - Configuring Frequency Synchronization on a Clock Interface 4
- Verifying the Frequency Synchronization Configuration 4
- Verifying the ESMC Configuration 7
- Verifying Synchronous Ethernet LEDs 8

CHAPTER 2

Understanding PTP 9

- Why PTP? 10
- Routers and Delays 11
- Message-Based Synchronization 11
- PTP Event Message Sequences 11
 - Synchronizing with Boundary Clocks 11
 - Synchronizing the Local Clock 13
- PTP Clocks 13
- Restrictions for PTP 13
- PTP Profiles 14
 - ITU-T Telecom Profiles for PTP 14
 - G.8265.1 14
 - G.8275.1 15

G.8275.2	16
PTP Virtual Port	18
Configuring the G.8265.1 Profile	18
Configuring the G.8275.1 Profile	19
Configuring the G.8275.2 Profile	20
Example: Configuring G.8275.2 in Hybrid Mode	22
Example: Configuring G.8275.2 in Non-Hybrid Mode	24
Configuring Virtual Port	27
Configuring APTS	27
PTP Over Bundled Virtual Interface	28
Limitations	28
Configuring PTP Over BVI	29
Verifying PTP Over BVI	30
Slow Tracking	30
PTP Holdover Traceability Suppression	31
IEEE Default Profile	31
Example: Hybrid Default Profile	32
PTP Hybrid Mode	32
Configuring PTP Hybrid Mode	33
Verifying the PTP Hybrid Mode Configurations	34
PTP Profile Interoperation	35
Verifying PTP Interoperation	36

CHAPTER 3
External Timing Source 39

GPS	39
Configuring GPS Settings for the Grandmaster Clock	40
Verifying the GPS Input	40
Building Integrated Timing Supply (BITS)	41
Prerequisite for BITS	41
Configuring BITS-IN	41
Configuring BITS-OUT	42
Verifying BITS-IN Configuration	42
Verifying BITS-OUT Configuration	43
Verify Quality Level Received and Clock Interfaces	43

CHAPTER 4	Implementing NTP	45
	Information About Implementing NTP	45
	Configuring NTP	46
	Configuring Poll-Based Associations	46
	Configuring Broadcast-Based Associations	46
	Configuring NTP Access Groups	47
	Configuring NTP Authentication	47
	Disabling NTP on an Interface	48
	Configuring the System as an Authoritative NTP Server	48
	Updating the Hardware Clock	48
	Configuring NTP Server Inside VRF Interface	49

CHAPTER 5	Workflow and Use Case	51
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CHAPTER 6	Configure the Global Navigation Satellite System	55
	Overview of GNSS	55
	Operation of GNSS Module	57
	Prerequisites for GNSS	58
	Restrictions for GNSS	59
	Configure GNSS	59



CHAPTER 1

Synchronous Ethernet ESMC and SSM

Table 1: Feature History Table

Feature Name	Release Information	Description
Frequency Synchronization on the N540X-4Z14G2Q-SYS-A/D routers.	Release 7.4.1	Based on the ITU-T G.8262 recommendations, precision frequency is enabled on timing devices to deliver frequency synchronization for bandwidth, frequency accuracy, holdover, and noise generation. This support allows for correct network operations when synchronous equipment is timed from either another synchronous equipment clock or a higher-quality clock.



Note On Cisco N540X-4Z14G2Q-SYS-A/D routers, the Synchronous Ethernet (SyncE) feature is not supported on ports 14 and 15.

Synchronous Ethernet is an extension of Ethernet designed to provide the reliability found in traditional SONET/SDH and T1/E1 networks to Ethernet packet networks by incorporating clock synchronization features. It supports the Synchronization Status Message (SSM) and Ethernet Synchronization Message Channel (ESMC) for synchronous Ethernet clock synchronization.

Synchronous Ethernet incorporates the Synchronization Status Message (SSM) used in Synchronous Optical Networking (SONET) and Synchronous Digital Hierarchy (SDH) networks. While SONET and SDH transmit the SSM in a fixed location within the frame, Ethernet Synchronization Message Channel (ESMC) transmits the SSM using a protocol: the IEEE 802.3 Organization-Specific Slow Protocol (OSSP) standard.

The ESMC carries a Quality Level (QL) value identifying the clock quality of a given synchronous Ethernet timing source. Clock quality values help a synchronous Ethernet node derive timing from the most reliable source and prevent timing loops.

When configured to use synchronous Ethernet, the router synchronizes to the best available clock source. If no better clock sources are available, the router remains synchronized to the current clock source.

The router supports QL-enabled mode.

- [Frequency Synchronization Timing Concepts, on page 2](#)
- [Configuring Frequency Synchronization, on page 3](#)
- [Verifying the Frequency Synchronization Configuration, on page 4](#)
- [Verifying the ESMC Configuration, on page 7](#)
- [Verifying Synchronous Ethernet LEDs, on page 8](#)

Frequency Synchronization Timing Concepts

The Cisco IOS XR frequency synchronization infrastructure is used to select between different frequency sources to set the router backplane frequency and time-of-day. There are two important concepts that must be understood with respect to the frequency synchronization implementation.

Sources

A source is a piece of hardware that inputs frequency signals into the system or transmits them out of the system. There are four types of sources:

- Line interfaces. This includes SyncE interfaces.
- Clock interfaces. These are external connectors for connecting other timing signals, such as, GPS, BITS.
- PTP clock. If IEEE 1588 version 2 is configured on the router, a PTP clock may be available to frequency synchronization as a source of the time-of-day and frequency.
- Internal oscillator. This is a free-running internal oscillator chip.

Each timing source has a Quality Level (QL) associated with it which gives the accuracy of the clock. This QL information is transmitted across the network via SSMs over the Ethernet Synchronization Messaging Channel (ESMC) or SSMs contained in the SONET/SDH frames so that devices know the best available source to synchronize to. In order to define a preferred network synchronization flow, and to help prevent timing loops, you can assign priority values to particular timing sources on each router. The combination of QL information and user-assigned priority levels allows each router to choose a timing source to use to clock its SyncE and SONET/SDH interfaces, as described in the ITU standard G.781.

Selection Points

A selection point is any point where a choice is made between several frequency signals, and possibly one or more of them are selected. Selection points form a graph representing the flow of timing signals between the different cards in a router running Cisco IOS XR software. For example, one or multiple selection points select between the different Synchronous Ethernet inputs available on a single line card, and the result of these selection points is forwarded to a selection point on the RSP to select between the selected source from each card.

The input signals to the selection points can be:

- Received directly from a source.
- The output from another selection point on the same card.
- The output from a selection point on a different card.

The output of a selection point can be used in a number of ways:

- Used to drive the signals sent out of a set of sources.
- As input into another selection point on the card.
- As input into a selection point on another card.

Use the show frequency synchronization selection command to see a detailed view of the different selection points within the system.

Restrictions



Note

The following restrictions are applicable only for N540-24Z8Q2C-SYS, N540X-ACC-SYS, N540-ACC-SYS, and N540-28Z4C-SYS variants.

- SyncE is not supported on Gigabit Ethernet 0/0/0/24 to 0/0/0/31 ports.
- The Precision Time Protocol (PTP) session flaps during Route Processor Failover (RPFO).

Configuring Frequency Synchronization

Enabling Frequency Synchronization on the Router

This task describes the router-level configuration required to enable frequency synchronization.

```
RP/0/RP0/CPU0:Router# configure
RP/0/RP0/CPU0:Router(config)# frequency synchronization
RP/0/RP0/CPU0:Router(config-freqsync)# clock-interface timing-mode system
RP/0/RP0/CPU0:Router(config-freqsync)# quality itu-t option 1 generation 1
RP/0/RP0/CPU0:Router(config-freqsync)# log selection changes
RP/0/RP0/CPU0:Router(config-freqsync)# commit
```

Configuring Frequency Synchronization on an Interface

By default, there is no frequency synchronization on line interfaces. Use this task to configure an interface to participate in frequency synchronization.

Before You Begin

You must enable frequency synchronization globally on the router.

```
RP/0/RP0/CPU0:R1#config terminal
RP/0/RP0/CPU0:R1(config)#interface TenGigabitEthernet 0/0/0/0
RP/0/RP0/CPU0:R1(config-if)#frequency synchronization
RP/0/RP0/CPU0:R1(config-if-freqsync)#selection input
RP/0/RP0/CPU0:R1(config-if-freqsync)#wait-to-restore 10
RP/0/RP0/CPU0:R1(config-if-freqsync)#priority 5
RP/0/RP0/CPU0:R1(config-if-freqsync)#quality transmit exact itu-t option 1 PRC
RP/0/RP0/CPU0:R1(config-if-freqsync)#quality receive exact itu-t option 1 PRC
RP/0/RP0/CPU0:R1(config-if-freqsync)#commit
```

```
or
RP/0/RP0/CPU0:router(config-freqsync)# commit
```

Configuring Frequency Synchronization on a Clock Interface

To enable a clock interface to be used as frequency input or output, you must configure the port parameters and frequency synchronization, as described in this task.

```
RP/0/RP0/CPU0:R1#configure
RP/0/RP0/CPU0:R1(config)# clock-interface sync 2 location 0/RP0/CPU0
RP/0/RP0/CPU0:R1(config-clock-if)# port-parameters
RP/0/RP0/CPU0:R1(config-clk-parms)# gps-input tod-format cisco pps-input ttl
RP/0/RP0/CPU0:R1(config-clk-parms)# exit
RP/0/RP0/CPU0:R1(config-clock-if)# frequency synchronization
RP/0/RP0/CPU0:R1(config-clk-freqsync)# selection input
RP/0/RP0/CPU0:R1(config-clk-freqsync)# wait-to-restore 1
RP/0/RP0/CPU0:R1(config-clk-freqsync)# quality receive exact itu-t option 1 PRC
```

Verifying the Frequency Synchronization Configuration

After performing the frequency synchronization configuration tasks, use this task to check for configuration errors and verify the configuration.

1. show frequency synchronization selection

```
RP/0/RP0/CPU0:R5# show frequency synchronization selection
Fri Apr 24 12:49:32.833 UTC
Node 0/RP1/CPU0:
=====
Selection point: T0-SEL-B (3 inputs, 1 selected)
  Last programmed 3d04h ago, and selection made 3d04h ago
  Next selection points
    SPA scoped      : None
    Node scoped     : CHASSIS-TOD-SEL
    Chassis scoped: LC_TX_SELECT
    Router scoped   : None
  Uses frequency selection
  Used for local line interface output
  S  Input                               Last Selection Point          QL  Pri  Status
  == =====
  4  HundredGigE0/7/0/0                 0/RP1/CPU0 ETH_RXMUX 4        PRC  10  Locked
      PTP [0/RP1/CPU0]                  n/a                          PRC  254 Available
      Internal0 [0/RP1/CPU0]            n/a                          SEC  255 Available

Selection point: 1588-SEL (2 inputs, 1 selected)
  Last programmed 3d04h ago, and selection made 3d04h ago
  Next selection points
    SPA scoped      : None
    Node scoped     : None
    Chassis scoped: None
    Router scoped   : None
  Uses frequency selection
  S  Input                               Last Selection Point          QL  Pri  Status
  == =====
  4  HundredGigE0/7/0/0                 0/RP1/CPU0 ETH_RXMUX 4        PRC  10  Locked
      Internal0 [0/RP1/CPU0]            n/a                          SEC  255 Available

Selection point: CHASSIS-TOD-SEL (2 inputs, 1 selected)
  Last programmed 3d04h ago, and selection made 3d04h ago
  Next selection points
```

```

SPA scoped      : None
Node scoped     : None
Chassis scoped: None
Router scoped   : None
Uses time-of-day selection
S  Input                Last Selection Point      Pri  Time  Status
== =====
1  PTP [0/RP1/CPU0]      n/a                100  Yes   Available
   HundredGigE0/7/0/0    0/RP1/CPU0 T0-SEL-B 4  100  No    Available

Selection point: ETH_RXMUX (1 inputs, 1 selected)
Last programmed 3d04h ago, and selection made 3d04h ago
Next selection points
SPA scoped      : None
Node scoped     : T0-SEL-B 1588-SEL
Chassis scoped: None
Router scoped   : None
Uses frequency selection
S  Input                Last Selection Point      QL  Pri  Status
== =====
4  HundredGigE0/7/0/0    n/a                PRC  10  Available

```

2. show frequency synchronization configuration-errors

```

RP/0/RP0/CPU0:router# show frequency synchronization configuration-errors
Node 0/2/CPU0:
=====
interface GigabitEthernet0/2/0/0 frequency synchronization
  * Frequency synchronization is enabled on this interface, but isn't enabled globally.
interface GigabitEthernet0/2/0/0 frequency synchronization quality transmit exact itu-t
option 2 generation 1 PRS
  * The QL that is configured is from a different QL option set than is configured globally.

```

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

- Frequency Synchronization is configured on an interface (line interface or clock-interface), but is not configured globally.
- The QL option configured on some interface does not match the global QL option. Under an interface (line interface or clock interface), the QL option is specified using the quality transmit and quality receive commands. The value specified must match the value configured in the global quality itu-t option command, or match the default (option 1) if the global quality itu-t option command is not configured.

Once all the errors have been resolved, meaning there is no output from the command, continue to the next step.

3. show frequency synchronization interfaces brief

```

RP/0/RP0/CPU0:R5# show frequency synchronization interfaces brief
Thu Feb 1 06:30:02.945 UTC
Flags: > - Up
        d - SSM Disabled
        s - Output squelched
Fl  Interface
D - Down          S - Assigned for selection
x - Peer timed out  i - Init state
Last Selection Point
Pri Time
Status

```

```

=====
>S  TenGigE0/0/0/0      PRC   PRC   1 DNU   TenGigE0/0/0/0
>x  TenGigE0/0/0/1      Fail  n/a   100 PRC   TenGigE0/0/0/0
>x  TwentyFiveGigE0/0/0/30 Fail  n/a   100 PRC   TenGigE0/0/0/0
=====

```

RP/0/RP0/CPU0:R5#

Verifies the configuration. Note the following points:

- All line interface that have frequency synchronization configured are displayed.
- All clock interfaces and internal oscillators are displayed.
- Sources that have been nominated as inputs (in other words, have selection input configured) have 'S' in the Flags column; sources that have not been nominated as inputs do not have 'S' displayed.



Note Internal oscillators are always eligible as inputs.

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

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

4. show processes fsyncmgr location node-id

This command verifies that the fsyncmgr process is running on the appropriate nodes.

```

RP/0/RP0/CPU0:R5# show processes fsyncmgr location 0/0/cPU0
Thu Feb 1 06:26:32.979 UTC
Job Id: 181
PID: HYPERLINK "tel:3411"3411
Process name: fsyncmgr
Executable path:
/opt/cisco/XR/packages/ncs540-iosxr-fwding-1.0.0.0-r63226I/all/bin/fsyncmgr Instance #:
1
Version ID: 00.00.0000
Respawn: ON
Respawn count: 1
Last started: Tue Jan 23 04:26:57 HYPERLINK "tel:2018"2018
Process state: Run
Package state: Normal
core: MAINMEM
Max. core: 0
Level: 100
Placement: None
startup_path:
/opt/cisco/XR/packages/ncs540-iosxr-fwding-1.0.0.0-r63226I/all/startup/fsyncmgr.startup
Ready: 2.063s
Process cpu time: 168.480 user, 129.980 kernel, 298.460 total
JID TID Stack pri state NAME rt_pri
181 HYPERLINK "tel:3411"3411 OK 20 Sleeping fsyncmgr 0
181 HYPERLINK "tel:3572"3572 OK 20 Sleeping lwm_debug_threa 0
181 HYPERLINK "tel:3573"3573 OK 20 Sleeping fsyncmgr 0
181 HYPERLINK "tel:3574"3574 OK 20 Sleeping lwm_service_thr 0
181 HYPERLINK "tel:3575"3575 OK 20 Sleeping qsm_service_thr 0
181 HYPERLINK "tel:3622"3622 OK 20 Sleeping fsyncmgr 0
181 HYPERLINK "tel:3781"3781 OK 20 Sleeping fsyncmgr 0
181 HYPERLINK "tel:3789"3789 OK 20 Sleeping fsyncmgr 0

```

Verifying the ESMC Configuration

show frequency synchronization interfaces

```
RP/0/RP0/CPU0:R5# show frequency synchronization interfaces
Thu Feb 1 06:33:26.575 UTC
Interface TenGigE0/0/0/0 (up)
Assigned as input for selection
Wait-to-restore time 0 minutes
SSM Enabled
Peer Up for 2d01h, last SSM received 0.320s ago
Peer has come up 1 times and timed out 0 times
ESMC SSMs Total Information Event DNU/DUS
Sent: HYPERLINK "tel:178479"178479 HYPERLINK "tel:178477"178477 2 HYPERLINK "tel:178463"178463
Received: HYPERLINK "tel:178499"178499 HYPERLINK "tel:178499"178499 0

0
Input:
Up
Last received QL: Opt-I/PRC
Effective QL: Opt-I/PRC, Priority: 1, Time-of-day Priority 100
Supports frequency
Output:
Selected source: TenGigE0/0/0/0
Selected source QL: Opt-I/PRC
Effective QL: DNU
Next selection points: ETH_RXMUX
Interface TenGigE0/0/0/1 (up)
Wait-to-restore time 5 minutes
SSM Enabled
Peer Timed Out for 2d01h, last SSM received never
Peer has come up 0 times and timed out 1 times
ESMC SSMs Total Information Event DNU/DUS
Sent: HYPERLINK "tel:178479"178479 HYPERLINK "tel:178477"178477 2 0
Received: 0 0 0 0
Input:
Down - not assigned for selection
Supports frequency
Output:
Selected source: TenGigE0/0/0/0
Selected source QL: Opt-I/PRC
Effective QL: Opt-I/PRC
Next selection points: ETH_RXMUX
Interface TwentyFiveGigE0/0/0/30 (up)
Wait-to-restore time 5 minutes
SSM Enabled
Peer Timed Out for 01:50:24, last SSM received 01:50:30 ago
Peer has come up 1 times and timed out 1 times
ESMC SSMs Total Information Event DNU/DUS
Sent: HYPERLINK "tel:75086"75086 HYPERLINK "tel:75085"75085 1 0
Received: HYPERLINK "tel:68457"68457 HYPERLINK "tel:68455"68455 2 HYPERLINK "tel:68443"68443
Input:
Down - not assigned for selection
Supports frequency
Output:
Selected source: TenGigE0/0/0/0
Selected source QL: Opt-I/PRC
Effective QL: Opt-I/PRC
Next selection points: ETH_RXMUX
```

Verifying Synchronous Ethernet LEDs

```
RP/0/RP0/CPU0:ios# show led
Mon Nov 2 09:29:34.637 UTC
=====
Location LED Name Mode Color
=====
0/FT0
Status OPERATIONAL GREEN
0/RP0/CPU0
Alarm OPERATIONAL AMBER
Status OPERATIONAL GREEN
Sync OPERATIONAL AMBER
```



CHAPTER 2

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 2: 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.

- [Why PTP?, on page 10](#)
- [Routers and Delays, on page 11](#)
- [Message-Based Synchronization, on page 11](#)
- [PTP Event Message Sequences, on page 11](#)
- [PTP Clocks, on page 13](#)
- [Restrictions for PTP, on page 13](#)
- [PTP Profiles, on page 14](#)
- [PTP Over Bundled Virtual Interface, on page 28](#)
- [Slow Tracking, on page 30](#)
- [PTP Holdover Traceability Suppression, on page 31](#)
- [IEEE Default Profile, on page 31](#)
- [PTP Hybrid Mode, on page 32](#)
- [Verifying the PTP Hybrid Mode Configurations, on page 34](#)
- [PTP Profile Interoperation, on page 35](#)

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

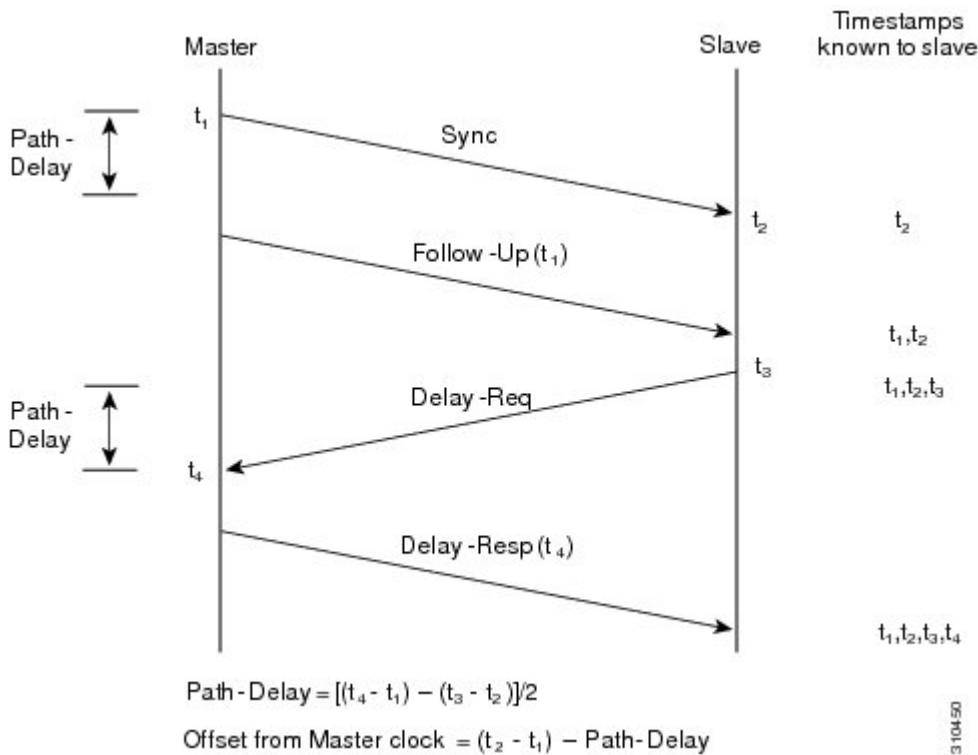
These messages are sent in the following sequence:

- 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 3: Feature History Table

Feature Name	Release Information	Description
PTP Profiles Support for N540-24Q8L2DD-SYS	Release 7.4.1	<p>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> <p>PTP Profiles are now supported on the following Cisco NCS 540 router variant:</p> <ul style="list-style-type: none">• N540-24Q8L2DD-SYS
PTP Profiles Support for N540X-16Z4G8Q2C-A/D	Release 7.0.1	<p>PTP Profiles are now supported on the following Cisco NCS 540 router variant:</p> <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
   profile slave
   transport ipv4
   Master ipv4 18.1.1.1
   port state slave-only
   ipv4 address 18.1.1.2/24
```

Configuring the G.8275.1 Profile

Configuring the Global Settings: Example

```
ptp
 clock
  domain 24
  profile g.8275.1 clock-type [T-BC | TGM | TTSC]
 !
profile profile1
 transport ethernet
 sync frequency 16
 announce frequency 8
 delay-request frequency 16
 !
profile profile2
 transport ethernet
 sync frequency 16
 announce frequency 8
 delay-request frequency 16
 !
 !
  physical-layer-frequency
 !
```

Configuring Client Port: Example

```

interface GigabitEthernet0/0/0/3
 ptp
  profile profile1
  multicast target-address ethernet 01-1B-19-00-00-00
  transport ethernet
  port state slave-only
  local-priority 10
!
  frequency synchronization
  selection input
  priority 1
  wait-to-restore 0
!
!
```

Configuring Server Port: Example

```

interface GigabitEthernet0/0/0/1
 ptp
  profile profile2
  multicast target-address ethernet 01-1B-19-00-00-00
  port state master-only
  transport ethernet
  sync frequency 16
  announce frequency 8
  delay-request frequency 16
!
  frequency synchronization
!
!
```

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
!

```

Example: Configuring G.8275.2 in Non-Hybrid Mode

```

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
 apts
 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 4: 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 • 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 does not support bundle interfaces within BVI.

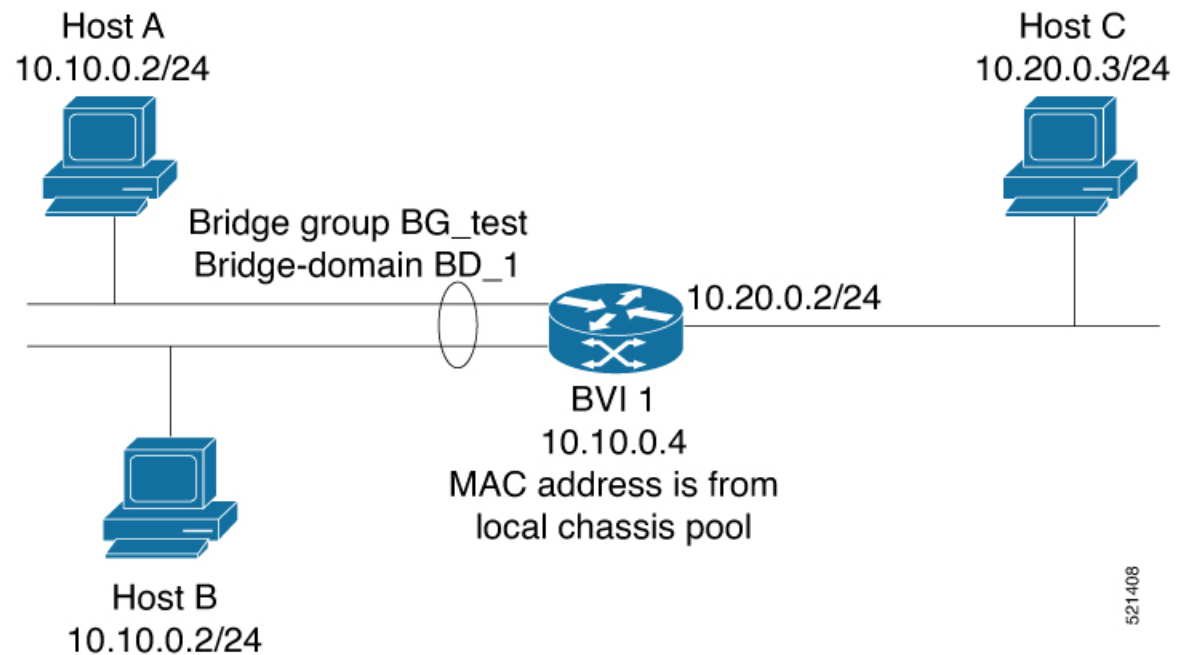
Configuring PTP Over BVI

Consider the following topology:

Router BVI1 acts as PTP server or a BC node. Hosts A and B act as clients. Bridge group **BG_test** and bridge-domain **BD_1** are part of a Layer 2 cloud.

Figure 2:

Figure 3: Sample Topology for Configuring PTP Over BVI



On the PTP Server, BVI1, configure the following:

```
ptp
!
interface GigabitEthernet0/0/0/1
l2transport
!
Interface Bundle-Ether 100
L2transport
!
interface BVI1
ptp
  profile master
!
ipv4 address 11.0.0.1 255.255.255.0
!
l2vpn
bridge group foo
```

```

bridge-domain bar
interface GigabitEthernet0/0/0/0
!
interface GigabitEthernet0/0/0/1
!
Interface Bundle-Ether 100
!
routed interface BVI1
!
!
!

```



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 5: 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
Fl 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 6: Feature History Table

Feature Name	Release Information	Description
PTP Profile Interoperation	Release 7.2.1	<p>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.</p> <p>For this release, interoperation is supported only between the G.8275.1 and G.8275.2 profiles.</p>

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.

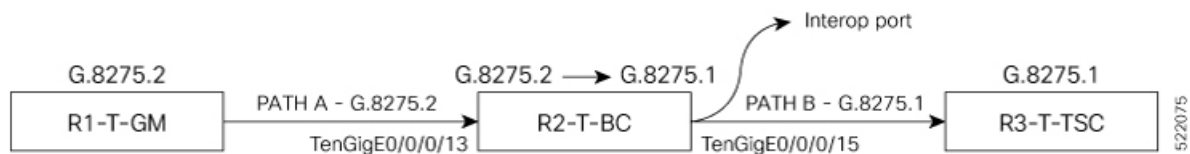
For each such interface, the following configuration are available:

- 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 Name	Port Number	Port State	Encap	Line 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)



CHAPTER 3

External Timing Source

Clock interfaces are external connectors for connecting other timing signals, such as, GPS, BITS.

- [GPS, on page 39](#)
- [Building Integrated Timing Supply \(BITS\), on page 41](#)

GPS

The router can receive 1PPS, 10 MHz, and ToD signals from an external clocking and timing source. The three inputs are combined as a Sync-2 interface to form the external timing source or the GPS input.

The GPS front panel connector details are:

- ToD—RS422 format as input
- 1PPS—RS422 or DIN connector as input
- 10MHz—DIN connector as input

GPS input starts only when all the three signals – 1PPS, 10MHz, and ToD are UP.

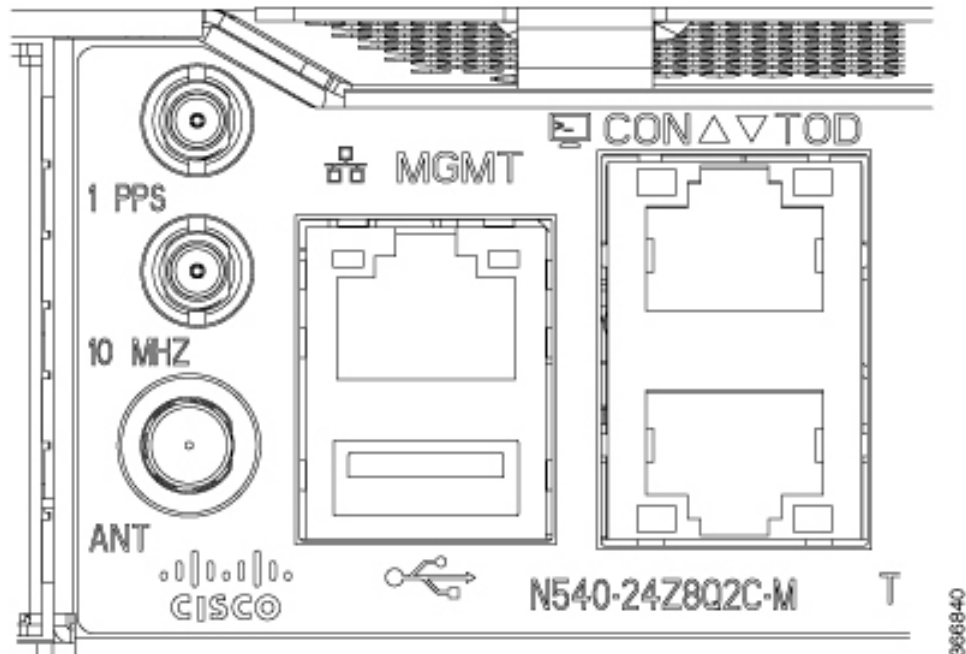


Note Unlike the Ethernet interface, the Sync-2 interface cannot receive or transmit QL. Ensure that you assign a QL value to the Sync-2 interface.

By default, 1PPS and 10MHz are in output mode. ToD output mode is not configurable.

For these variants - N540-24Z8Q2C-SYS, N540X-ACC-SYS, N540-ACC-SYS, N540-28Z4C-SYS, 10MHZ and 1PPS can operate in output mode only when PTP Client or BC mode are configured.

Figure 5: 1PPS, 10MHz, and the ToD ports on the Router's Front Panel



Configuring GPS Settings for the Grandmaster Clock

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# clock-interface sync 2 location 0/RP0/CPU0
RP/0/RP0/CPU0:router(config-clock-if)# port-parameters
RP/0/RP0/CPU0:router(config-clk-parms)# gps-input tod-format cisco pps-input ttl
RP/0/RP0/CPU0:router(config-clk-parms)# exit
RP/0/RP0/CPU0:router(config-clock-if)# frequency synchronization
RP/0/RP0/CPU0:router(config-clk-freqsync)# selection input
RP/0/RP0/CPU0:router(config-clk-freqsync)# wait-to-restore 0
RP/0/RP0/CPU0:router(config-clk-freqsync)# quality receive exact itu-t option 1 PRC
RP/0/RP0/CPU0:router(config-clk-freqsync)# exit
RP/0/RP0/CPU0:router(config-clock-if)# frequency synchronization
RP/0/RP0/CPU0:router(config-clk-freqsync)# quality itu-t option 1
RP/0/RP0/CPU0:router(config-clk-freqsync)# clock-interface timing-mode system
RP/0/RP0/CPU0:router(config-clk-freqsync)# end
or
RP/0/RP0/CPU0:router(config-clk-freqsync)# commit
```

Verifying the GPS Input

```
RP/0/RP0/CPU0:R1# show controllers timing controller clock
```

```
SYNCC Clock-Setting: -1 -1 6 -1
  Port 0  Port 1  Port 2  Port 3
Config :      No      No      Yes      No
Mode : -      -      GPS      -
Submode1 : -      -      CISCO    -
Submode2 : -      -      UTC      -
Submode3 : 0      0      0      0
Shutdown : 0      0      0      0
Direction : RX/TX  RX/TX  RX      RX/TX
```

```

Baud-Rate :      -      -      9600      -
QL Option  :    O1      O1      -      -
RX_ssm(raw):      -      -      -      -
TX_ssm     :      -      -      -      -
If_state   :    DOWN    DOWN    UP      DOWN  << Port 2 is UP when GPS input is
valid.

```

```
RP/0/RP0/CPU0:R1#
```

When the front panel timing LED is Green, it indicates that the GPS is configured and 1PPS, ToD, and 10M inputs are valid.

Timing LED Behavior:

- Timing LED is off: Indicates that no GPS is configured or the GPS port is down.
- Timing LED is green: Indicates that the GPS port is up.

SYNC LED Behavior:

- SYNC LED is applicable: Only when the timing configuration is applied.
- SYNC LED is green: Indicates that SyncE is locked.
- SYNC LED is amber: Indicates a holdover or free-running state.
- SYNC LED is off: Indicates that the configuration is removed.

Building Integrated Timing Supply (BITS)

Router supports receiving (Rx) and transmitting (Tx) of frequency via BITS interface. To receive and transmit BITS signals, configuration is done under the clock-interface sync 0 on the route processor (RP).

Prerequisite for BITS

Frequency synchronization must be configured with the required quality level option at the global level.

```

RP/0/RP0/CPU0:ios#show running-config frequency synchronization
Wed Aug 21 12:37:32.524 UTC
frequency synchronization
quality itu-t option 1
!

```



Note BITS-In and BITS-Out on the peer nodes must be configured with the same mode and format.

Configuring BITS-IN

```

RP/0/RP0/CPU0:ios#configure
Wed Aug 21 12:29:59.162 UTC
RP/0/RP0/CPU0:ios(config)#clock-interface sync 0 location 0/RP0/CPU0
RP/0/RP0/CPU0:ios(config-clock-if)#port-parameters
RP/0/RP0/CPU0:ios(config-clk-parms)#bits-input e1 crc-4 sa4 ami
RP/0/RP0/CPU0:ios(config-clk-parms)#exit

```

```

RP/0/RP0/CPU0:ios(config-clock-if)#frequency synchronization
RP/0/RP0/CPU0:ios(config-clk-freqsync)#selection input
RP/0/RP0/CPU0:ios(config-clk-freqsync)#wait-to-restore 0
RP/0/RP0/CPU0:ios(config-clk-freqsync)#priority 1
RP/0/RP0/CPU0:ios(config-clk-freqsync)#commit
Wed Aug 21 12:30:53.296 UTC

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

```

Configuring BITS-OUT

```

RP/0/RP0/CPU0:ios#configure
Wed Aug 21 12:53:24.189 UTC
RP/0/RP0/CPU0:ios(config)#clock-interface sync 0 location 0/RP0/CPU0
RP/0/RP0/CPU0:ios(config-clock-if)#port-parameters
RP/0/RP0/CPU0:ios(config-clk-parms)#bits-output e1 crc-4 sa4 ami
RP/0/RP0/CPU0:ios(config-clk-parms)#commit
Wed Aug 21 12:53:39.411 UTC

RP/0/RP0/CPU0:ios#show running-config clock-interface sync 0 location 0/RP0/CPU0
Wed Aug 21 12:54:02.853 UTC
clock-interface sync 0 location 0/RP0/CPU0
  port-parameters
    bits-output e1 crc-4 sa4 ami
  !
  !

```



Note Based on the quality level chosen in global configuration, E1/T1 modes can be changed as required. But in all the cases, both TX and RX side modes and submodes must be the same.

For non-CRC-4/D4 modes, SSM is not present in BITS and manual receive quality level must be configured.

Verifying BITS-IN Configuration

```

RP/0/RP0/CPU0:ios#show controllers timing controller clock
Wed Aug 21 12:38:20.394 UTC

```

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

	Port 0	Port 1	Port 2	Port 3
Config	: Yes	No	No	No
Mode	: E1	-	-	-
Submode1	: CRC-4	-	-	-
Submode2	: AMI	-	-	-
Submode3	: 0	0	0	0
Shutdown	: 0	0	0	0
Direction	: RX	RX/TX	RX/TX	RX/TX


```

Baud-Rate : -           -           -           -
QL Option  : 01          01          -           -
RX_ssm(raw): 99          -           -           -
TX_ssm     : -           -           -           -
If_state    : UP          DOWN        DOWN        DOWN

```

Verifying BITS-OUT Configuration

```

RP/0/RP0/CPU0:ios#show controllers timing controller clock
Wed Aug 21 12:49:32.923 UTC
SYNCC Clock-Setting: 1 -1 -1 -1

```

	Port 0	Port 1	Port 2	Port 3
Config	: Yes	No	No	No
Mode	: E1	-	-	-
Submodel	: CRC-4	-	-	-
Submode2	: AMI	-	-	-
Submode3	: 0	0	0	0
Shutdown	: 0	0	0	0
Direction	: TX	RX/TX	RX/TX	RX/TX
Baud-Rate	: -	-	-	-
QL Option	: 01	01	-	-
RX_ssm(raw)	: -	-	-	-
TX_ssm	: 22	-	-	-
If_state	: UP	DOWN	DOWN	DOWN

Verify Quality Level Received and Clock Interfaces

```

RP/0/RP0/CPU0:ios#show frequency synchronization clock-interfaces brief
Sat Mar 16 07:35:08.351 UTC
Flags: > - Up           D - Down           S - Assigned for selection
        d - SSM Disabled s - Output squelched L - Looped back
Node 0/RP0/CPU0:
=====

```

Fl	Clock Interface	QLrcv	QLuse	Pri	QLsnd	Output driven by
>S	Sync0	PRS	PRS	5	n/a	n/a
D	Sync1	n/a	n/a	n/a	n/a	n/a
D	Sync2	n/a	n/a	n/a	n/a	n/a
>S	Internal0	n/a	ST3	255	n/a	n/a



CHAPTER 4

Implementing NTP

Network Time Protocol (NTP) is a protocol designed to time-synchronize devices within a network. Cisco IOS XR software implements NTPv4. NTPv4 retains backwards compatibility with the older versions of NTP, including NTPv3 and NTPv2 but excluding NTPv1, which has been discontinued due to security vulnerabilities.

- [Information About Implementing NTP, on page 45](#)
- [Configuring NTP, on page 46](#)

Information About Implementing NTP

NTP synchronizes timekeeping among a set of distributed time servers and clients. This synchronization allows events to be correlated when system logs are created and other time-specific events occur.

NTP uses the User Datagram Protocol (UDP) as its transport protocol. All NTP communication uses Coordinated Universal Time (UTC). An NTP network usually receives its time from an authoritative time source, such as a radio clock or an atomic clock attached to a time server. NTP distributes this time across the network. NTP is efficient; no more than one packet per minute is necessary to synchronize two machines to within a millisecond of each other.

NTP uses the concept of a “stratum” to describe how many NTP “hops” away a machine is from an authoritative time source. A “stratum 1” time server typically has an authoritative time source (such as a radio or atomic clock, or a GPS time source) directly attached, a “stratum 2” time server receives its time via NTP from a “stratum 1” time server, and so on.

NTP avoids synchronizing to a machine whose time may not be accurate, in two ways. First, NTP never synchronizes to a machine that is not synchronized itself. Second, NTP compares the time reported by several machines and does not synchronize to a machine whose time is significantly different than the others, even if its stratum is lower. This strategy effectively builds a self-organizing tree of NTP servers.

The Cisco implementation of NTP does not support stratum 1 service; in other words, it is not possible to connect to a radio or atomic clock (for some specific platforms, however, you can connect a GPS time-source device). We recommend that time service for your network be derived from the public NTP servers available in the IP Internet.

If the network is isolated from the Internet, the Cisco implementation of NTP allows a machine to be configured so that it acts as though it is synchronized via NTP, when in fact it has determined the time using other means. Other machines can then synchronize to that machine via NTP.

Several manufacturers include NTP software for their host systems, and a publicly available version for systems running UNIX and its various derivatives is also available. This software also allows UNIX-derivative

servers to acquire the time directly from an atomic clock, which would subsequently propagate time information along to Cisco routers.

The communications between machines running NTP (known as associations) are usually statically configured; each machine is given the IP address of all machines with which it should form associations. Accurate timekeeping is made possible by exchanging NTP messages between each pair of machines with an association.

The Cisco implementation of NTP supports two ways that a networking device can obtain NTP time information on a network:

- By polling host servers
- By listening to NTP broadcasts

In a LAN environment, NTP can be configured to use IP broadcast messages. As compared to polling, IP broadcast messages reduce configuration complexity, because each machine can simply be configured to send or receive broadcast or multicast messages. However, the accuracy of timekeeping is marginally reduced because the information flow is one-way only.

An NTP broadcast client listens for broadcast messages sent by an NTP broadcast server at a designated IPv4 address. The client synchronizes the local clock using the first received broadcast message.

The time kept on a machine is a critical resource, so we strongly recommend that you use the security features of NTP to avoid the accidental or malicious setting of incorrect time. Two mechanisms are available: an access list-based restriction scheme and an encrypted authentication mechanism.

When multiple sources of time (VINES, hardware clock, manual configuration) are available, NTP is always considered to be more authoritative. NTP time overrides the time set by any other method.



Note NTP-PTP interworking is not supported on Cisco NCS 540 Series routers.

Configuring NTP

Configuring Poll-Based Associations

The following example shows an NTP configuration in which the router's system clock is configured to form a peer association with the time server host at IP address 192.168.22.33, and to allow the system clock to be synchronized by time server hosts at IP address 10.0.2.1 and 172.19.69.1:

```
ntp
 server 10.0.2.1 minpoll 5 maxpoll 7
 peer 192.168.22.33
 server 172.19.69.1
```

Configuring Broadcast-Based Associations

The following example shows an NTP client configuration in which interface 0/2/0/0 is configured to receive NTP broadcast packets, and the estimated round-trip delay between an NTP client and an NTP broadcast server is set to 2 microseconds:

```
ntp
interface tengige 0/2/0/0
  broadcast client
  exit
broadcastdelay 2
```

The following example shows an NTP server configuration where interface 0/2/0/2 is configured to be a broadcast server:

```
ntp
interface tengige 0/2/0/0
  broadcast
```

Configuring NTP Access Groups

The following example shows a NTP access group configuration where the following access group restrictions are applied:

Peer restrictions are applied to IP addresses that pass the criteria of the access list named peer-acl. Serve restrictions are applied to IP addresses that pass the criteria of access list named serve-acl.

Serve-only restrictions are applied to IP addresses that pass the criteria of the access list named serve-only-acl.

Query-only restrictions are applied to IP addresses that pass the criteria of the access list named query-only-acl.

```
ntp
peer 10.1.1.1
peer 10.1.1.1
peer 10.2.2.2
peer 10.3.3.3
peer 10.4.4.4
peer 10.5.5.5
peer 10.6.6.6
peer 10.7.7.7
peer 10.8.8.8
access-group peer peer-acl
access-group serve serve-acl
access-group serve-only serve-only-acl
access-group query-only query-only-acl
exit
ipv4 access-list peer-acl
10 permit ip host 10.1.1.1 any
20 permit ip host 10.8.8.8 any
exit
ipv4 access-list serve-acl
10 permit ip host 10.4.4.4 any
20 permit ip host 10.5.5.5 any
exit
ipv4 access-list query-only-acl
10 permit ip host 10.2.2.2 any
20 permit ip host 10.3.3.3 any
exit
ipv4 access-list serve-only-acl
10 permit ip host 10.6.6.6 any
20 permit ip host 10.7.7.7 any
exit
```

Configuring NTP Authentication

The following example shows an NTP authentication configuration. In this example, the following is configured:

NTP authentication is enabled.

Two authentication keys are configured (key 2 and key 3).

The router is configured to allow its software clock to be synchronized with the clock of the peer (or vice versa) at IP address 10.3.32.154 using authentication key 2.

The router is configured to allow its software clock to be synchronized with the clock by the device at IP address 10.32.154.145 using authentication key 3.

The router is configured to synchronize only to systems providing authentication key 3 in their NTP packets.

```
ntp
  authenticate
  authentication-key 2 md5 encrypted 06120A2D40031D1008124
  authentication-key 3 md5 encrypted 1311121E074110232621
  trusted-key 3
  server 10.3.32.154 key 3
  peer 10.32.154.145 key 2
```

Disabling NTP on an Interface

The following example shows an NTP configuration in which 0/2/0/0 interface is disabled:

```
ntp
  interface tengige 0/2/0/0
    disable
  exit
  authentication-key 2 md5 encrypted 06120A2D40031D1008124
  authentication-key 3 md5 encrypted 1311121E074110232621
  authenticate
  trusted-key 3
  server 10.3.32.154 key 3
  peer 10.32.154.145 key 2
```

Configuring the System as an Authoritative NTP Server

The following example shows a NTP configuration in which the router is configured to use its own NTP server clock to synchronize with peers when an external NTP source becomes unavailable:

```
ntp
  master 6
```

Updating the Hardware Clock

The following example shows an NTP configuration in which the router is configured to update its hardware clock from the software clock at periodic intervals:

```
ntp
  server 10.3.32.154
  update-calendar
```

Configuring NTP Server Inside VRF Interface



Note No specific command enables NTP; the first NTP configuration command that you issue enables NTP.

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# ntp
RP/0/RP0/CPU0:router(config)# ntp vrf Customer_A
RP/0/RP0/CPU0:router(config)# ntp vrf Customer_A source bvi 70
RP/0/RP0/CPU0:router(config-ntp)# end
or
RP/0/RP0/CPU0:router(config-ntp)# commit
```

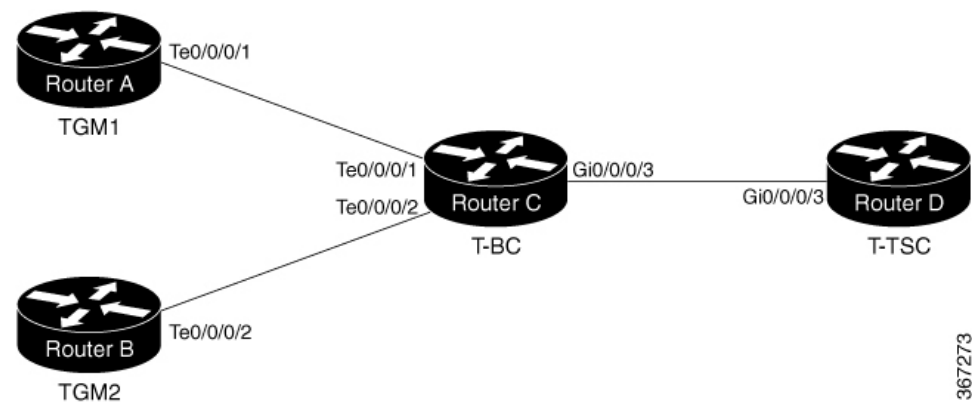



CHAPTER 5

Workflow and Use Case

Consider the following topology for configuring the G.8275.1:

Figure 6: Sample G.8275.1 Topology



Configuration on TGM1

```

frequency synchronization
quality itu-t option 1
clock-interface timing-mode system
!
clock-interface sync 2 location 0/RP0/CPU0
port-parameters
gps-input tod-format cisco pps-input ttl
!
frequency synchronization
selection input
wait-to-restore 0
quality receive exact itu-t option 1 PRC
!
ptp clock
domain 24
profile g.8275.1 clock-type T-GM
!
profile master
transport ethernet
sync frequency 16
announce frequency 8
delay-request frequency 16
!
interface GigabitEthernet0/0/0/1

```

```

ptp
  profile master
  multicast target-address ethernet 01-1B-19-00-00-00
  port state master-only
  transport ethernet
  sync frequency 16
  announce frequency 8
  delay-request frequency 16
!
frequency synchronization
!

```

Configuration on TGM2

```

frequency synchronization
  quality itu-t option 1
  clock-interface timing-mode system
!
clock-interface sync 2 location 0/RP0/CPU0
port-parameters
  gps-input tod-format cisco pps-input ttl
!
frequency synchronization
  selection input
  wait-to-restore 0
  quality receive exact itu-t option 1 PRC
!
ptp clock
domain 24
  profile g.8275.1 clock-type T-BC
!
profile master
  transport ethernet
  sync frequency 16
  announce frequency 8
  delay-request frequency 16
!
interface GigabitEthernet0/0/0/2
ptp
  profile master
  multicast target-address ethernet 01-1B-19-00-00-00
  port state master-only
  transport ethernet
  sync frequency 16
  announce frequency 8
  delay-request frequency 16
!
frequency synchronization
!

```

Configuration on T-BC

```

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

```

```

!
physical-layer frequency
!

profile master
  transport ethernet
  sync frequency 16
  announce frequency 8
  delay-request frequency 16
! !
interface TenGigE0/0/0/1
  ptp
  profile slave
  multicast target-address ethernet 01-1B-19-00-00-00
  transport ethernet
  sync frequency 16
  local-priority 10
  announce frequency 8
  delay-request frequency 16
!
frequency synchronization
  selection input
  priority 1
  wait-to-restore 0
! !
interface TenGigE0/0/0/2
  ptp
  profile slave
  multicast target-address ethernet 01-1B-19-00-00-00
  transport ethernet
  port state any
  sync frequency 16
  local-priority 20
  announce frequency 8
  delay-request frequency 16
!
frequency synchronization
  selection input
  priority 1
  wait-to-restore 0
! !
interface GigabitEthernet0/0/0/3
  ptp
  profile master
  multicast target-address ethernet 01-1B-19-00-00-00
  transport ethernet
  port state any
  sync frequency 16
  announce frequency 8
  delay-request frequency 16
!
frequency synchronization
! !

```

Configuration on T-TSC

```

frequency synchronization
  quality itu-t option 1
  clock-interface timing-mode system
! ptp
clock
  domain 24
  profile g.8275.1 clock-type T-TSC
!
profile slave

```

```
transport ethernet
sync frequency 16
announce frequency 8
delay-request frequency 16
!
physical-layer frequency
!
!
interface GigabitEthernet0/0/0/3
ptp
profile slave
multicast target-address ethernet 01-1B-19-00-00-00
transport ethernet
port state slave-only
local-priority 10
!
frequency synchronization
selection input
priority 1
wait-to-restore 0
!
```



CHAPTER 6

Configure the Global Navigation Satellite System

This chapter describes the Global Navigation Satellite System (GNSS) and how to configure it.

In typical telecom networks, network synchronization works in a hierarchical manner where the core network is connected to a stratum-1 clock. The timing from the stratum-1 clock is then distributed along the network in a tree-like structure. However, with a GNSS receiver, clocking is changed to a flat architecture, where access networks can directly take clock from the satellites by using an on-board GPS chip.

Router now uses a satellite receiver, also called the Global Navigation Satellite System (GNSS), as the new timing interface.

This capability simplifies network synchronization planning and provides flexibility and resilience in resolving network synchronization issues in the hierarchical network.

- [Overview of GNSS, on page 55](#)
- [Operation of GNSS Module , on page 57](#)
- [Prerequisites for GNSS, on page 58](#)
- [Restrictions for GNSS, on page 59](#)
- [Configure GNSS, on page 59](#)

Overview of GNSS

Effective Cisco IOS XR Release 7.1.1, the following Cisco NCS 540 variants support GNSS receiver:

- N540X-16Z4G8Q2C-A
- N540X-16Z4G8Q2C-D
- N540X-12Z16G-SYS-A
- N540X-12Z16G-SYS-D
- N540-24Z8Q2C-SYS
- N540-28Z4C-SYS
- N540-ACC-SYS
- N540X-ACC-SYS

Effective Cisco IOS XR Release 7.3.1, the following Cisco NCS 540 variants support GNSS receiver:

- N540-24Z8Q2C-SYS
- N540-28Z4C-SYS
- N540-ACC-SYS
- N540X-ACC-SYS

Effective Cisco IOS XR Release 7.4.1, the following Cisco NCS 540 variant supports GNSS receiver:

- N540-24Q8L2DD-SYS

No license is required to enable the GNSS module. The GNSS LED on the front panel indicates the status of the module. The following table describes the different status of GNSS LED:

LED Status	Description
Green	GNSS NormalState.Selfsurvey is complete.
Amber	GNSS not shut and not locked
OFF	If GNSS is not configured or is shut.

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



Note NCS-55A2-MOD-SE-S can also receive 1PPS, 10 MHz, and ToD signals from an external clocking and timing source. However, the timing signals from the GNSS module (when enabled) take precedence over those of the external source.



Note NCS540X can also receive 1PPS, 10 MHz, and ToD signals from an external clocking and timing source. However, the timing signals from the GNSS module (when enabled) take precedence over those of the external source.



Note We do not recommend that you configure both the front panel (10M, 1PPS and ToD) input configuration and the GNSS input configuration.

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

Operation of GNSS Module

Operation of GNSS Module on the N540-24Z8Q2C-SYS, N540-28Z4C-SYS, N540-ACC-SYS, and N540X-ACC-SYS Routers

The GNSS module has the following stages of acquiring and providing timing signals to the Cisco router:

- Self-survey mode - When the router is reset, the GNSS module comes up in self-survey mode. It tries to lock on to a minimum of four different satellites and computes approximately 2000 different positions of the satellites to obtain a 3-D location (Latitude, Longitude, and Height) of its current position. This operation takes about 35 to 40 minutes. During this stage, the module is also able to generate accurate timing signals and achieve a Normal or Phase-locked state.

When GNSS moves into Normal state, you can start using the 1PPS, 10 MHz, and ToD inputs from GNSS. The quality of the signal in self-survey mode with Normal state is considered good enough to lock to GNSS.

- Over determined clock mode - The router switches to over determined (OD) mode when the self-survey mode is complete, and the position information is stored in non-volatile memory on the router. In this mode, the module only processes the timing information based on satellite positions captured in self-survey mode.

The router saves the tracking data, which is retained even when the router is reloaded.

The GNSS module stays in OD mode until one of the following conditions occur:

- A position relocation of the antenna of more than 100 meters is detected. This detection causes an automatic restart of the self-survey mode.
- A manual restart of the self-survey mode or when the stored reference position is deleted.
- A worst-case recovery option after a jamming-detection condition that cannot be resolved with other methods.

You can configure the GNSS module to automatically track any satellite or configure it to explicitly use a specific constellation. However, the module uses configured satellites in only the OD mode.



Note GLONASS and BeiDou satellites cannot be enabled simultaneously.

When the router is reloaded, it always comes up in OD mode unless:

- the router is reloaded when the self-survey mode is in progress.
- the physical location of the router is changed to more than 100 meters from its pre-reloaded condition.

When the system restarts the GNSS self-survey by using the default `gnss slot R0/R1` command in config mode, the 10MHz, 1PPS, and ToD signals are not changed and remain up.

Operation of GNSS Module on the N540X-16Z4G8Q2C-A, N540X-16Z4G8Q2C-D, N540X-12Z16G-SYS-A, and N540X-12Z16G-SYS-D Routers, N540X-6Z18G-SYS-A, N540X-6Z18G-SYS-D, N540X-8Z16G-SYS - A, N540X-8Z16G-SYS - D

The GNSS module has the following stages of acquiring and providing timing signals to the Cisco router:

- Self-survey mode - Self-survey is the procedure that is performed prior to using time mode. It determines the position of a stationary receiver by building a weighted mean of all valid 3D position solutions.

To stop self-survey mode, the following two requirements must be met:

- The minimum observation time defines a minimum amount of observation time regardless of the actual number of valid fixes that are used for position calculation. Reasonable values range from one day for high accuracy position calculation to a few minutes for coarse position determination.
- The required 3D position standard deviation defines a limit on the spread of positions that contribute to the calculated mean. As the position error translates into a time error when using time mode, you should carefully evaluate the time accuracy requirements and choose an appropriate value.

Self-survey ends when both requirements are met. After self-survey is completed successfully, the receiver automatically enters time-fix mode.

Recommendations

- Self-survey must run for at least twenty-four hours because it is important to cover a full constellation run and a day-night cycle.
- CNO or signal strength for achieving time-fix during self-survey is 35dB.
- Time-fix mode - In order to use the time-fix mode, the exact position of the receiver must be known. The exact position of the receiver is determined by using self-survey. Errors in the fixed position translate into time errors depending on the satellite constellation.

There is no minimum and maximum value (Time) in the self-survey process and the receiver makes the best effort to achieve the time-fix mode.

For achieving the time-fix mode, a minimum of four satellites are required and it may take several days to get into the time-fix mode.

If the position is already known, the module can achieve time-fix mode even if there is only one satellite received.

You can configure the GNSS module to automatically track any satellite or configure it to explicitly use a specific constellation.

When the router is reloaded, it always comes up in the time-fix mode unless the router is reloaded when the self-survey mode is in progress.

Prerequisites for GNSS

To use GNSS, the antenna must see as much as possible from the sky. For proper timing, a minimum of four satellites must be locked. For more information, see the *Cisco NCS 540 Series Router Hardware Installation Guide*.

Restrictions for GNSS

- The GNSS module is not supported through SNMP; all configurations are performed through commands.
- The GNSS holdover performance is one microsecond in two hours of holdover after twelve hours of GNSS lock time.
- GNSS module is not supported in default profile mode.

Configure GNSS

Configuration Example

This section describes how you can configure GNSS for a router.

```
/* Enable the GNSS receiver and enter the gnss-receiver submode */

Router(config)# gnss-receiver 0 location 0/RP0/CPU0
Router(config-gnss)# no shutdown
Router(config-gnss)# frequency synchronization
Router(config-gnss-freqsync)# selection input
Router(config-gnss-freqsync)# commit
```

Optional Configuration Example

```
Router(config)# gnss-receiver 0 location 0/RP0/CPU0
Router(config-gnss)# anti-jam disable
Router(config-gnss)# constellation GPS
Router(config-gnss)# snr threshold 10
Router(config-gnss)# frequency synchronization
Router(config-gnss-freqsync)# selection input
Router(config-gnss-freqsync)# priority 5
Router(config-gnss-freqsync)# wait-to-restore 0
```

Running Configuration

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

Verification

The following is the output of the **show gnss-receiver** command on the router models.

The following is the output of the **show gnss-receiver** command on the router models - N540-24Z8Q2C-SYS, N540-28Z4C-SYS, N540-ACC-SYS, and N540X-ACC-SYS.

```
RP/0/RP0/CPU0:R6# show gnss-receiver
Fri Jan 17 07:27:34.804 UTC
```

```

GNSS-receiver 0 location 0/RP0/CPU0
  Status: Available, Up
  Position: 12:56.18 N 77:41.77 E 0.823km
  Time: 2020:01:17 07:31:41 (UTC offset: 0s)
  Locked at: 2020:01:15 17:15:28
  Firmware version: TIM 1.10
  Lock Status: Phase Locked, Receiver Mode: Time fix only
  Survey Progress: 100, Holdover Duration: Unknown
  Major Alarms: Unknown
  Minor Alarms: Unknown
  Anti-jam: Enabled, Cable-delay compensation: 0
  1PPS polarity: Positive
  PDOP: 99.990, HDOP: 99.990, VDOP: 99.990, TDOP: 0.240
  Constellation: GPS, Satellite Count: 17
  Satellite Thresholds:
    SNR - 0 dB-Hz, Elevation - 0 degrees, PDOP - 0, TRAIM - 0 us
  Satellite Info:
    CHN: Channel, AQUN: Aquisition, EPH: Ephemeris

```

PRN No.	CHN	AQUN Flag	EPH Flag	SV Type	Signal Strength	Elevat'n	Azimuth
1	n/a	On	On	GPS	44.000	19.000	220.000
3	n/a	On	On	GPS	48.000	62.000	299.000
4	n/a	On	On	GPS	46.000	30.000	338.000
7	n/a	On	On	GPS	47.000	9.000	261.000
8	n/a	On	On	GPS	41.000	17.000	172.000
9	n/a	On	On	GPS	44.000	7.000	317.000
11	n/a	On	On	GPS	42.000	10.000	202.000
14	n/a	On	On	GPS	42.000	22.000	90.000
16	n/a	On	On	GPS	46.000	66.000	59.000
22	n/a	On	On	GPS	47.000	71.000	238.000
23	n/a	On	On	GPS	46.000	27.000	332.000
26	n/a	On	On	GPS	48.000	40.000	40.000

The following is the output of the **show gnss-receiver** command on the router models - N540X-16Z4G8Q2C-A, N540X-16Z4G8Q2C-D, N540X-12Z16G-SYS-A, N540X-12Z16G-SYS-D, N540X-6Z18G-SYS-A, N540X-6Z18G-SYS-D, N540X-8Z16G-SYS - A, N540X-8Z16G-SYS - D.

```

RP0/RP0/CPU0:ios#show gnss-receiver
Sun Sep 29 09:25:29.477 UTC
GNSS-receiver 0 location 0/RP0/CPU0
  Status: Available, Up
  Position: 12:56.18 N 77:41.77 E 0.823km
  Time: 2019:10:24 11:32:21 (UTC offset: 0s)
  Locked at: 2019:09:29 09:19:20
  Firmware version: TIM 1.10
  Lock Status: Phase Locked, Receiver Mode: Time fix only
  Survey Progress: 100, Holdover Duration: Unknown
  Major Alarms: Unknown
  Minor Alarms: Unknown
  Anti-jam: Enabled, Cable-delay compensation: 0
  1PPS polarity: Positive
  PDOP: 99.990, HDOP: 99.990, VDOP: 99.990, TDOP: 0.450
  Constellation: Auto, Satellite Count: 5
  Satellite Thresholds:
    SNR - 0 dB-Hz, Elevation - 0 degrees, PDOP - 0, TRAIM - 0 us
  Satellite Info:
    CHN: Channel, AQUN: Aquisition, EPH: Ephemeris

```

PRN No.	CHN	AQUN Flag	EPH Flag	SV Type	Signal Strength	Elevat'n	Azimuth
1	n/a	On	On	GLONASS	28.000	19.000	342.000
7	n/a	On	On	GLONASS	25.000	30.000	91.000

8	n/a	On	On	GLONASS	25.000	42.000	28.000
10	n/a	On	On	GLONASS	33.000	54.000	211.000
11	n/a	On	On	GLONASS	33.000	78.000	217.000

