Timing and Synchronization Configuration Guide, Cisco IOS XE 17 (Cisco NCS 520 Series)

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CONTENTS

Feature History

The following table lists the new and modified features supported in the Timing and Synchronization Configuration Guide in Cisco IOS XE 17 releases, on Cisco NCS 520 Series Ethernet Access Device.

Feature	Description
Cisco IOS XE Bengaluru 17.5.1	
G.8275.1 Telecom Profile	The Cisco NCS 520 Ethernet Access Devices support **G.8275.1** telecom profile. This profile targets accurate time and phase distribution and requires boundary clocks at every node in the network.
Cisco IOS XE Bengaluru 17.4.1	
Clocking and Timing	You can configure clocks and ports on the Cisco NCS 520 Ethernet Access Device as part of the Synchronous Ethenet Support feature.
Synchronous Ethernet ESMC and SSM	The Cisco NCS 520 Ethernet Access Device support Synchronization Status Message (SSM) and Ethernet Synchronization Message Channel (ESMC) for synchronous ethernet clock synchronization.

CHAPTER 2

Clocking and Timing

This chapter explains how to configure timing ports on the Cisco NCS 520 Ethernet Access Device.

Table 1: Feature History

Feature Name	Release Information	Feature Description
Clocking and Timing	Cisco IOS XE Bengaluru 17.4.1	You can configure clocks and ports on the Cisco NCS 520 Ethernet Access Device as part of the Synchronous Ethenet Support feature.

Clocking and Timing Restrictions

The following clocking and timing restrictions apply to the Cisco NCS 520 Series Ethernet Access Device:

- Precision Time Protocol (PTP) is supported over physical interface.

- Synchronous Ethernet clock sources are not supported with PTP. Conversely, PTP clock sources are not supported with synchronous Ethernet except when configured as hybrid clock. However, you can use hybrid clocking to allow the router to obtain frequency using Synchronous Ethernet, and phase using PTP.

- Time of Day (ToD) and 1 Pulse per Second (1PPS) input is not supported when the router is in boundary clock mode.

- Multiple ToD clock sources are not supported.

- In order to configure time of day input, you must configure both an input 10 Mhz and an input 1 PPS source.

- PTP functionality is restricted by license type.

- Building Integrated Timing Supply (BITS) is not supported on the NCS 520 Series Ethernet Access Device.

- Transparent Clock is not supported.

The table below summarizes the PTP functionalities that are available, by license type:

Table 2: PTP Functions Supported by Different Licenses

License	PTP Support
Metro Services	Not supported
Metro IP Service	Ordinary Subordinate Clock
Metro Aggregation Service	Ordinary Subordinate Clock
Metro IP Service + IEEE 1588-2008 BC/MC	All PTP functionality including boundary and server clock
Metro Aggregation Service + IEEE 1588-2008 BC/MC	All PTP functionality including boundary and server clock

Note If you install the IEEE 1588-2008 BC/MC license, you must reload the router to use the full PTP functionality.

- G.8265.1 telecom profiles are not supported with PTP over Ethernet.

- IEEE1588-2008 default profile, G.8265.1 and G.8275.2 are not supported.

The following restrictions apply when configuring synchronous Ethernet SSM and ESMC:

- To use the **network-clock synchronization ssm option** command, ensure that the router configuration does not include the following:

  - Input clock source

  - Network clock quality level

  - Network clock source quality source (Synchronous Ethernet interfaces)

- The **network-clock synchronization ssm option** command must be compatible with the **network-clock eec** command in the configuration.

- To use the **network-clock synchronization ssm option** command, ensure that there is not a network clocking configuration applied to synchronous Ethernet interfaces and timing port interfaces.

- We recommended that you do not configure multiple input sources with the same priority as this impacts the TSM (Switching message delay).

- The **network-clock input-interface ptp domain** command is not supported.

- To shift from non hybrid clock configuration to hybrid clock configuration, you must first unconfigure PTP, unconfigure netsync, reconfigure netsync and configure hybrid PTP.

Clocking and Timing Overview

The Cisco NCS 520 Series Ethernet Access Device have the following timing ports:

- 1 PPS Input/Output

- 10 Mhz Input/Output

- ToD

You can use the timing ports on the Cisco NCS 520 Series Ethernet Access Device to perform the following tasks:

- Provide or receive 1 PPS messages

- Provide or receive time of day (ToD) messages

- Provide output clocking at 10 Mhz, 2.048 Mhz, and 1.544 Mhz

- Receive input clocking at 10 Mhz, 2.048 Mhz, and 1.544 Mhz

SyncE is supported in both LAN and WAN mode on a 10 Gigabit Ethernet interface.

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 are organized into a server-client hierarchy. PTP identifies the switch 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 cock and are referred to as members. Constantly exchanged timing messages ensure continued synchronization.

PTP is particularly useful for industrial automation systems and process control networks, where motion and precision control of instrumentation and test equipment are important.

Table 3: 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 clocks.

PTP Redundancy

PTP redundancy is an implementation on different clock nodes. This helps the PTP subordinate clock node achieve the following:

- Interact with multiple server ports such as grandmaster clocks and boundary clock nodes.

- Open PTP sessions.

- Select the best server clock from the existing list of server clocks (referred to as the PTP server port or server clock source).

- Switch to the next best server clock available in case the first server clock fails, or its connectivity is lost.

> ✎
>
> **Note** BMCA can also be triggered if clock class of the newly-added server clock is better. This is true for both, normal PTP as well as PTP with hybrid.

For instructions on how to configure PTP redundancy, see Configuring PTP Transperancy.

PTP Redundancy Using Hop-By-Hop Topology Design

Real world deployments for IEEE-1588v2 for mobile backhaul requires the network elements to provide synchronization and phase accuracyalong with redundancy.

In a ring topology, a ring of PTP boundary clock nodes are provisioned such that each boundary clock node provides synchronization to a number of PTP client clocks connected to it. Each such ring includes at least two PTP server clocks with a PRC traceable clock.

However, with this topology the following issues may occur:

- Node asymmetry and delay variation—In a ring topology, each boundary clock uses the same server clock, and the PTP traffic is forwarded through intermediate boundary clock nodes. As intermediate nodes do not correct the timestamps, variable delay and asymmetry for PTP are introduced based on the other traffic passing through such nodes, thereby leading to incorrect results.

- Clock redundancy—Clock redundancy provides redundant network path when a node goes down. In a ring topology with PTP, for each unicast PTP solution, the roles of each node is configured. The PTP clock path may not be able to reverse without causing timing loops in the ring.

No On-Path Support Topology

The topology (see the figure below) describes a ring with no on-path support. S1 to S5 are the boundary clocks that use the same server clocks. GM1 and GM2 are the grandmaster clocks. In this design, the following issues are observed:

- Timestamps are not corrected by the intermediate nodes.

- Difficult to configure the reverse clocking path for redundancy.

- Formation of timings loops.

Figure 1: Deployment in a Ring - No On-Path Support
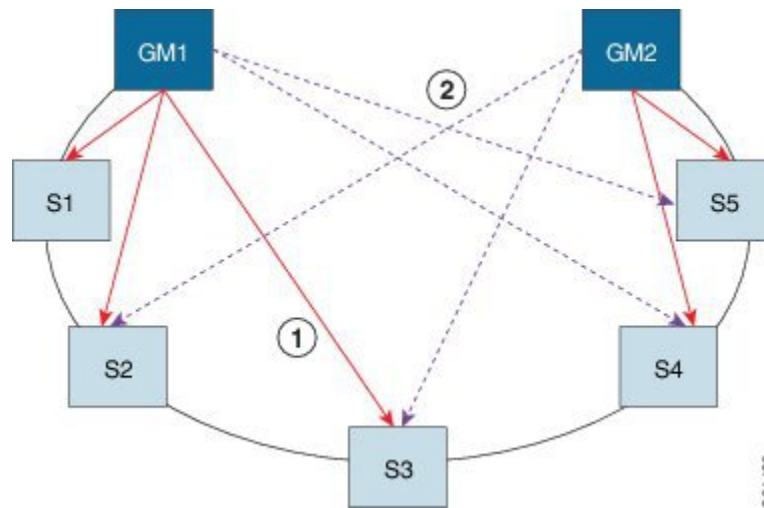
Table 4: PTP Ring Topology—No On-Path Support

Clock Nodes	Behavior in the PTP Ring
GM1	Grandmaster Clock
GM2	Grandmaster Clock
S1	Server clocks: M1 (1st), M2 (2nd)
S2	Server clocks: M1 (1st), M2 (2nd)
S3	Server clocks: M1 (1st), M2 (2nd)
S4	Server clocks: M2 (1st), M1 (2nd)
S5	Server clocks: M2 (1st), M1 (2nd)

A solution to the above issue is addressed by using Hop-by-Hop topology configuration.

Hop-By-Hop Topology in a PTP Ring

PTP Ring topology is designed by using Hop-By-Hop configuration of PTP boundary clocks. In this topology, each BC selects its adjacent nodes as PTP server clocks, instead of using the same GM as the PTP server clock. These PTP BC server clocks are traceable to the GM in the network. Timing loop are not formed between adjacent BC nodes. The hot Standby BMCA configuration is used for switching to next the best server clock during failure.

Prerequisites

- PTP boundary clock configuration is required on all clock nodes in the ring, except the server clock nodes (GM), which provide the clock timing to ring. In the above example nodes S1—S5 must be configured as BC.

- The server clock (GM1 and GM2 in the above figure) nodes in the ring can be either a OC server clock or BC server clock.

- Instead of each BC using same the GM as a PTP server clock, each BC selects its adjacent nodes as PTP server clocks. These PTP BC-server clocks are traceable to the GM in the network.

Restrictions

- Timing loops should not exist in the topology. For example, if for a node there are two paths to get the same clock back, then the topology is not valid. Consider the following topology and configuration.
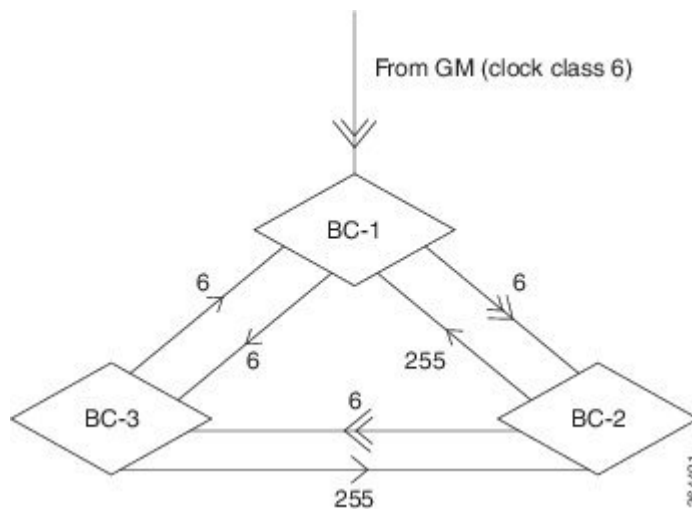
The paths with double arrows (>>) are the currently active clock paths and paths with single arrow (>) are redundant clock path. This configuration results in a timing loop if the link between the BC-1 and GM fails.

Link from GM fails
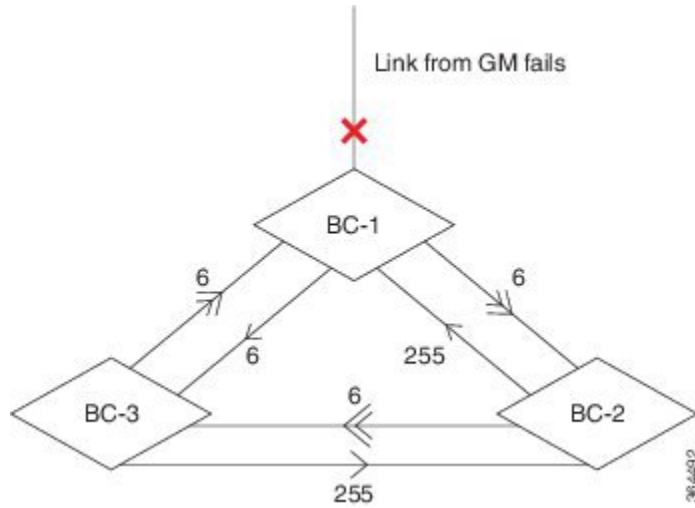
On-Path Support Topology Scenario

Consider the topology as shown in the figure:

Figure 2: PTP Ring Topology—On-Path Support
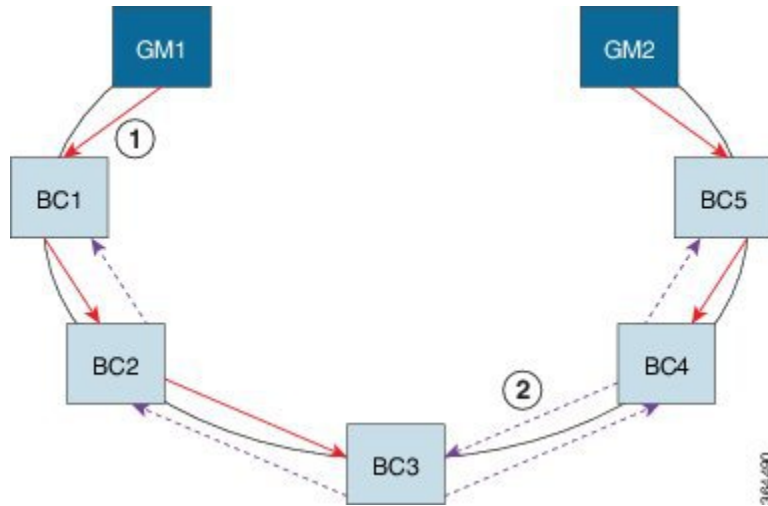
Table 5: PTP Ring Topology—On-Path Support

Clock Node	Behavior in the PTP Ring
GM1	Grandmaster Clock
GM2	Grandmaster Clock
BC1	Server clocks: M1 (1st), BC2 (2nd) Client clocks: BC2

Clock Node	Behavior in the PTP Ring
BC2	Server clocks: BC1(1st), BC3 (2nd) Client clocks: BC1, BC3
BC3	Server clocks: BC2 (1st), BC4 (2nd) Client clocks: BC2, BC4
BC4	Server clocks: BC5 (1st), BC3 (2nd) Client clocks: BC3, BC5
BC5	Server clocks: M2(1st), BC4 (2nd) Client clocks: BC4

Now consider there is a failure between BC1 and BC2 (see the figure below). In this case, the BC2 cannot communicate with GM1. Node BC2 receives the clock from BC3, which in turn receives the clock from GM2.

Figure 3: Deployment in a Ring—On-Path Support (Failure)
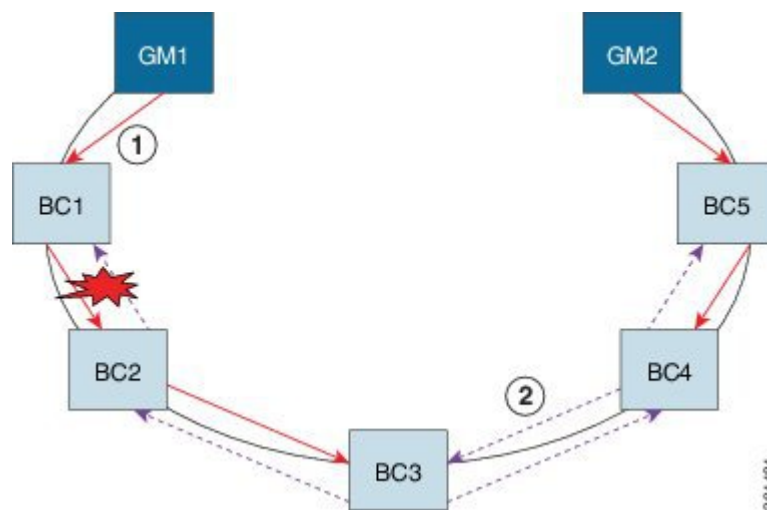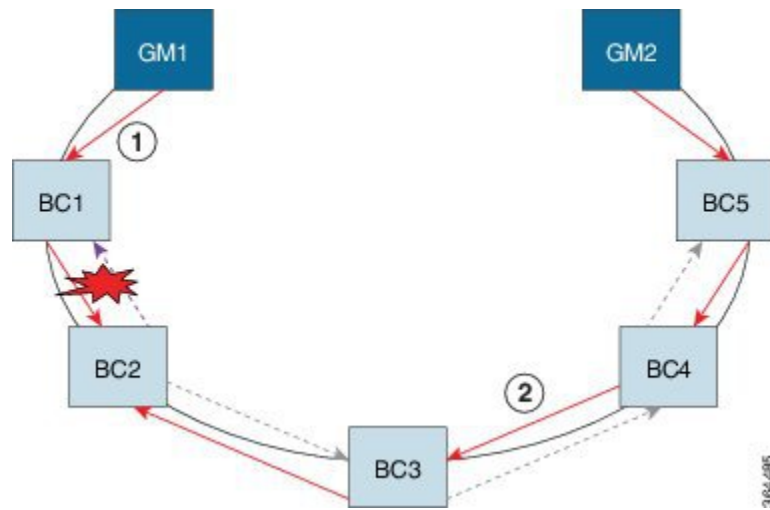
Table 6: PTP Ring Topology—On-Path Support (Failure)

Clock Node	Behavior in the PTP Ring[1]
GM1	Grandmaster Clock
GM2	Grandmaster Clock
BC1	Server clocks: M1 (1st), BC2 (2nd) Client clocks: BC2
BC2	Server clocks: BC1(1st), BC3 (2nd) Client clocks: BC1, BC3
BC3	Server clocks: BC2 (1st), BC4 (2nd) Client clocks: BC2, BC4
BC4	Server clocks: BC5 (1st), BC3 (2nd) Client clocks: BC3, BC5
BC5	Server clocks: M2(1st), BC4 (2nd) Client clocks: BC4

[1] Red indicates that GM is not traceable and there is no path to the slave.

Hybrid Clocking

The Cisco Router support a hybrid clocking mode that uses clock frequency obtained from the synchronous Ethernet port while using the phase (ToD or 1 PPS) obtained using PTP. The combination of using physical source for frequency and PTP for time and phase improves the performance as opposed to using only PTP.

Note   When configuring a hybrid clock, ensure that the frequency and phase sources are traceable to the same server clock.

Time of Day (TOD)

You can use the time of day (ToD) and 1PPS ports on the Cisco Router to exchange ToD clocking. In server mode, the router can receive time of day (ToD) clocking from an external GPS unit; the router requires a ToD, 1PPS, and 10MHZ connection to the GPS unit.

In client mode, the router can recover ToD from a PTP session and repeat the signal on ToD and 1PPS interfaces.

For instructions on how to configure ToD on the Cisco Router, see the Configuring a Server Ordinary Clock, on page 13 and Configuring a Client Ordinary Clock, on page 18.

Understanding Synchronous Ethernet ESMC and SSM

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 Cisco 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.

For more information about Ethernet ESMC and SSM, seeConfiguring Synchronous Ethernet ESMC and SSM, on page 26.

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

Note   PTP clock sources are not supported with synchronous Ethernet.

Clock Selection Modes

The Cisco Router supports two clock selection modes, which are described in the following sections.

QL-Enabled Mode

In QL-enabled mode, the router considers the following parameters when selecting a clock source:

- Clock quality level (QL)
- Clock availability
- Priority

QL-Disabled Mode

In QL-disabled mode, the router considers the following parameters when selecting a clock source:

- Clock availability
- Priority

> **Note** You can use override the default clock selection using the commands described in the Specifying a Clock Source, on page 30 and Disabling a Clock Source, on page 31 sections.

Managing Clock Selection

You can manage clock selection by changing the priority of the clock sources; you can also influence clock selection by modifying modify the following clock properties:

- Hold-Off Time—If a clock source goes down, the router waits for a specific hold-off time before removing the clock source from the clock selection process. By default, the value of hold-off time is 300 ms.
- Wait to Restore—The amount of time that the router waits before including a newly active synchronous Ethernet clock source in clock selection. The default value is 300 seconds.
- Force Switch—Forces a switch to a clock source regardless of clock availability or quality.
- Manual Switch—Manually selects a clock source, provided the clock source has a equal or higher quality level than the current source.

For more information about how to use these features, see Specifying a Clock Source, on page 30 and Disabling a Clock Source, on page 31 sections.

Configuring Clocking and Timing

The following sections describe how to configure clocking and timing features on the Cisco NCS 520 Series Ethernet Access Device:

Configuring a Server Ordinary Clock

Follow these steps to configure the Cisco Router to act as a server ordinary clock.

Procedure

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Router> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters configuration mode.
Step 3	**platform ptp 1pps GPS** **Example:** `Router(config)#platform ptp 1pps GPS`	Enables 1pps SMA port.

Step 4	**ptp clock ordinary domain** *domain-number*
	Example:
	
	`Router(config)# ptp clock ordinary`
	`domain 0`
		Configures the PTP clock. You can create the following clock types:
		
		• ordinary—A 1588 clock with a single PTP port that can operate in Server or Client mode.

Step 5	**priority1** *priorityvalue*
	Example:
	
	`Router(config-ptp-clk)# priority1`
	`priorityvalue`
		Sets the preference level for a clock. Client devices use the priority1 value when selecting a server clock: a lower priority1 value indicates a preferred clock. The priority1 value is considered above all other clock attributes.
		
		Valid values are from 0-255. The default value is 128.

Step 6	**priority2** *priorityvalue*
	Example:
	
	`Router(config-ptp-clk)# priority2`
	`priorityvalue`
		Sets a secondary preference level for a clock. Subordinaate devices use the priority2 value when selecting a server clock: a lower priority2 value indicates a preferred clock. The priority2 value is considered only when the router is unable to use priority1 and other clock attributes to select a clock.
		
		Valid values are from 0-255. The default value is 128.

Step 7	**utc-offset** *value* **leap-second "date time" offset** {-1 | 1} **Example:** `Router(config-ptp-clk)#` **utc-offset** **45 leap-second "01-01-2017** **00:00:00" offset 1**	(Optional) Starting with Cisco IOS-XE Release 3.18SP, the new utc-offset CLI is used to set the UTC offset value. Valid values are from 0-255. The default value is 36. (Optional) Starting with Cisco IOS-XE Release 3.18.1SP, you can configure the current UTC offset, leap second event date and Offset value (+1 or -1). Leap second configuration will

	Command or Action	Purpose
		work only when the frequency source is locked and ToD was up before.
		• *"date time"*— Leap second effective date in dd-mm-yyyy hh:mm:ss format.
Step 8	input [1pps] {R0 | R1} **Example:** Router(config-ptp-clk)# input 1pps R0	Enables Precision Time Protocol input 1PPS using a 1PPS input port. Use R0 or R1 to specify the active RSP slot.
Step 9	**tod** {**R0** | **R1**} {**ubx** | **nmea** | **cisco** | **ntp**} **Example:** Router(config-ptp-clk)# tod R0 ntp	Configures the time of day message format used by the ToD interface. **Note** It is mandatory that when electrical ToD is used, the **utc-offset** command is configured *before* configuring the **tod R0**, otherwise there will be a time difference of approximately 37 seconds between the server and client clocks. **Note** The ToD port acts as an input port in case of Server clock and as an output port in case of Client clock.
Step 10	**clock-port** *port-name* {**master** | **slave**} [**profile** {**g8275.1**}] **Example:** Router(config-ptp-clk)# **clock-port** *server-port* **master**	Defines a new clock port and sets the port to PTP server or client mode; in server mode, the port exchanges timing packets with PTP client devices. The **profile** keyword configures the clock to use the G8275.1 recommendations for establishing PTP sessions, determining the best server clock, handling SSM, and mapping PTP classes. **Note** Using a telecom profile requires that the clock have a domain number of 4–23.

Step 11	Do one of the following:
	
	    • **transport ethernet unicast** [**negotiation**]
	    • **multicast interface** *interface-type interface-number*
	
	Example:
		Specifies the transport mechanism for clocking traffic; you can use Ethernet transport.
		
		The **negotiation** keyword configures the router to discover a PTP server clock from all available PTP clock sources.

	Command or Action	Purpose
	Router(config-ptp-port)# transport ethernet multicast interface gi0/0/0	**Note** PTP redundancy is supported only on unicast negotiation mode.
Step 12	**exit**	Exits clock-port configuration.
Step 13	**network-clock synchronization automatic** **Example:** Router(config)# network-clock synchronization automatic	Enables automatic selection of a clock source. **Note** This command is mandatory to configure the **leap second** command. **Note** This command must be configured before any input source.
Step 14	**network-clock synchronization mode ql-enabled** **Example:** Router(config)# **network-clock synchronization mode ql-enabled**	Enables automatic selection of a clock source based on quality level (QL). **Note** This command is disabled by default.
Step 15	Use one of the following options: • network-clock input-source <priority> controller {SONET | wanphy} • network-clock input-source <priority> external {R0 | R1} [10m | 2m] • network-clock input-source <priority> interface <type/slot/port> **Example:** Router(config)# network-clock input-source 1 external R0 10m	• (Optional) To nominate SDH or SONET controller as network clock input source. • (Optional) To nominate 10Mhz port as network clock input source.
Step 16	**sync interval** *interval* **Example:** Router(config-ptp-port)# sync interval -4	Specifies the interval used to send PTP synchronization messages. The intervals are set using log base 2 values, as follows: • 1—1 packet every 2 seconds • 0—1 packet every second • -1—1 packet every 1/2 second, or 2 packets per second • -2—1 packet every 1/4 second, or 4 packets per second • -3—1 packet every 1/8 second, or 8 packets per second

	Command or Action	Purpose
		• -4—1 packet every 1/16 seconds, or 16 packets per second.
		• -5—1 packet every 1/32 seconds, or 32 packets per second.
		• -6—1 packet every 1/64 seconds, or 64 packets per second.
		• -7—1 packet every 1/128 seconds, or 128 packets per second.
Step 17	**announce interval** *interval* **Example:** `Router(config-ptp-port)# announce interval 2`	Specifies the interval for PTP announce messages. The intervals are set using log base 2 values, as follows: • 3—1 packet every 8 seconds • 2—1 packet every 4 seconds • 1—1 packet every 2 seconds • 0—1 packet every second • -1—1 packet every 1/2 second, or 2 packets per second • -2—1 packet every 1/4 second, or 4 packets per second • -3—1 packet every 1/8 second, or 8 packets per second
Step 18	**end** **Example:** `Router(config-ptp-port)# end`	Exit configuration mode.

Example

The following example shows that the utc-offset is configured before configuring the ToD to avoid a delay of 37 seconds between the server and client clocks:

```
ptp clock ordinary domain 24

local-priority 1

priority2 128
utc-offset 37
tod R0 cisco
clock-port server-port-1 master profile g8275.1 local-priority 1
transport ethernet multicast interface Gig 0/0/1
```

Configuring a Client Ordinary Clock

Follow these steps to configure the Cisco Router to act as a client ordinary clock.

Procedure

	Command or Action	**Purpose**
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enter configuration mode.
Step 3	**ptp clock ordinary domain** *domain-number* [**hybrid**] **Example:** `Router(config)# ptp clock ordinary domain 0`	Configures the PTP clock. You can create the following clock types: • ordinary—A 1588 clock with a single PTP port that can operate in server or client mode.
Step 4	**output [1pps] {R0	R1} [offset** *offset-value*] [**pulse-width** *value*] **Example:** `Router(config-ptp-clk)# output 1pps R0 offset 200 pulse-width 20 μsec`	Enables Precision Time Protocol input 1PPS using a 1PPS input port. Use R0 or R1 to specify the active RSP slot. **Note** Effective Cisco IOS XE Everest 16.6.1, the 1pps pulse bandwith can be changed from the default value of 500 milliseconds to up to 20 microsecond.
Step 5	**tod {R0	R1} {ubx	nmea	cisco	ntp}** **Example:** `Router(config-ptp-clk)# tod R0 ntp`	Configures the time of day message format used by the ToD interface. **Note** The ToD port acts as an input port in case of Server clock and as an output port in case of Client clock.
Step 6	**clock-port** *port-name* {**master**	**slave**} [**profile** {**g8275.1**}] **Example:** `Router(config-ptp-clk)# clock-port client-port slave`	Sets the clock port to PTP server or client mode; in client mode, the port exchanges timing packets with a PTP server clock. The **profile** keyword configures the clock to use the G8275.1 recommendations for establishing PTP sessions, determining the best server clock, handling SSM, and mapping PTP classes.

	Command or Action	Purpose
		Note Using a telecom profile requires that the clock have a domain number of 4–23.
Step 7	Do one of the following: • **transport ethernet unicast** [**negotiation**] **Example:** `Router(config-ptp-port)#transport ethernet multicast interface gi0/0/0`	Specifies the transport mechanism for clocking traffic; you can use Ethernet transport. The **negotiation** keyword configures the router to discover a PTP server clock from all available PTP clock sources. **Note** PTP redundancy is supported only on unicast negotiation mode.
Step 8	**clock source** *source-address* | *mac-address* { } | **interface** *interface-name*} [*priority*] **Example:** `Router(config-ptp-port)# clock-source 8.8.8.1`	Specifies the IP or MAC address of a PTP server clock. • *priority*—Sets the preference level for a PTP clock. • *delay asymmetry value*—Performs the PTP asymmetry readjustment on a PTP node to compensate for the delay in the network.
Step 9	**announce timeout** *value* **Example:** `Router(config-ptp-port)# announce timeout 8`	Specifies the number of PTP announcement intervals before the session times out. Valid values are 1-10.
Step 10	**delay-req interval** *interval* **Example:** `Router(config-ptp-port)# delay-req interval 1`	Configures the minimum interval allowed between PTP delay-request messages when the port is in the server state. The intervals are set using log base 2 values, as follows: • 3—1 packet every 8 seconds • 2—1 packet every 4 seconds • 1—1 packet every 2 seconds • 0—1 packet every second • -1—1 packet every 1/2 second, or 2 packets per second • -2—1 packet every 1/4 second, or 4 packets per second • -3—1 packet every 1/8 second, or 8 packets per second

	Command or Action	Purpose
		• -4—1 packet every 1/16 seconds, or 16 packets per second.
		• -5—1 packet every 1/32 seconds, or 32 packets per second.
		• -6—1 packet every 1/64 seconds, or 64 packets per second.
		• -7—1 packet every 1/128 seconds, or 128 packets per second.
Step 11	**end** **Example:** `Router(config-ptp-port)# end`	Exit configuration mode.

Hybrid Clocking

The Cisco Router support a hybrid clocking mode that uses clock frequency obtained from the synchronous Ethernet port while using the phase (ToD or 1 PPS) obtained using PTP. The combination of using physical source for frequency and PTP for time and phase improves the performance as opposed to using only PTP.

✎ **Note** When configuring a hybrid clock, ensure that the frequency and phase sources are traceable to the same server clock.

Configuring a Hybrid Boundary Clock

Follow these steps to configure a hybrid clocking in boundary clock mode.

✎ **Note** When configuring a hybrid clock, ensure that the frequency and phase sources are traceable to the same server clock.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enter configuration mode.

	Command or Action	**Purpose**
	`Router# configure terminal`	
Step 3	**ptp clock** {**ordinary** | **boundary**} **domain** *domain-number* **hybrid** **Example:** `Router(config)# ptp clock ordinary domain 0 hybrid`	Configures the PTP clock. You can create the following clock types: • ordinary—A 1588 clock with a single PTP port that can operate in server or client mode. • boundary—Terminates PTP session from Grandmaster and acts as PTP server to clients downstream.
Step 4	time-properties persist **value** **Example:** `Router(config-ptp-clk)#` **time-properties persist 600**	(Optional) Starting with Cisco IOS-XE Release 3.18.1SP, you can configure time properties holdover time. Valid values are from 0 to 10000 seconds. The default value is 300 seconds. When a server clock is lost, the time properties holdover timer starts. During this period, the time properties flags (currentUtcOffset, currentUtcOffsetValid, leap61, leap59) persist for the holdover timeout period. Once the holdover timer expires, currentUtcOffsetValid, leap59, and leap61 flags are set to false and the currentUtcOffset remains unchanged. In case leap second midnight occurs when holdover timer is running, utc-offset value is updated based on leap59 or leap61 flags. This value is used as long as there are no PTP packets being received from the selected server clock. In case the selected server clock is sending announce packets, the time-properties advertised by server is used.
Step 5	**utc-offset** *value* **leap-second "date time" offset** {-1 | 1} **Example:** `Router(config-ptp-clk)#` **utc-offset 45 leap-second "01-01-2017 00:00:00" offset 1**	(Optional) Starting with Cisco IOS-XE Release 3.18SP, the new utc-offset CLI is used to set the UTC offset value. Valid values are from 0-255. The default value is 36. (Optional) Starting with Cisco IOS-XE Release 3.18.1SP, you can configure the current UTC offset, leap second event date and Offset value (+1 or -1). Leap second configuration will work only when the frequency source is locked and ToD was up before. • *"date time"*— Leap second effective date in dd-mm-yyyy hh:mm:ss format.

	Command or Action	Purpose
Step 6	**min-clock-class** *value* **Example:** Router(config-ptp-clk)# **min-clock-class 157**	Sets the threshold clock-class value. This allows the PTP algorithm to use the time stamps from an upstream server clock, only if the clock-class sent by the server clock is less than or equal to the configured threshold clock-class. Valid values are from 0-255. **Note** Min-clock-class value is supported only for PTP with single server source configuration.
Step 7	**clock-port** *port-name* {**master** | **slave**} [**profile** {**g8275.1**}] **Example:** Router(config-ptp-clk)# clock-port client-port slave	Sets the clock port to PTP server or client mode; in client mode, the port exchanges timing packets with a PTP server clock. **Note** Hybrid mode is only supported with client clock-ports; server mode is not supported. The **profile** keyword configures the clock to use the G.8275.1 recommendations for establishing PTP sessions, determining the best server clock, handling SSM, and mapping PTP classes. **Note** Using a telecom profile requires that the clock have a domain number of 4–23.
Step 8	**clock-source** *source-address [priority]* **Example:** Router(config-ptp-port)# clock source 133.133.133.133	Specifies the address of a PTP server clock. You can specify a priority value as follows: • No priority value—Assigns a priority value of 0. • 1—Assigns a priority value of 1. • 2—Assigns a priority value of 2, the highest priority.
Step 9	**clock-port** *port-name* {**master** | **slave**} [**profile** {**g8275.1**}] **Example:** Router(config-ptp-port)# clock-port server-port master	Sets the clock port to PTP server or client mode; in server mode, the port exchanges timing packets with PTP client devices. The **profile** keyword configures the clock to use the G.8275.1 recommendations for establishing PTP sessions, determining the best server clock, handling SSM, and mapping PTP classes.

	Command or Action	Purpose
		Note Using a telecom profile requires that the clock have a domain number of 4–23.
Step 10	**exit**	Exits clock-port configuration.
Step 11	**network-clock synchronization automatic** **Example:** Router(config)# network-clock synchronization automatic	Enables automatic selection of a clock source. **Note** This command is mandatory to configure the **leap second** command. **Note** This command must be configured before any input source.
Step 12	**network-clock synchronization mode ql-enabled** **Example:** Router(config)# network-clock synchronization mode ql-enabled	Enables automatic selection of a clock source based on quality level (QL). **Note** This command is disabled by default.
Step 13	Use one of the following options: • network-clock input-source <priority> controller {SONET | wanphy} • network-clock input-source <priority> external {R0 | R1} [10m | 2m] • network-clock input-source <priority> interface <type/slot/port> **Example:** Router(config)# network-clock input-source 1 external R0 10m	• (Optional) To nominate SDH or SONET controller as network clock input source. • (Optional) To nominate 10Mhz port as network clock input source. • (Optional) To nominate Ethernet interface as network clock input source.
Step 14	network-clock synchronization input-threshold *ql value* **Example:** Router(config)# **network-clock synchronization input-threshold ql value**	(Optional) Starting with Cisco IOS-XE Release 3.18SP, this new CLI is used to set the threshold QL value for the input frequency source. The input frequency source, which is better than or equal to the configured threshold QL value, will be selected to recover the frequency. Otherwise, internal clock is selected.
Step 15	**network-clock hold-off** {**0** | *milliseconds*} **Example:** Router(config)# network-clock hold-off 0	(Optional) Configures a global hold-off timer specifying the amount of time that the router waits when a synchronous Ethernet clock source fails before taking action.

	Command or Action	Purpose
		Note You can also specify a hold-off value for an individual interface using the **network-clock hold-off** command in interface mode.
Step 16	**end** **Example:** `Router(config)# end`	Exit configuration mode.

Synchronizing the System Time to a Time-of-Day Source

The following sections describe how to synchronize the system time to a time of day (ToD) clock source.

Synchronizing the System Time to a Time-of-Day Source (Server Mode)

Note System time to a ToD source (Server Mode) can be configured only when PTP server is configured. See Configuring a Server Ordinary Clock, on page 13. Select any one of the four available ToD format; cisco, nmea, ntp or ubx.10m must be configured as network clock input source.

Follow these steps to configure the system clock to a ToD source in server mode.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enter configuration mode.
Step 3	**tod-clock input-source** *priority* {**gps** {**R0** | **R1**} | **ptp domain** *domain*} **Example:** `Router(config)# TOD-clock 2 gps R0/R1`	In server mode, specify a GPS port connected to a ToD source.

	Command or Action	Purpose
Step 4	**exit** **Example:** `Router(config)# exit`	Exit configuration mode.

Synchronizing the System Time to a Time-of-Day Source (Client Mode)

Note   System time to a ToD source (Client Mode) can be configured only when PTP client is configured. See Configuring a Client Ordinary Clock, on page 18.

Follow these steps to configure the system clock to a ToD source in client mode. In client mode, specify a PTP domain as a ToD input source.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enter configuration mode.
Step 3	**tod-clock input-source** *priority* {**gps** {**R0** | **R1**} | **ptp domain** *domain*} **Example:** `Router(config)# TOD-clock 10 ptp domain 0`	In client mode, specify a PTP domain as a ToD input source.
Step 4	`Router(config)#` **end**	Exit configuration mode.

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.

Configuring Synchronous Ethernet ESMC and SSM

Follow these steps to configure ESMC and SSM on the Cisco Router:

Procedure

	Command or Action	**Purpose**
Step 1	**enable** **Example:** Router> enable	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** Router# configure terminal	Enters global configuration mode.
Step 3	**network-clock synchronization automatic** **Example:** Router(config)# network-clock synchronization automatic	Enables the network clock selection algorithm. This command disables the Cisco-specific network clock process and turns on the G.781-based automatic clock selection process. **Note** This command must be configured before any input source.
Step 4	**network-clock eec {1 | 2}** **Example:** Router(config)# network-clock eec 1	Specifies the Ethernet Equipment Clock (EEC) type. Valid values are • 1—ITU-T G.8262 option 1 (2048) • 2—ITU-T G.8262 option 2 and Telcordia GR-1244 (1544)
Step 5	**network-clock synchronization ssm option {1 | 2 {GEN1 | GEN2}}** **Example:** Router(config)# network-clock synchronization ssm option 2 GEN2	Configures the G.781 synchronization option used to send synchronization messages. The following guidelines apply for this command: • Option 1 refers to G.781 synchronization option 1, which is designed for Europe. This is the default value. • Option 2 refers to G.781 synchronization option 2, which is designed for the United States. • GEN1 specifies option 2 Generation 1 synchronization. • GEN2 specifies option 2 Generation 2 synchronization.

	Command or Action	**Purpose**

Step 6	Use one of the following options:
	
	• network-clock input-source <priority> controller {SONET | wanphy}
	• network-clock input-source <priority> external {R0 | R1} [10m | 2m]
	• network-clock input-source <priority> interface <type/slot/port>
	• network-clock input-source <priority> ptp domain <domain-number>
	
	Example:
	
	`Router(config)# network-clock`
	`input-source 1 external R0 10m`
		• (Optional) To nominate SDH or SONET controller as network clock input source.
		
		• (Optional) To nominate 10Mhz port as network clock input source.
		
		• (Optional) To nominate PTP as network clock input source.

Step 7	**network-clock synchronization mode ql-enabled**
	
	Example:
	
	`Router(config)# network-clock`
	`synchronization mode ql-enabled`
		Enables automatic selection of a clock source based on quality level (QL).
		
		Note This command is disabled by default.

Step 8	**network-clock hold-off** {**0** | *milliseconds*}
	
	Example:
	
	`Router(config)# network-clock hold-off`
	` 0`
		(Optional) Configures a global hold-off timer specifying the amount of time that the router waits when a synchronous Ethernet clock source fails before taking action.
		
		Note You can also specify a hold-off value for an individual interface using the **network-clock hold-off** command in interface mode.

Step 9	**network-clock wait-to-restore** *seconds*
	
	Example:
	
	`Router(config)# network-clock`
	`wait-to-restore 70`
		(Optional) Configures a global wait-to-restore timer for synchronous Ethernet clock sources. The timer specifies how long the router waits before including a restored clock source in the clock selection process.
		
		Valid values are 0 to 86400 seconds. The default value is 300 seconds.
		
		Note You can also specify a wait-to-restore value for an individual interface using the **network-clock wait-to-restore** command in interface mode.

Step 10	**network-clock revertive** **Example:**	(Optional) Sets the router in revertive switching mode when recovering from a

	Command or Action	Purpose
	`Router(config)# network-clock revertive`	failure. To disable revertive mode, use the **no** form of this command.
Step 11	**esmc process** **Example:** `Router(config)# esmc process`	Enables the ESMC process globally.
Step 12	**network-clock external** *slot*/*card*/*port* **hold-off** {**0** | *milliseconds*} **Example:** `Router(config)# network-clock external 0/1/0 hold-off 0`	Overrides the hold-off timer value for the external interface.
Step 13	**network-clock quality-level** {**tx** | **rx**} *value* {**controller** [**E1**|] *slot/card/port* | external [**2m** | **10m** | **2048k** | **t1** | **e1**] } **Example:** `Router(config)# network-clock quality-level rx qL-pRC external R0 e1 cas crc4`	Specifies a quality level for a line or external clock source. The available quality values depend on the G.781 synchronization settings specified by the **network-clock synchronization ssm option** command: • Option 1—Available values are QL-PRC, QL-SSU-A, QL-SSU-B, QL-SEC, and QL-DNU. • Option 2, GEN1—Available values are QL-PRS, QL-STU, QL-ST2, QL-SMC, QL-ST4, and QL-DUS. • Option 2, GEN 2—Available values are QL-PRS, QL-STU, QL-ST2, QL-TNC, QL-ST3, QL-SMC, QL-ST4, and QL-DUS.

Step 14	**interface** *type number*
	
	Example:
	
	`Router(config)# interface GigabitEthernet 0/0/1`
	
	Example:
	
	`Router(config-if)#`
		Enters interface configuration mode.

Step 15	**synchronous mode** **Example:** `Router(config-if)# synchronous mode`	Configures the Ethernet interface to synchronous mode and automatically enables the ESMC and QL process on the interface.

	Command or Action	**Purpose**
Step 16	network-clock source quality-level *value* {**tx** | **rx**} **Example:** Router(config-if)# network-clock source quality-level QL-PrC tx	Applies quality level on sync E interface. The available quality values depend on the G.781 synchronization settings specified by the **network-clock synchronization ssm option** command: • Option 1—Available values are QL-PRC, QL-SSU-A, QL-SSU-B, QL-SEC, and QL-DNU. • Option 2, GEN1—Available values are QL-PRS, QL-STU, QL-ST2, QL-SMC, QL-ST4, and QL-DUS. • Option 2, GEN 2—Available values are QL-PRS, QL-STU, QL-ST2, QL-TNC, QL-ST3, QL-SMC, QL-ST4, and QL-DUS.
Step 17	**esmc mode** [**ql-disabled** | **tx** | **rx**] *value* **Example:** Router(config-if)# esmc mode rx QL-STU	Enables the ESMC process at the interface level. The **no** form of the command disables the ESMC process.
Step 18	**network-clock hold-off** {*0* | *milliseconds*} **Example:** Router(config-if)# network-clock hold-off 0	(Optional) Configures an interface-specific hold-off timer specifying the amount of time that the router waits when a synchronous Ethernet clock source fails before taking action. You can configure the hold-off time to either 0 or any value between 50 to 10000 ms. The default value is 300 ms.
Step 19	**network-clock wait-to-restore** *seconds* **Example:** Router(config-if)# network-clock wait-to-restore 70	(Optional) Configures the wait-to-restore timer for an individual synchronous Ethernet interface.
Step 20	**end** **Example:** Router(config-if)# end	Exits interface configuration mode and returns to privileged EXEC mode.

What to do next

You can use the **show network-clocks** command to verify your configuration.

Specifying a Clock Source

The following sections describe how to specify a synchronous Ethernet clock source during the clock selection process:

Selecting a Specific Clock Source

To select a specific interface as a synchronous Ethernet clock source, use the network-clock switch manual command in global configuration mode.

✎

Note   The new clock source must be of higher quality than the current clock source; otherwise the router does not select the new clock source.

Command	Purpose
network-clock switch manual external R0 | R1 {{E1 {crc4 | cas |fas}} {T1 {d4 | sf | esf}} } `Router# network-clock switch manual external r0 e1 crc4`	Manually selects a synchronization source, provided the source is available and is within the range.
network-clock clear switch {t0 | external *slot/card/port* [**10m | 2m**]} `Router# network-clock clear switch t0`	Disable a clock source selection.

Forcing a Clock Source Selection

To force the router to use a specific synchronous Ethernet clock source, use the **network-clock switch force** command in global configuration mode.

✎

Note   This command selects the new clock regardless of availability or quality.

✎

Note   Forcing a clock source selection overrides a clock selection using the **network-clock switch manual command.**

Command	Purpose
network-clock switch force external R0 | R1 {{E1 {crc4 | cas |fas}} {T1 {d4 | sf | esf}} } `Router# network-clock switch force r0 e1 crc4`	Forces the router to use a specific synchronous Ethernet clock source, regardless of clock quality or availability.

Command	Purpose
network-clock clear switch {**t0** | **external** *slot/card/port* [**10m** | **2m**]} `Router# network-clock clear switch t0`	Disable a clock source selection.

Disabling Clock Source Specification Commands

To disable a **network-clock switch manual** or **network-clock switch force** configuration and revert to the default clock source selection process, use the **network-clock clear switch** command.

Command	Purpose
network-clock clear switch {**t0** | **external** *slot/card/port* [**10m** | **2m**]} `Router# `**`network-clock clear switch t0`**	Disable a clock source selection.

Disabling a Clock Source

The following sections describe how to manage the synchronous Ethernet clock sources that are available for clock selection:

Locking Out a Clock Source

To prevent the router from selecting a specific synchronous Ethernet clock source, use the network-clock set lockout command in global configuration mode.

Command	Purpose

`network-clock set lockout` `{`**`interface`**
`interface_name slot/card/port` `| `**`external`** `{`**`R0`** `| `**`R1`** `[ {`
`t1` `{`**`sf`** `| `**`esf`** `}` **`linecode`** `{`**`ami`** `| `**`b8zs`**`}} | `**`e1`** `[`**`crc4`**
`| `**`fas`**`]` **`linecode`** `[`**`hdb3`** `| `**`ami`**`]}`
 	
`Router# network-clock set lockout interface GigabitEthernet`
` 0/0/0`
	Prevents the router from selecting a specific synchronous Ethernet clock source.

network-clock clear lockout {**interface** *interface_name slot/card/port* | **external** {**R0** | **R1** [{ **t1** {**sf** | **esf** } **linecode** {**ami** | **b8zs**}} | **e1** [**crc4** | **fas**] **linecode** [**hdb3** | **ami**] }
 	
`Router# network-clock clear lockout interface`
`GigabitEthernet 0/0/0`
	Disable a lockout configuration on a synchronous Ethernet clock source.

Restoring a Clock Source

To restore a clock in a lockout condition to the pool of available clock sources, use the **network-clock clear lockout** command in global configuration mode.

Command	Purpose

network-clock clear lockout {**interface** *interface_name slot/card/port* | **external external** {**R0** | **R1** [{ **t1** {**sf** | **esf** } **linecode** {**ami** | **b8zs**}} | **e1** [**crc4** | **fas**] **linecode** [**hdb3** | **ami**] }
 	
`Router# network-clock clear lockout interface`
`GigabitEthernet 0/0/0`
	Forces the router to use a specific synchronous Ethernet clock source, regardless of clock quality or availability.

Verifying the Configuration

You can use the following commands to verify a clocking configuration:

- **show esmc**—Displays the ESMC configuration.
- **show esmc detail**—Displays the details of the ESMC parameters at the global and interface levels.
- **show network-clock synchronization**—Displays the router clock synchronization state.
- **show network-clock synchronization detail**—Displays the details of network clock synchronization parameters at the global and interface levels.
- **show ptp clock dataset**
- **show ptp port dataset**
- **show ptp clock running**
- **show platform software ptpd statistics**
- **show platform ptp all**
- **show platform ptp tod all**

Troubleshooting

The below table list the debug commands that are available for troubleshooting the SyncE configuration on the Cisco Router:

⚠️

Caution   We recommend that you do not use **debug** commands without TAC supervision.

Table 7: SyncE Debug Commands

Debug Command	Purpose
debug platform network-clock	Debugs issues related to the network clock including active-standby selection, alarms, and OOR messages.
debug network-clock	Debugs issues related to network clock selection.

Debug Command	Purpose
debug esmc error **debug esmc event** debug esmc packet [interface *interface-name*] debug esmc packet rx [interface *interface-name*] debug esmc packet tx [interface *interface-name*]	These commands verify whether the ESMC packets are transmitted and received with proper quality-level values.

The below table provides the information about troubleshooting your configuration

Table 8: Troubleshooting Scenarios

Problem	Solution
Clock selection	• Verify that there are no alarms on the interfaces using the show network-clock synchronization detail command. • Ensure that the nonrevertive configurations are in place. • Reproduce the issue and collect the logs using the debug network-clock errors, debug network-clock event, and debug network-clock sm commands. Contact Cisco Technical Support if the issue persists.
Incorrect QL values	• Ensure that there is no framing mismatch with the SSM option. • Reproduce the issue using the debug network-clock errors and debug network-clock event commands.
Alarms	• Reproduce the issue using the debug platform network-clock command enabled in the RSP. Alternatively, enable the debug network-clock event and debug network-clock errors commands.
Incorrect clock limit set or queue limit disabled mode	• Verify that there are no alarms on the interfaces using the show network-clock synchronization detail command. • Use the **show network-clock synchronization** command to confirm if the system is in revertive mode or nonrevertive mode and verify the non-revertive configurations. • Reproduce the current issue and collect the logs using the debug network-clock errors, debug network-clock event, and debug network-clock sm RSP commands.
Incorrect QL values when you use the **show network-clock synchronization detail** command.	• Use the **network clock synchronization SSM** (*option 1* /*option 2*) command to confirm that there is no framing mismatch. Use the **show run interface** command to validate the framing for a specific interface. For the SSM option 1, framing should be SDH or E1, and for SSM option 2, it should be T1. • Reproduce the issue using the debug network-clock errors and debug network-clock event RSP commands.

CHAPTER 3

Configuring Synchronous Ethernet ESMC and SSM

Table 9: Feature History

Feature Name	Release Information	Feature Description
Synchronous Ethernet ESMC and SSM	Cisco IOS XE Bengaluru 17.4.1	Effective Cisco IOS XE Bengaluru 17.4.1, the Cisco NCS 520 Ethernet Access Device support Synchronization Status Message (SSM) and Ethernet Synchronization Message Channel (ESMC) for synchronous ethernet clock synchronization.

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.

Clock Selection Modes

The Cisco Router supports two clock selection modes, which are described in the following sections.

QL-Enabled Mode

In QL-enabled mode, the router considers the following parameters when selecting a clock source:

- Clock quality level (QL)

- Clock availability

- Priority

QL-Disabled Mode

In QL-disabled mode, the router considers the following parameters when selecting a clock source:

- Clock availability

- Priority

Note   You can use override the default clock selection by using the commands described in *Specifying a Clock Source* and *Disabling a Clock Source* sections.

Managing Clock Selection

You can manage clock selection by changing the priority of the clock sources; you can also influence clock selection by modifying the following clock properties:

- Hold-Off Time: If a clock source goes down, the router waits for a specific hold-off time before removing the clock source from the clock selection process. By default, the value of hold-off time is 300 ms.

- Wait to Restore: The amount of time that the router waits before including a newly active synchronous Ethernet clock source in clock selection. The default value is 300 seconds.

- Force Switch: Forces a switch to a clock source regardless of clock availability or quality.

- Manual Switch: Manually selects a clock source, provided the clock source has a equal or higher quality level than the current source.

For more information about how to use these features, see the *Specifying a Clock Source* and *Disabling a Clock Source* sections.

Restrictions and Usage Guidelines

The following restrictions apply when configuring Synchronous Ethernet SSM and ESMC:

- To use the **network-clock synchronization ssm option** command, ensure that the router configuration does not include the following:

    - Input clock source

    - Network clock quality level

    - Network clock source quality source (Synchronous Ethernet interfaces)

- The **network-clock synchronization ssm option** command must be compatible with the **network-clock eec** command in the configuration.

- To use the **network-clock synchronization ssm option** command, ensure that a network clocking configuration applied to the Sychronous Ethernet interfaces and timing port interfaces.

- It is recommended that you do not configure multiple input sources with the same priority as the TSM (Switching message delay).

- You can configure a maximum of two clock sources on interface modules.

Specifying a Clock Source

The following sections describe how to specify a synchronous Ethernet clock source during the clock selection process:

Selecting a Specific Clock Source

To select a specific interface as a synchronous Ethernet clock source, use the **network-clock switch manual** command in global configuration mode.

Note The new clock source must be of higher quality than the current clock source; otherwise the router does not select the new clock source.

Command	Purpose
network-clock switch manual external R0 Router(config)# network-clock switch manual external r0 crc4	Manually selects a synchronization source, provided the source is available and is within the range.
network-clock clear switch {**t0** | **external** *slot/card/port* [**10m** | **2m**]} Router(config)# network-clock clear switch t0	Disable a clock source selection.

Forcing a Clock Source Selection

To force the router to use a specific synchronous Ethernet clock source, use the **network-clock switch force** command in global configuration mode.

Note This command selects the new clock regardless of availability or quality.

Command	Purpose
network-clock switch force external R0 Router# network-clock switch force r0	Forces the router to use a specific synchronous Ethernet clock source, regardless of clock quality or availability.

Command	Purpose
network-clock clear switch {**t0** | **external** *slot/card/port* [**10m** | **2m**]} Router# network-clock clear switch t0	Disable a clock source selection.

Disabling Clock Source Specification Commands

To disable a **network-clock switch manual** or **network-clock switch force** configuration and revert to the default clock source selection process, use the **network-clock clear switch** command.

Command	Purpose
network-clock clear switch {**t0** | **external** *slot/card/port* [**10m** | **2m**]} Router# **network-clock clear switch t0**	Disable a clock source selection.

Disabling a Clock Source

The following sections describe how to manage the synchronous Ethernet clock sources that are available for clock selection:

Locking Out a Clock Source

To prevent the router from selecting a specific synchronous Ethernet clock source, use the **network-clock set lockout** command in global configuration mode.

Command	Purpose
network-clock set lockout {**interface** *interface_name slot/card/port* | **external R0** Router(config)# network-clock set lockout interface GigabitEthernet 0/0/0	Prevents the router from selecting a specific synchronous Ethernet clock source.
network-clock clear lockout {**interface** *interface_name slot/card/port* | **external R0** Router(config)# network-clock clear lockout interface GigabitEthernet 0/0/0	Disable a lockout configuration on a synchronous Ethernet clock source.

Restoring a Clock Source

To restore a clock in a lockout condition to the pool of available clock sources, use the **network-clock clear lockout** command in global configuration mode.

Command	Purpose
network-clock clear lockout {**interface** *interface_name slot/card/port* | **external external R0** Router(config)# network-clock clear lockout interface GigabitEthernet 0/0/0	Forces the router to use a specific synchronous Ethernet clock source, regardless of clock quality or availability.

Verifying the Configuration

You can use the following commands to verify your configuration:

- show esmc—Displays the ESMC configuration.
- show esmc detail—Displays the details of the ESMC parameters at the global and interface levels.
- show network-clock synchronization—Displays the router clock synchronization state.
- show network-clock synchronization detail—Displays the details of network clock synchronization parameters at the global and interface levels.

Troubleshooting

The table below list the debug commands that are available for troubleshooting the SyncE configuration on the Cisco Router:

⚠️

Caution   We recommend that you do not use debug commands without TAC supervision.

Table 10: SyncE Debug Commands

Debug Command	Purpose
debug platform network-clock	Debugs issues related to the network clock, such as alarms, OOR, active-standby sources not selected correctly, and so on.
debug network-clock	Debugs issues related to network clock selection.

Debug Command	Purpose

`debug esmc error`
 	
`debug esmc event`
 	
`debug esmc packet [interface <interface name>]`
 	
`debug esmc packet rx [interface <interface name>]`
 	
`debug esmc packet tx [interface <interface name>]`
	Verify the ESMC packets are transmitted and received with proper quality-level values.

The table below provides the information about troubleshooting your configuration.

Table 11: Troubleshooting Scenarios

Problem	Solution
Clock selection	• Verify that there are no alarms on the interfaces using the **show network-clock synchronization detail** command. • Ensure that the nonrevertive configurations are in place. • Reproduce the issue and collect the logs using the debug network-clock errors, debug network-clock event, and debug network-clock sm commands. Contact Cisco Technical Support if the issue persists.
Incorrect QL values	• Ensure that there is no framing mismatch with the SSM option. • Reproduce the issue using the **debug network-clock errors** and **debug network-clock event** commands.
Alarms	• Reproduce the issue using the **debug platform network-clock command**. Alternatively, enable the **debug network-clock event** and **debug network-clock errors** commands.
Incorrect clock limit set or queue limit disabled mode	• Verify that there are no alarms on the interfaces using the **show network-clock synchronization detail** command. • Use the **show network-clock synchronization** command to confirm if the system is in revertive mode or nonrevertive mode and verify the non-revertive configurations. • Reproduce the current issue and collect the logs using the **debug network-clock errors, debug network-clock event**, and **debug network-clock sm** commands.

Problem	Solution
Incorrect QL values when you use the **show network-clock synchronization detail** command.	• Use the **network clock synchronization SSM** (*option 1* /*option 2*) command to confirm that there is no framing mismatch. Use the **show run interface** command to validate the framing for a specific interface. For the SSM option 1, framing should be SDH or E1, and for SSM option 2, it should be T1. • Reproduce the issue using the **debug network-clock errors** and **debug network-clock event** commands.

G.8275.1 Telecom Profile

Table 12: Feature History

Feature Name	Release Information	Feature Description
G.8275.1 Telecom Profile	Cisco IOS XE Bengaluru 17.5.1	The Cisco NCS 520 Ethernet Access Devices support **G.8275.1** telecom profile. This profile targets accurate time and phase distribution and requires boundary clocks at every node in the network.

Precision Time Protocol (PTP) is a protocol for distributing precise time and frequency over packet networks. PTP is defined in the IEEE Standard 1588. It defines an exchange of timed messages.

PTP allows for separate profiles to be defined in order to adapt PTP 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.

This recommendation allows for proper network operation for phase and time synchronization distribution when network equipment embedding a telecom boundary clock (T-BC) and a telecom time subordinaate clock (T-TSC) is timed from another T-BC or a telecom grandmaster clock (T-GM). This recommendation addresses only the distribution of phase and time synchronization with the full timing support architecture as defined in ITU-T G.8275.

Why G.8275.1?

The G.8275.1 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.

The G.8275.1 profile is also used in telecom networks where phase or time-of-day synchronization is required and where each network device participates in the PTP protocol.

Because a boundary clock is used at every node in the chain between PTP Grandmaster and PTP Subordinate, there is reduction in time error accumulation through the network.

More About G.8275.1

The G.8275.1 must meet the following requirements:

- Non-participant devices, that is, devices that only forward PTP packets, and PTP transparent clocks are not allowed.

- 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-GM in locked mode must have phase and frequency sources that are traceable to PRTC. T-GM in locked mode must always have QL-PRC/PRS frequency. T-GM can be in holdover when losing phase. In such case, its default clock class is defined based on the available frequency source quality.

- The telecom time subordinate 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.

- 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.

The following figure describes a sample G.8275.1 topology.

Figure 4: A Sample G.8275.1 Topology
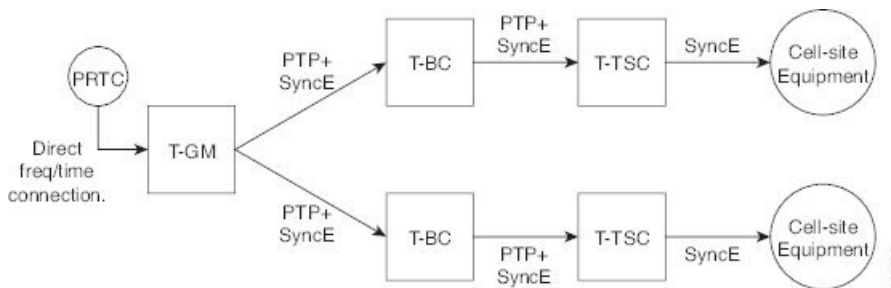
PTP Domain

A PTP domain is a logical grouping of clocks that communicate with each other using the PTP protocol.

A single computer network can have multiple PTP domains operating separately, for example, one set of clocks synchronized to one time scale and another set of clocks synchronized to another time scale. PTP can run over either Ethernet or IP, so a domain can correspond to a local area network or it can extend across a wide area network.

The allowed domain numbers of PTP domains within a G.8275.1 network are between 24 and 43 (both inclusive).

PTP Messages and Transport

The following PTP transport parameters are defined:

- For transmitting PTP packets, either the forwardable multicast MAC address (01-1B-19-00-00-00) or the non-forwardable multicast MAC address (01-80-C2-00-00-0E) must be used as the destination MAC address. The MAC address in use is selected on a per-port basis through the configuration. However, the non-forwardable multicast MAC address (01-80-C2-00-00-0E) will be used if no destination MAC is configured.

The source MAC address is the interface MAC address.

- For receiving PTP packets, both multicast MAC addresses (01-80-C2-00-00-0E and 01-1B-19-00-00-00) are supported.
- The packet rate for Announce messages is 8 packets-per-second. For Sync, Delay-Req, and Delay-Resp messages, the rate is 16 packets-per-second.
- Signaling and management messages are not used.

PTP Modes

Two-Way Operation

To transport phase and time synchronization and to measure propagation delay, PTP operation must be two-way in this profile. Therefore, only two-way operation is allowed in this profile.

One-Step and Two-Step Clock Mode

Both one-step and two-step clock modes are supported in the G.8275.1 profile.

A client port must be capable of receiving and processing messages from both one-step clocks and two-step clocks, without any particular configuration. However, the server clock supports only one-step mode.

PTP Clocks

Two types of ordinary clocks and boundary clocks are used in this profile:
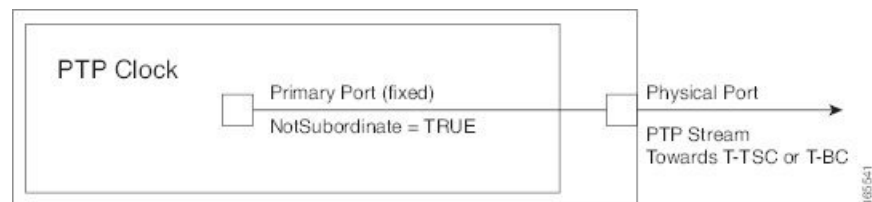
Ordinary Clock (OC)

- OC that can only be a grandmaster clock (T-GM). In this case, one PTP port will be used as a server port.

The T-GM uses the frequency, 1PPS, and ToD input from an upstream grandmaster clock.

Note The T-GM server port is a fixed server port.

Figure 5: Ordinary Clock As T-GM

- OC that can only be a subordinate/client clock (T-TSC). In this case, only one PTP port is used for T-TSC, which in turn will have only one PTP server associated with it.

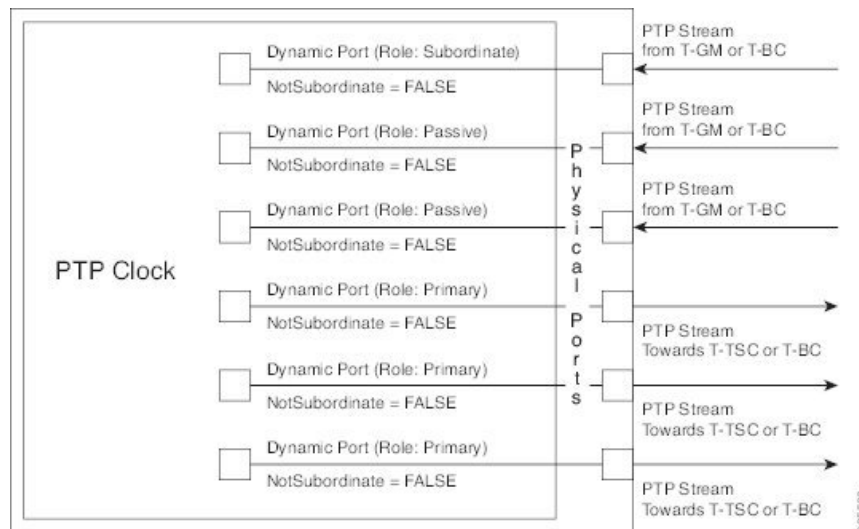*Figure 6: Ordinary Clock As Subordinate/Client Clock (T-TSC)*
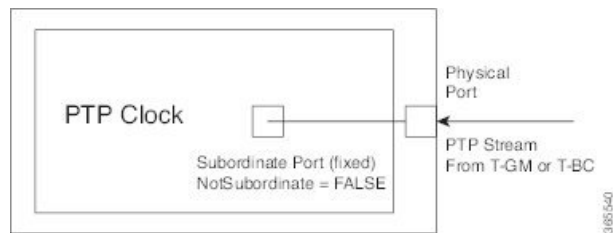
Boundary Clock (T-BC)

1. T-BC that can only be a grandmaster clock (T-GM).

2. T-BC that can become a server clock and can also be a client clock to another PTP clock.

If the BMCA selects a port on the T-BC to be a client port, all other ports are moved into the server role or a passive state.

Figure 7: Boundary Clock

PTP Ports

A port can be configured to perform either fixed Server or Client role or can be configured to change its role dynamically. If no role is assigned to a port, it can dynamically assume a server, passive, or client role based on the BMCA.

A server port provides the clock to its downstream peers.

A client port receives clock from an upstream peer.

A dynamic port can work either as a server or a client based on the BMCA decision.

In Cisco's implementation of the G.8275.1:

- OC clocks can support only fixed Server or Client port.

- One PTP port can communicate with only one PTP peer.

• BC can have a maximum of 64 ports. Fixed client ports are not supported on the BC.

PTP Asymmetry Readjustment

Each PTP node can introduce delay asymmetry that affects the adequate time and phase accuracy over the networks. Asymmetry in a network occurs when one-way-delay of forward path (also referred as forward path delay or ingress delay) and reverse path (referred as reverse path delay or egress delay) is different. The magnitude of asymmetry can be either positive or negative depending on the difference of the forward and reverse path delays.

Effective Cisco IOS XE Gibraltar 16.10.1, PTP asymmetry readjustment can be performed on each PTP node to compensate for the delay in the network.

Virtual Port Support on T-BC

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

Alternate BMCA

The BMCA implementation in G.8275.1 is different from that in the default PTP profile. The G.8275.1 implementation is called the Alternate BMCA. Each device uses the alternate BMCA to select a clock to synchronize to, and to decide the port states of its local ports.

Benefits

With upcoming technologies like LTE-TDD, LTE-A CoMP, LTE-MBSFN and Location-based services, eNodeBs (base station devices) are required to be accurately synchronized in phase and time. Having GNSS systems at each node is not only expensive, but also introduces vulnerabilities. The G.8275.1 profile meets the synchronization requirements of these new technologies.

Prerequisites for Using the G.8275.1 Profile

• PTP over Multicast Ethernet must be used.

• Every node in the network must be PTP aware.

• It is mandatory to have a stable physical layer frequency whilst using PTP to define the phase.

• Multiple active grandmasters are recommended for redundancy.

Restrictions for Using the G.8275.1 Profile

• PTP Transparent clocks are not permitted in this profile.

• Changing PTP profile under an existing clock configuration is not allowed. Different ports under the same clock cannot have different profiles. You must remove clock configuration before changing the PTP profile. Only removing all the ports under a clock is not sufficient.

• One PTP port is associated with only one physical port in this profile.

• There is no support for BDI and VLAN.

• Signaling and management messages are not used.

• PTP message rates are not configurable.

• Non-hybrid T-TSC and T-BC clock configurations are not supported.

• Virtual port is not supported on the Cisco NCS 520 Ethernet Access Device.

Configuring the G.8275.1 Profile

Note   To know more about the commands referenced in this module, see the Cisco IOS Interface and Hardware Component Command Reference or the Cisco IOS Master Command List.

Configuring Physical Frequency Source

For more information, see the Configuring Synchronous Ethernet ESMC and SSM section in the Clocking and Timing chapter of this book.

Creating a Server-Only Ordinary Clock

```
ptp clock ordinary domain 24
local-priority 1
priority2 128
clock-port server-port-1
master profile g8275.1
local-priority 1
transport ethernet multicast interface Gig 0/0/1
clock-port server-port-2
master profile g8275.1
```

Note   It is mandatory that when electrical ToD is used, the **utc-offset** command is configured before configuring the **tod R0**, otherwise there will be a time difference of approximately 37 seconds between the server and client clocks.

The following example shows that the utc-offset is configured before configuring the ToD to avoid a delay of 37 seconds between the server and client clocks:

```
ptp clock ordinary domain 0
 utc-offset 37
tod R0 cisco
input 1pps R0
clock-port server-port master
  transport ipv4 unicast interface Loopback0 negotiation
```

Associated Commands

• ptp clock

Creating an Ordinary Client

```
ptp clock ordinary domain 24
hybrid
clock-port slave-port
slave profile g8275.1
transport ethernet multicast interface Gig 0/0/0
delay-asymmetry 1000
```

Creating Dynamic Ports

✎

Note   Dynamic ports can be created when you do not specify whether a port is Server or Client. In such cases, the BMCA dynamically choses the role of the port.

```
ptp clock boundary domain 24 hybrid
time-properties persist 600
utc-offset 45 leap-second "01-01-2017 00:00:00" offset 1
clock-port bc-port-1 profile g8275.1local-priority 1
transport ethernet multicast interface Gig 0/0/0
delay-asymmetry 500
clock-port bc-port-2 profile g8275.1 local-priority 2
transport ethernet multicast interface Gig 0/0/1
delay-asymmetry -800
```

Verifying the Local Priority of the PTP Clock

```
Router# show ptp clock dataset default
CLOCK [Boundary Clock, domain 24]
  Two Step Flag: No
  Clock Identity: 0x2A:0:0:0:58:67:F3:4
  Number Of Ports: 1
  Priority1: 128
  Priority2: 90
  Local Priority: 200
  Domain Number: 24
  Slave Only: No
  Clock Quality:
    Class: 224
    Accuracy: Unknown
    Offset (log variance): 4252
```

Verifying the Port Parameters

```
Router# show ptp port dataset port
PORT [SERVER]
  Clock Identity: 0x49:BD:D1:0:0:0:0:0
```

```
Port Number: 0
Port State: Unknown
Min Delay Req Interval (log base 2): 42
Peer Mean Path Delay: 648518346341351424
Announce interval (log base 2): 0
Announce Receipt Timeout: 2
Sync Interval (log base 2): 0
Delay Mechanism: End to End
Peer Delay Request Interval (log base 2): 0
PTP version: 2
Local Priority: 1
Not-slave: True
```

Verifying the Foreign Master Information

```
Router# show platform software ptp foreign-master domain 24
PTPd Foreign Master Information:

Current Master: SLA

Port: SLA
  Clock Identity: 0x74:A2:E6:FF:FE:5D:CE:3F
  Clock Stream Id: 0
  Priority1: 128
  Priority2: 128
  Local Priority: 128
  Clock Quality:
    Class: 6
    Accuracy: Within 100ns
    Offset (Log Variance): 0x4E5D
  Steps Removed: 1
  Not-Slave: FALSE
```

# Verifying Current PTP Time

```
Router# show platform software ptpd tod
PTPd ToD information:

Time: 01/05/70 06:40:59
```

G.8275.1 Deployment Scenario

The following example illustrates a possible configuration for a G.8275.1 network with two server clocks, a boundary clock and a client. Let's assume that server A is the main server and B is the backup server.

Figure 8: Topology for a Configuration Example
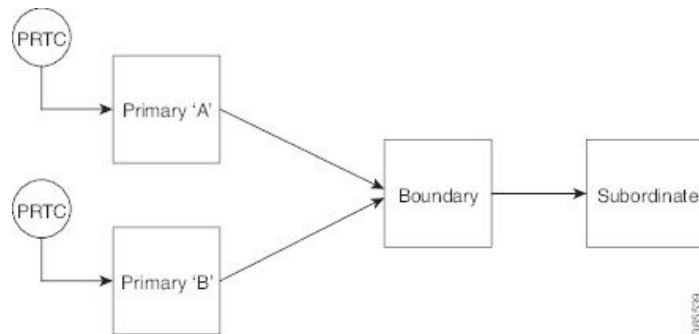
The configuration on server clock A is:

```
ptp clock ordinary domain 24
  clock-port server-port profile g8275.1
    transport ethernet multicast interface GigabitEthernet 0/0/0
```

The configuration on server clock B is:

```
ptp clock ordinary domain 25
  clock-port server-port profile g8275.1
```

transport ethernet multicast interface GigabitEthernet 0/1/0

The configuration on the boundary clock is:

```
ptp clock boundary domain 24 hybrid
  local-priority 3
  clock-port client-port-a profile g8275.1 local-priority 1
    transport ethernet multicast interface Gig 0/0/1
  clock-port client-port-b profile g8275.1 local-priority 2
    transport ethernet multicast interface Gig 0/1/1
  clock-port server-port profile g8275.1
    transport Ethernet multicast interface Gig 0/2/1
```

The configuration on the client clock is:

```
ptp clock ordinary domain 24 hybrid
  clock-port client-port slave profile g8275.1
    transport Ethernet multicast interface Gig 0/0/0
```

Feature Information for G.8275.1

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn . An account on Cisco.com is not required.

> **Note** Table 13: Feature Information for G.8275.1 , on page 52 lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 13: Feature Information for G.8275.1

Feature Name	Releases	Feature Information

G.8275.1	Cisco IOS XE Bengaluru 17.5.1	This PTP telecom profile introduces phase and time synchronization with full timing support from the network.
		
		The following commands were introduced
		
		   • **local-priority**
		
		The following commands were modified:
		
		   • **clock-port**
		   • **show ptp clock dataset default**
		   • **show ptp port dataset port**
		
		The following command is deprecated for the G.8275.1 profile clocks:
		
		   • **show ptp port running**
		
		The alternate command is **show platform software ptp foreign-master [domain-number].**
		
		Note This command is applicable only for the G.8275.1 profile clocks.