CONTENTS

CHAPTER 1
Synchronous Ethernet ESMC and SSM 1
  Frequency Synchronization Timing Concepts 1
    Sources 2
    Selection Points 2
  Restrictions 2
  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 3
    Configuring Synchronous Ethernet ESMC and QL 3
  Verifying the Frequency Synchronization Configuration 4
  Verifying the ESMC Configuration 7

CHAPTER 2
Understanding PTP 9
  PTP Profiles 10
    ITU-T Telecom Profiles for PTP 10
      G.8265.1 10
      G.8275.1 11
      G.8275.2 12
    Configuring the G.8275.1 Profile 13
  IEEE Default Profile 13
  PTP Hybrid Mode 14
    Configuring PTP Hybrid Mode 14
    Example: PTP Hybrid Mode 15
  Verifying the PTP Hybrid Mode Configurations 16
CHAPTER 3  External Timing Source  19
   Configuring GPS Settings for the Grand Master Clock  19
   Verifying the GPS Input  20

CHAPTER 4  Implementing NTP  21
   Information About Implementing NTP  21
      NTP-PTP Interworking  22
   Configuring NTP  22
      Configuring Poll-Based Associations  22
      Configuring Broadcast-Based Associations  23
   Configuring NTP Access Groups  23
   Configuring NTP Authentication  24
   Disabling NTP on an Interface  24
   Configuring the System as an Authoritative NTP Server  24
   Updating the Hardware Clock  24
   Configuring NTP Server Inside VRF Interface  25

CHAPTER 5  Workflow and Use Case  27
Synchronous Ethernet ESMC and SSM

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. The 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 two clock selection modes: QL-enabled and QL-disabled. Each mode uses different criteria to select the best available clock source.

The router can only operate in one clock selection mode at a time.

- Frequency Synchronization Timing Concepts, on page 1
- Restrictions, on page 2
- Configuring Frequency Synchronization, on page 3
- Verifying the Frequency Synchronization Configuration, on page 4
- Verifying the ESMC Configuration, on page 7

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.
- 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 GigabitEthernet 0/0/0/24 to 0/0/0/31 ports.
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 2 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
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
```

Configuring Synchronous Ethernet ESMC and QL

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.
This supports the Synchronization Status Message (SSM) and Ethernet Synchronization Message Channel (ESMC) for synchronous Ethernet clock synchronization.

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
Thu Feb 1 06:28:03.784 UTC
Node 0/0/CPU0:
----------------
Selection point: ETH_RXMUX (1 inputs, 1 selected)  
Last programmed 2d01h ago, and selection made 2d01h ago
Next selection points
 SPA scoped : None
 Node scoped : None
 Chassis scoped: T0-SEL-B 1588-SEL
 Router scoped : None
Uses frequency selection
S Input Last Selection Point QL Pri Status
== ------------------------ ============= ===== === ===========
1 TenGigE0/0/0/0 n/a

Selection point: LC_TX_SELECT (1 inputs, 1 selected)  
Last programmed 2d01h ago, and selection made 2d01h ago
Next selection points
 SPA scoped : None
 Node scoped : None
 Chassis scoped: None
 Router scoped : None
Uses frequency selection
Used for local line interface output
S Input Last Selection Point
== ------------------------ ============= ===== === ===========
7 TenGigE0/0/0/0 0/RP0/CPU0 T0-SEL-B 1 PRC 1 Available

Node 0/RP0/CPU0:
----------------
Selection point: T0-SEL-B (3 inputs, 1 selected)  
Last programmed 2d01h ago, and selection made 00:04:43 ago
Next selection points
 SPA scoped : None
 Node scoped : CHASSIS-TOD-SEL
 Chassis scoped: LC_TX_SELECT
 Router scoped : None
Uses frequency selection
Used for local line interface output
S Input Last Selection Point QL Pri Status
== ------------------------ ============= ===== === ===========
1 TenGigE0/0/0/0  PTP [0/RP0/CPU0] Internal0 [0/RP0/CPU0] 0/0/CPU0 ETH_RXMUX 1 PRC 1 Locked
 n/a SEC 254 Available
 n/a SEC 255 Available
Selection point: 1588-SEL (2 inputs, 1 selected)  
Last programmed 2d01h ago, and selection made 00:04:43 ago
Next selection points
 SPA scoped : None
 Node scoped : None
```
Chassis scoped: None  
Router scoped: None  
Uses frequency selection  

<table>
<thead>
<tr>
<th>S Input</th>
<th>Last Selection Point</th>
<th>QL</th>
<th>Pri</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>TenGigE0/0/0/0 0/0/0/CPU0 ETH_RXMUX</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal0 [0/RP0/CPU0] n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Selection point: CHASSIS-TOD-SEL (2 inputs, 1 selected)  
Last programmed 2d01h ago, and selection made 2d01h ago  
Next selection points  
SPA scoped: None  
Node scoped: None  
Chassis scoped: None  
Router scoped: None  
PRC 1 Locked  
SEC 255 Available  
Uses time-of-day selection  

<table>
<thead>
<tr>
<th>S Input</th>
<th>Last Selection Point</th>
<th>QL</th>
<th>Pri</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTP [0/RP0/CPU0] n/a</td>
<td>100 Yes Available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TenGigE0/0/0/0 0/RP0/CPU0 T0-SEL-B</td>
<td>100 No Available</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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  
F1 Interface  
D - Down  
S - Assigned for selection  
x - Peer timed out  
i - Init state  
Last Selection Point  
Fri Time  
Status
Verifying the Frequency Synchronization Configuration

Verifies the configuration. Note the following points:

• All line interfaces 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/CP00: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:
/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_thread 0
181 HYPERLINK "tel:3573"3573 0K 20 Sleeping fsyncmgr 0
181 HYPERLINK "tel:3574"3574 0K 20 Sleeping lwm_service_thread 0
181 HYPERLINK "tel:3575"3575 0K 20 Sleeping qsm_service_thread 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
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
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
Effective QL: Opt-I/PRC
Next selection points: ETH_RXMUX

Network Synchronization Configuration Guide for Cisco NCS 540 Series Routers, IOS XR Release 6.3.x
Verifying the ESMC Configuration
Understanding PTP

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

Table 1: Nodes within a PTP Network

<table>
<thead>
<tr>
<th>Network Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grandmaster (GM)</td>
<td>A network device physically attached to the primary time source. All clocks are synchronized to the grandmaster clock.</td>
</tr>
<tr>
<td>Ordinary Clock (OC)</td>
<td>An ordinary clock is a 1588 clock with a single PTP port that can operate in one of the following modes:</td>
</tr>
<tr>
<td></td>
<td>• Master mode—Distributes timing information over the network to one or more slave clocks, thus allowing the slave to synchronize its clock to the master.</td>
</tr>
<tr>
<td></td>
<td>• Slave mode—Synchronizes its clock to a master clock. You can enable the slave mode on up to two interfaces simultaneously in order to connect to two different master clocks.</td>
</tr>
<tr>
<td>Boundary Clock (BC)</td>
<td>The device participates in selecting the best master clock and can act as the master clock if no better clocks are detected.</td>
</tr>
<tr>
<td></td>
<td>Boundary clock starts its own PTP session with a number of downstream slaves. The boundary clock mitigates the number of network hops and results in packet delay variations in the packet network between the Grand Master and Slave.</td>
</tr>
</tbody>
</table>
PTP Profiles

PTP allows for separate profiles to be defined in order to adapt itself for use in different scenarios. A profile is a specific selection of PTP configuration options that are selected to meet the requirements of a particular application.

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 Best Master Clock Algorithm (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 Master or Slave 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.

---

<table>
<thead>
<tr>
<th>Network Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent Clock (TC)</td>
<td>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.</td>
</tr>
</tbody>
</table>

- PTP Profiles, on page 10
- IEEE Default Profile, on page 13
- PTP Hybrid Mode, on page 14
- Verifying the PTP Hybrid Mode Configurations, on page 16
• 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: All PTP port numbers can only be 1 because all clocks in a this profile network are Ordinary Clocks.

The G.8265.1 profile is not supported in this release.

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 master to slave 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 master-only port state to enforce the port to be a master 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): Provides timing for other network devices and does not synchronize its local clock to other network devices.
- Telecom Time Slave Clock (T-TSC): A slave 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): 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.8275.1 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 to a T-BC to synchronize to, it may act as a grandmaster.
- T-TSC: The telecom time slave 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 Cisco NCS 540 Series router is compliant with Class A and 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 and IPv6 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.

Note

The G.8275.2 profile is not supported in this release.
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
!
```

Configuring Slave 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 Master 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
!
```

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 operate over any network technology. The Default Profile requires the following PTP options:
• The standard Best Master Clock Algorithm (BCMA), with both priority fields set to 128.
• All management messages implemented
• Domain number zero

Note
Under the default profile, only hybrid boundary clock is supported in Cisco IOS XR Release 6.3.2.

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.871, 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.

You configure hybrid mode by selecting PTP for the time-of-day (ToD) and another source for the frequency. This task summaries the hybrid configuration. Refer to 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 Cisco ASR 9000 Series Aggregation Services Router Interface and Hardware Component Configuration Guide.

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

4. Configure Slave 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 Master 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

Example: PTP Hybrid Mode

At the global level

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
Verifying the PTP Hybrid Mode Configurations

Use the following show commands to verify the configurations:

- **show frequency synchronization selection**

  ```
  RP/0/RP0/CPU0:R3# show frequency synchronization selection
  Tue Feb 6 06:34:17.627 UTC
  Node 0/0/CPU0:---------------------
  Selection point: ETH_RXMUX (1 inputs, 1 selected)
  Last programmed 3d23h ago, and selection made 3d23h ago
  Next selection points
  SPA scoped : None
  Node scoped : None
  Chassis scoped: T0-SEL-B 1588-SEL
  Router scoped : None
  Uses frequency selection
  S  Input Last Selection Point QL Pri Status
  ------------------------------- ------------- ------ ------ ------
  1 GigabitEthernet0/0/0/2 n/a PRC 1 Available
  Selection point: LC_TX_SELECT (1 inputs, 1 selected)
  Last programmed 3d23h ago, and selection made 3d23h ago
  Next selection points
  SPA scoped : None
  Node scoped : None
  Chassis scoped: None
  Router scoped : None
  Uses frequency selection
  ```
Selection point: T0-SEL-B (3 inputs, 1 selected)
Last programmed 1d00h ago, and selection made 00:36:33 ago
Next selection points
SPA scoped : None
Node scoped : CHASSIS-TOD-SEL
Chassis scoped: LC_TX_SELECT
Router scoped : None
Uses frequency selection

Selection point: 1588-SEL (2 inputs, 1 selected)
Last programmed 3d23h ago, and selection made 00:36:33 ago
Next selection points
SPA scoped : None
Node scoped : CHASSIS-TOD-SEL
Chassis scoped: None
Router scoped : None
Uses frequency selection

Selection point: CHASSIS-TOD-SEL (2 inputs, 1 selected)
Last programmed 1d00h ago, and selection made 1d00h ago
Next selection points
SPA scoped : None
Node scoped : CHASSIS-TOD-SEL
Chassis scoped: None
Router scoped : None
PRC 1 Locked
SEC 255 Available

Last Selection Point
QL Pri Status
Uses time-of-day selection

• show running-config ptp

RP/0/RP0/CP00: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

• 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

The Cisco NCS 540 Series routers 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 SMA connector as input
- 10MHz—SMA connector as input

Figure 1: 1PPS, 10MHz, and the ToD ports on the Cisco NCS 540 Series Router Front Panel

Configuring GPS Settings for the Grand Master Clock

```
RP/0/RP0/CPU0# 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
```
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 TX
  Baud-Rate : - - 9600 -
  QL Option : O1 O1 - -
  RX_ssm(raw): - - - -
  TX_ssm : - - - -
  If_state : DOWN DOWN UP DOWN
  << UP means the 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 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.
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 21
- Configuring NTP, on page 22

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.

**NTP-PTP Interworking**

NTP-PTP interworking provides the ability to use PTP, as well as other valid time of day (TOD) sources such as Data over Cable Service Interface Specification (DOCSIS) Timing Interface (DTI) and global positioning system (GPS), as the time source for the operating system. Prior to the support of NTP-PTP interworking, only backplane time was supported for the operating system time.

NTP-PTP interworking also provides the means to communicate status changes between PTP and NTP processes. It also supports the unambiguous control of the operating system time and backplane time in the event of bootup, switchovers or card and process failures.

**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.

```
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.

```conf
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:

```conf
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 master clock to synchronize with peers when an external NTP source becomes unavailable:

```conf
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:

```conf
ntp
  server 10.3.32.154
  update-calendar
```
Configuring NTP Server Inside VRF Interface

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
```
Workflow and Use Case

Consider the following topology for configuring the G.8275.1:

**Figure 2: Sample G.8275.1 Topology**

```
TGM1

Router A
Te0/0/0/1

Router B
Te0/0/0/2

TGM2

Te0/0/0/1

Te0/0/0/2

Gi0/0/0/3

Gi0/0/0/3

T-BC

Router C

Router D
```

**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-BC

! 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
!
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
!
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
!
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
   selection input
   priority 1
   wait-to-restore 0
!
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
!
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