Network Synchronization Configuration Guide for Cisco NCS 560 Series Routers, IOS XR Release 6.6.x

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CHAPTER 1

Synchronous Ethernet ESMC and SSM

Table 1: Feature History Table

Note Effective Cisco IOS XR Software Release 7.7.1, on 1G ports of Cisco N540X-16Z4G8Q2C-A/D, clock recovery is supported only on port 4 to port 19.

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

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

- 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 tt1
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
                              QLrcv QLuse Pri QLsnd Output driven by
==== ======================== ===== ===== === ===== ========================
>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 0K 20 Sleeping fsyncmgr 0
181 HYPERLINK "tel:3572"3572 0K 20 Sleeping lwm_debug_threa 0
181 HYPERLINK "tel:3573"3573 0K 20 Sleeping fsyncmgr 0
181 HYPERLINK "tel:3574"3574 0K 20 Sleeping lwm_service_thr 0
181 HYPERLINK "tel:3575"3575 0K 20 Sleeping qsm_service_thr 0
181 HYPERLINK "tel:3622"3622 0K 20 Sleeping fsyncmgr 0
181 HYPERLINK "tel:3781"3781 0K 20 Sleeping fsyncmgr 0
181 HYPERLINK "tel:3789"3789 0K 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
```

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: • 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)	The device participates in selecting the best server clock and can act as the server clock if no better clocks are detected. 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.
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.

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.

The following figure shows a typical 1588 PTP network that includes grandmaster clocks, routers in boundary clock mode, and TSC mode. In this diagram, Server 1 is the grandmaster clock. If Server 1 becomes unavailable, the boundary clock clients switch to Server 2 for synchronization.

Figure 1: PTP Network

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

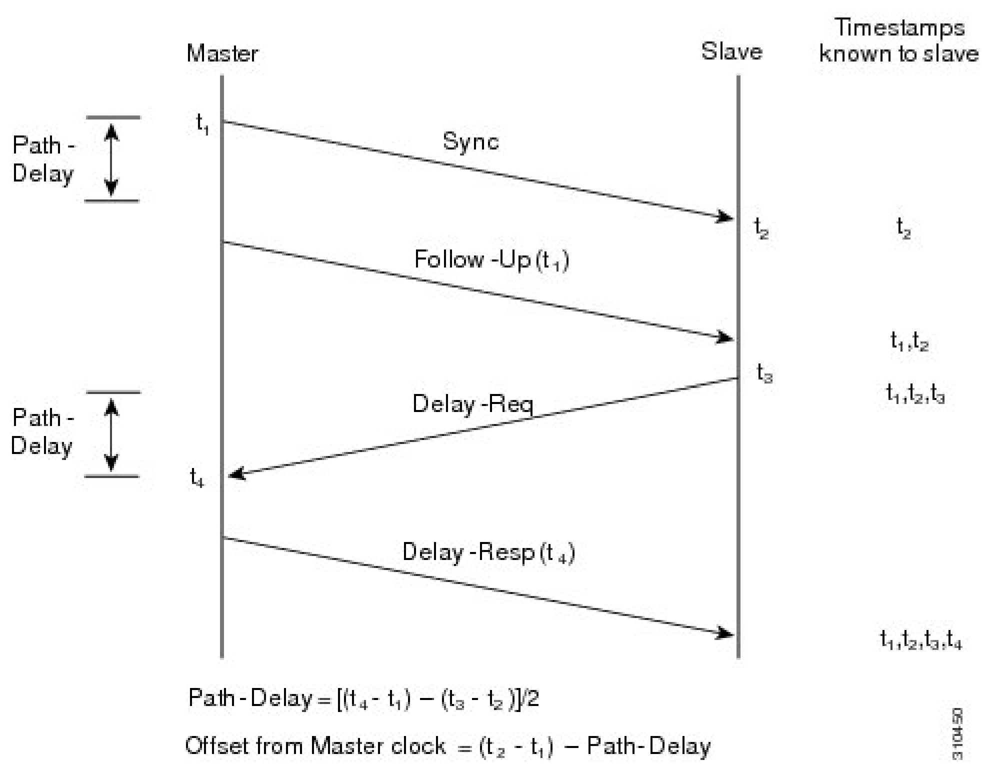
These messages are sent in the following sequence:

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

After this sequence, the client possesses all four timestamps. These timestamps can be used to compute the offset of the client clock relative to the 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 2: 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.

The following figure illustrates PTP clocks in a server-client hierarchy within a PTP network.

Figure 3: PTP Clock Hierarchy

PTP Profiles

Table 3: Feature History Table

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.

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
```

b. Configuring global PTP

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

c. Configuring global frequency

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

d. Enabling GPS for phase and frequency input

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

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

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

3. Configuring G.8275.2 on T-BC

a. Configuring global SyncE

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

b. Configuring global PTP

```
ptp
clock
domain 44
profile g.8275.2 clock-type T-BC
!
```

```
profile 8275.2
  transport ipv4
  port state any
  sync frequency 64
  announce frequency 8
  delay-request frequency 64
!
physical-layer-frequency  <-- This is a mandatory command -->
!
```

c. Configuring Client port on Hybrid BC

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

d. Configuring Server port on Hybrid BC

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

4. Configuring G8275.2 on T-TSC

a. Configuring global SyncE

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

b. Configuring global PTP

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

c. Configuring Client port on Hybrid BC

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

```
frequency synchronization
selection input
priority 1
wait-to-restore 0
!
!
```

Example: Configuring G.8275.2 in Non-Hybrid Mode

1. Configuring Sync2

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

2. Configuring the T-GM with GNSS as source

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

a. Enabling GNSS

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

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
!
!
```

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
!
```

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 summaries 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 560 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#
```

CHAPTER 3

External Timing Source

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

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.

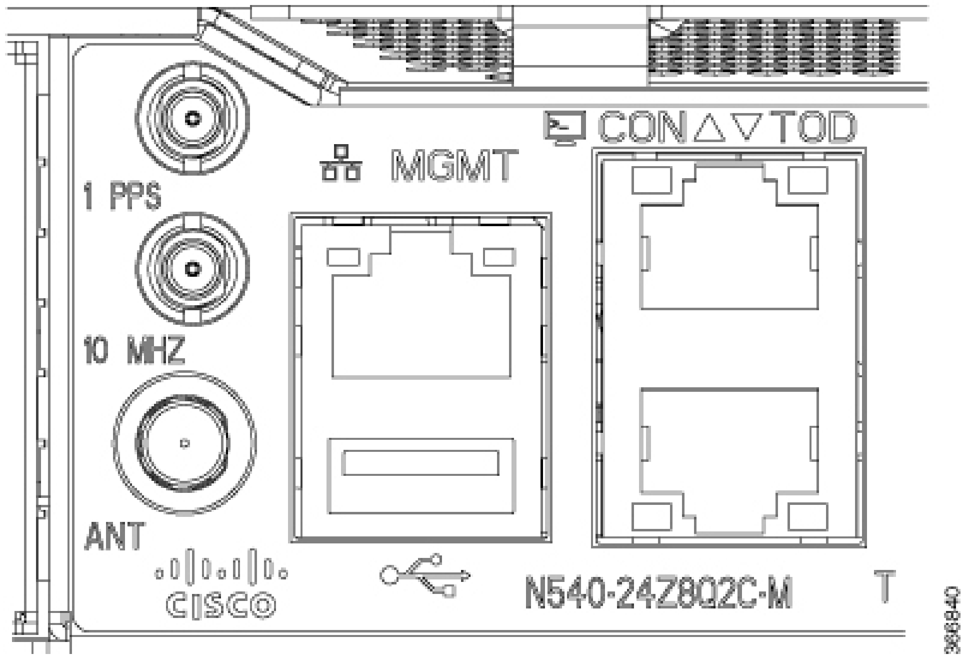


Figure 4: 1PPS, 10MHz, and the ToD ports on the Router's Front Panel

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 iputs are valid.

Timing LED Behavior:

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

SYNCE LED Behavior:

- SYNCE LED is green: Indicates that time core is synchronized to either external source, or SyncE or 1588.
- SYNCE LED is amber: Indicates a Holdover or Acquiring state.
- SYNCE LED is off: Indicates synchronization in disable or free-running state.

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  : O1            O1            -             -
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             -               -               -
Submode1   : CRC-4          -               -               -
Submode2   : AMI            -               -               -
Submode3   : 0              0               0               0
Shutdown   : 0              0               0               0
Direction  : TX             RX/TX           RX/TX           RX/TX
Baud-Rate  : -              -               -               -
QL Option  : O1             O1              -               -
RX_ssm(raw): -              -               -               -
TX_ssm     : 22             -               -               -
If_state   : UP             DOWN            DOWN            DOWN
```

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

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 extremely 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.

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
```

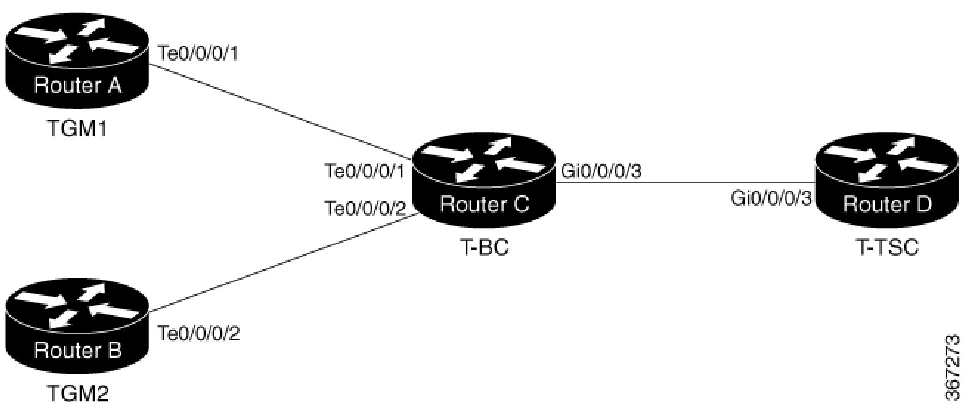
```
or
RP/0/RP0/CPU0:router(config-ntp)# commit
```

CHAPTER 5

Workflow and Use Case

Consider the following topology for configuring the G.8275.1:

Figure 5: 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
!
```