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 Ethernet 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

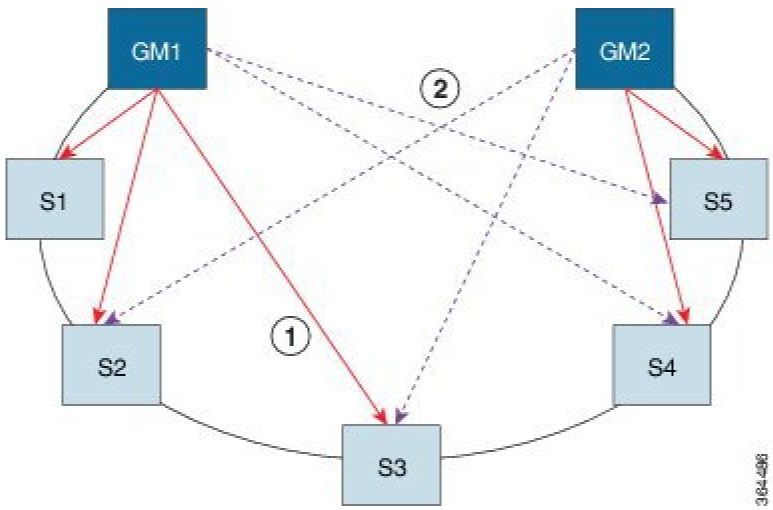


Table 4: PTP Ring Topology—No On-Path Support

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

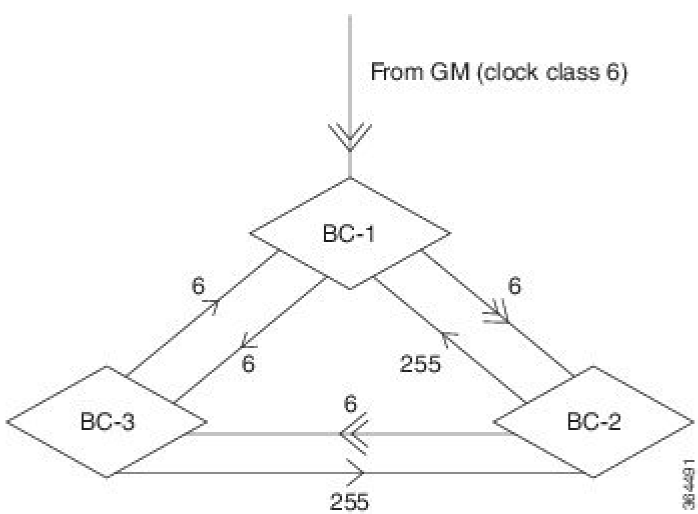
PTP Ring topology is designed by using Hop-By-Hop configuration of PTP boundary clocks. In this topology, each BC selects its adjacent nodes as PTP server clocks, instead of using the same GM as the PTP server clock. These PTP BC server clocks are traceable to the GM in the network. Timing loop are not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

Prerequisites

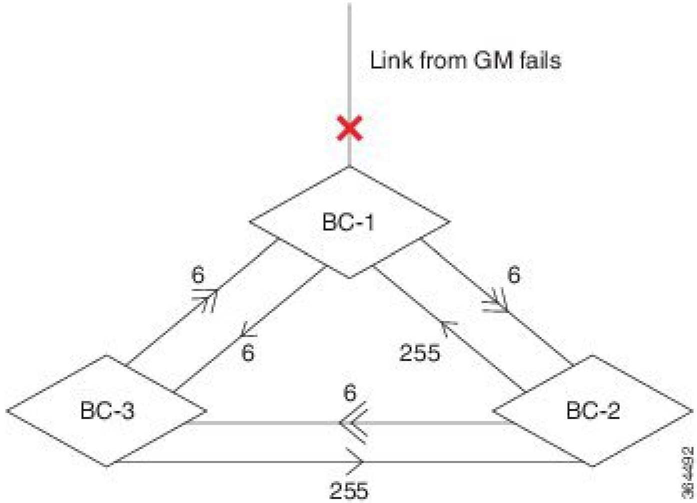
- PTP boundary clock configuration is required on all clock nodes in the ring, except the server clock nodes (GM), which provide the clock timing to ring. In the above example nodes S1—S5 must be configured as BC.
- The server clock (GM1 and GM2 in the above figure) nodes in the ring can be either a 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.



On-Path Support Topology Scenario

Consider the topology as shown in the figure:

Figure 2: PTP Ring Topology—On-Path Support

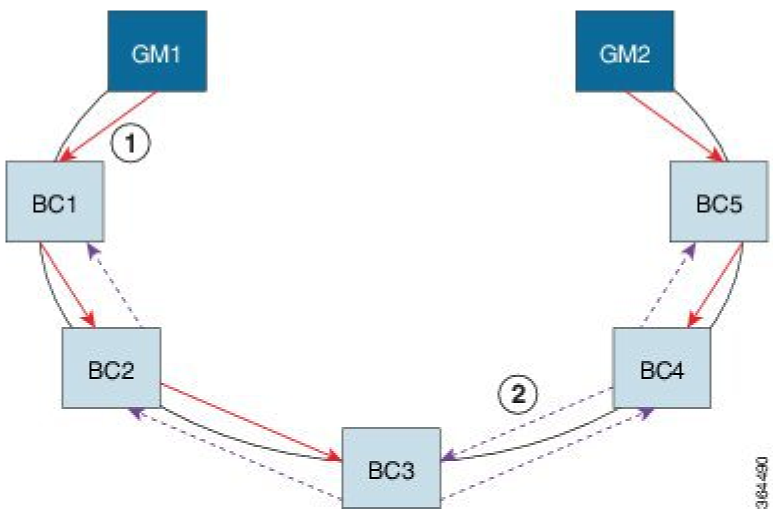


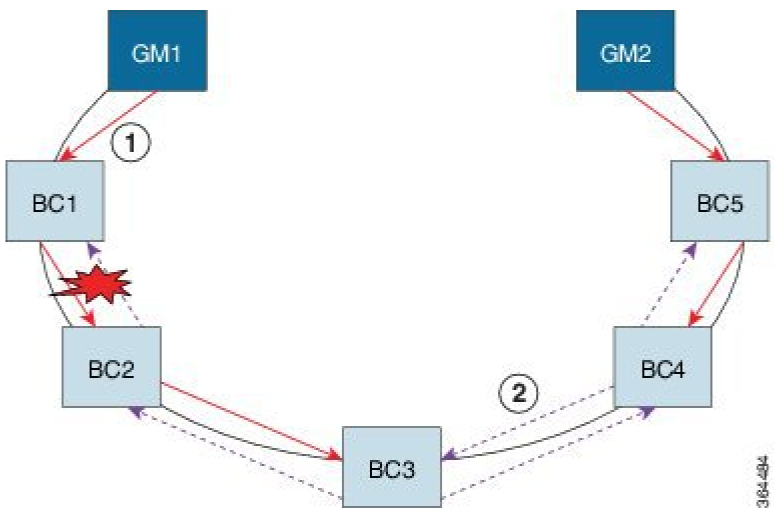
Table 5: PTP Ring Topology—On-Path Support

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)



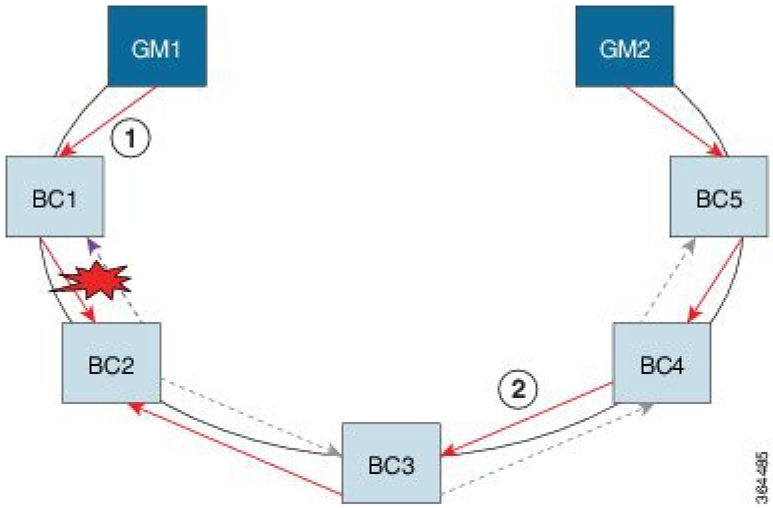


Table 6: PTP Ring Topology—On-Path Support (Failure)

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 11 and Configuring a Client Ordinary Clock, on page 16.

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 24.

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 28 and Disabling a Clock Source, on page 29 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 28 and Disabling a Clock Source, on page 29 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 11. 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 16.

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.