System Management Configuration Guide for Cisco ASR 9000 Series Routers, IOS XR Release 25.1.x , 25.2.x , 25.3.x , 25.4.x

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Preface

From Release 6.1.2 onwards, Cisco introduces support for the 64-bit Linux-based IOS XR operating system. Extensive feature parity is maintained between the 32-bit and 64-bit environments. Unless explicitly marked otherwise, the contents of this document are applicable for both the environments. For more details on Cisco IOS XR 64 bit, refer to the Release Notes for Cisco ASR 9000 Series Routers, Release 6.1.2 document.

This guide describes the System Management configuration details for Cisco IOS XR software. This chapter contains details on the changes made to this document.

- Changes to This Document, on page iii
- Communications, Services, and Additional Information, on page iii

Changes to This Document

This table lists the changes made to this document since it was first released.

Table 1: Changes to This Document

Date	Summary
September 2025	Republished for Release 25.3.1
June 2025	Republished for Release 25.2.1
March 2025	Initial release of this document

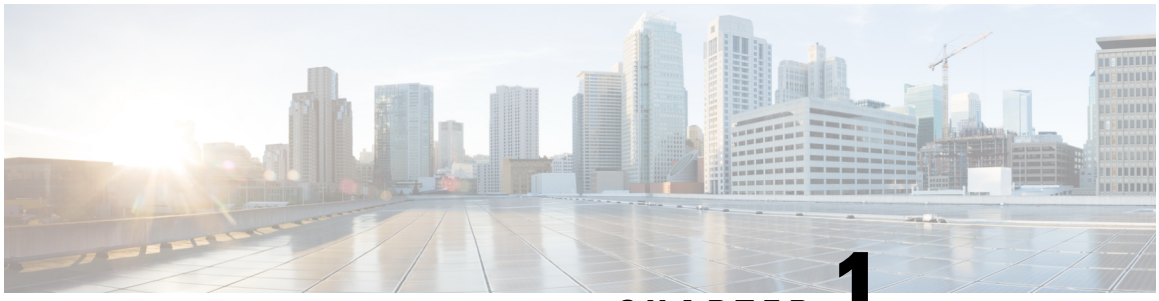
Communications, Services, and Additional Information

- To receive timely, relevant information from Cisco, sign up at Cisco Profile Manager.
- To get the business results you're looking for with the technologies that matter, visit Cisco Services.
- To submit a service request, visit Cisco Support.
- To discover and browse secure, validated enterprise-class apps, products, solutions and services, visit Cisco DevNet.
- To obtain general networking, training, and certification titles, visit Cisco Press.

- To find warranty information for a specific product or product family, access Cisco Warranty Finder.

Cisco Bug Search Tool

Cisco Bug Search Tool (BST) is a web-based tool that acts as a gateway to the Cisco bug tracking system that maintains a comprehensive list of defects and vulnerabilities in Cisco products and software. BST provides you with detailed defect information about your products and software.



CHAPTER 1

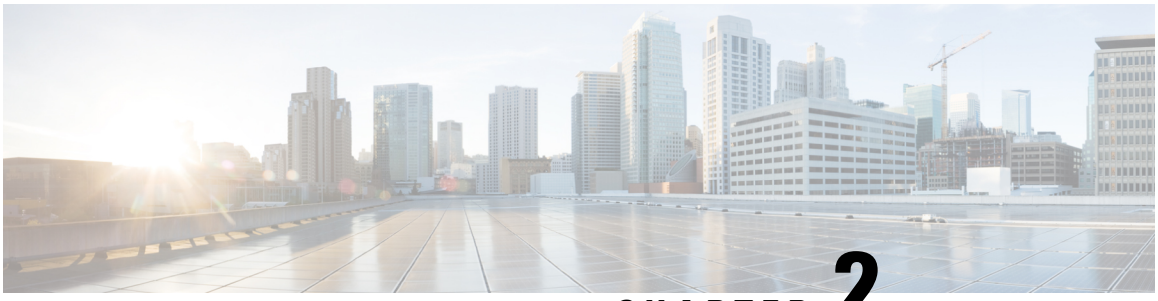
New and Changed System Management Features

This chapter lists all the features that have been added or modified in this guide. The table also contains references to these feature documentation sections.

- System Management Features Added or Modified in IOS XR Release 25.x.x, on page 1

System Management Features Added or Modified in IOS XR Release 25.x.x

Feature	Description	Changed in Release	Where Documented
None	No new features introduced	Not applicable	Not applicable



CHAPTER 2

YANG Data Models for System Management Features

This chapter provides information about the YANG data models for System Management features.

- Using YANG Data Models, on page 3

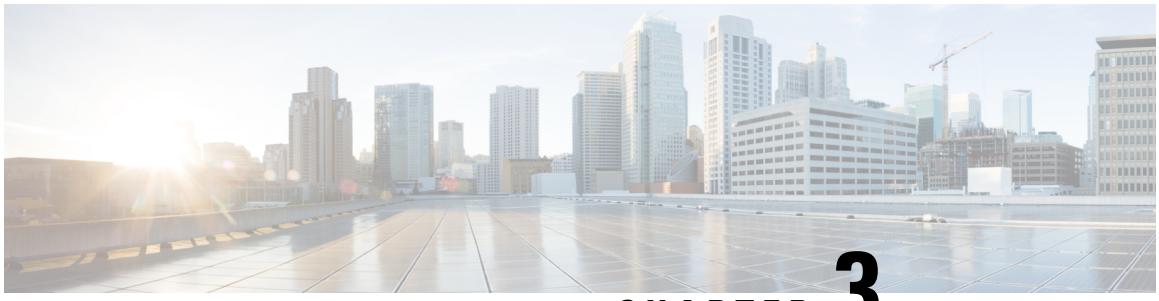
Using YANG Data Models

Cisco IOS XR supports a programmatic way of configuring and collecting operational data of a network device using YANG data models. Although configurations using CLIs are easier and human-readable, automating the configuration using model-driven programmability results in scalability.

The data models are available in the release image, and are also published in the Github repository. Navigate to the release folder of interest to view the list of supported data models and their definitions. Each data model defines a complete and cohesive model, or augments an existing data model with additional XPaths. To view a comprehensive list of the data models supported in a release, navigate to the **Available-Content.md** file in the repository.

You can also view the data model definitions using the YANG Data Models Navigator tool. This GUI-based and easy-to-use tool helps you explore the nuances of the data model and view the dependencies between various containers in the model. You can view the list of models supported across Cisco IOS XR releases and platforms, locate a specific model, view the containers and their respective lists, leaves, and leaf lists presented visually in a tree structure. This visual tree form helps you get insights into nodes that can help you automate your network.

To get started with using the data models, see the *Programmability Configuration Guide*.



CHAPTER 3

Configuring Network Time Protocol

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

This module describes the tasks you need to implement NTP on the Cisco IOS XR software.

For more information about NTP on the Cisco IOS XR software and complete descriptions of the NTP commands listed in this module, see Related Documents, on page 31. To locate documentation for other commands that might appear in the course of running a configuration task, search online in *Cisco ASR 9000 Series Aggregation Services Router Commands Master List*.

Table 2: Feature History for Implementing NTP on Cisco IOS XR Software

Release	Modification
Release 3.7.2	This feature was introduced.
Release 3.9.0	Support was added for IPv6 addresses, VRFs, multicast-based associations, and burst and iburst modes for poll-based associations.
Release 4.3.0	Support was added for NTP-PTP interworking.
Release 4.3.1	Support was added for NTP server inside VRF interface

This module contains the following topics:

- Prerequisites for Implementing NTP on Cisco IOS XR Software, on page 6
- Information About Implementing NTP, on page 6
- How to Implement NTP, on page 8
- Configuration Examples for Implementing NTP, on page 25
- FQDN for NTP Server, on page 28
- Configuring NTP server inside VRF interface, on page 30
- Additional References, on page 31

Prerequisites for Implementing NTP on Cisco IOS XR Software

You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

Information About Implementing NTP

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

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

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

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

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

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

Several manufacturers include NTP software for their host systems, and a publicly available version for systems running UNIX and its various derivatives is also available. This software also allows UNIX-derivative servers to acquire the time directly from an atomic clock, which would subsequently propagate time information along to Cisco routers.

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

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

- By polling host servers
- By listening to NTP broadcasts

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

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

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

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

Note NTP associations will not be formed if the packets received are from a VRF which is different from the VRF that is configured for the NTP server or peer.

Preventing Issues due to GPS Week Number Rollover (WNRO)

- If there are no GPS sources in the NTP source chain or server chain, there is no impact of GPS Week Number Rollover (WNRO).
- GPS WNRO affects only the system clock and not user traffic.
- Contact your GPS manufacturer to fix the GPS source for this condition.

To mitigate impact of GPS sources that are subject to GPS WNRO perform the following optional workarounds:

- If the GPS source has been identified to be a cause of potential disruption on April 6, 2019 (or after), configure ntp master in the Cisco that is device connected to this source, and its clock on the Stratum 1 device to preventively isolate it. This configuration enables the device to present its own clock for synchronization to downstream NTP clients.

Note The usage of ntp master command as mentioned above is only a workaround to this condition. Use this command until the GPS source-related conditions are resolved, and to prevent the distribution of incorrect clock values throughout the network.

- Configure multiple NTP servers (ideally 4, but more than 3) at Stratum 2 level of the network, to enable NTP clients at Stratum 2 level to get clock from more than one Stratum 1 server. This way, WNRO affected Stratum 1 servers are staged to be marked as ‘false ticker’ or ‘outlier’ clock sources as compared to other non-WNRO affected Stratum 1 servers.

NTP-PTP Interworking

NTP-PTP interworking provides the ability to use PTP, as well as other valid time of day (TOD) sources such as Data over Cable Service Interface Specification (DOCSIS) Timing Interface (DTI) and global positioning

system (GPS), as the time source for the operating system. Prior to the support of NTP-PTP interworking, only backplane time was supported for the operating system time.

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

Related Topics

Configuring NTP-PTP Interworking, on page 21

How to Implement NTP

Configuring Poll-Based Associations

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

You can configure the following types of poll-based associations between the router and other devices (which may also be routers):

- Client mode
- Symmetric active mode

The client and the symmetric active modes should be used when NTP is required to provide a high level of time accuracy and reliability.

When a networking device is operating in the client mode, it polls its assigned time serving hosts for the current time. The networking device then picks a host from all the polled time servers to synchronize with. Because the relationship that is established in this case is a client-host relationship, the host does not capture or use any time information sent by the local client device. This mode is most suited for file-server and workstation clients that are not required to provide any form of time synchronization to other local clients. Use the **server** command to individually specify the time-serving hosts that you want your networking device to consider synchronizing with and to set your networking device to operate in the client mode.

When a networking device is operating in the symmetric active mode, it polls its assigned time-serving hosts for the current time and it responds to polls by its hosts. Because this is a peer-to-peer relationship, the host also retains time-related information about the local networking device that it is communicating with. This mode should be used when there are several mutually redundant servers that are interconnected via diverse network paths. Most stratum 1 and stratum 2 servers on the Internet today adopt this form of network setup. Use the **peer** command to individually specify the time-serving hosts that you want your networking device to consider synchronizing with and to set your networking device to operate in the symmetric active mode.

When the router polls several other devices for the time, the router selects one device with which to synchronize.

Note To configure a peer-to-peer association between the router and another device, you must also configure the router as a peer on the other device.

You can configure multiple peers and servers, but you cannot configure a single IP address as both a peer and a server at the same time.

To change the configuration of a specific IP address from peer to server or from server to peer, use the **no** form of the **peer** or **server** command to remove the current configuration before you perform the new configuration. If you do not remove the old configuration before performing the new configuration, the new configuration does not overwrite the old configuration.

SUMMARY STEPS

1. **configure**
2. **ntp**
3. **server** *ip-address* [**version** *number*] [**key** *key-id*] [**minpoll** *interval*] [**maxpoll** *interval*] [**source** *type interface-path-id*] [**prefer**] [**burst**] [**iburst**]
4. **peer** *ip-address* [**version** *number*] [**key** *key-id*] [**minpoll** *interval*] [**maxpoll** *interval*] [**source** *type interface-path-id*] [**prefer**]
5. Use one of the following commands:
   - **end**
   - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ntp** **Example:** `RP/0/RSP0/CPU0:router(config)# ntp`	Enters NTP configuration mode.

Step 3	**server** *ip-address* [**version** *number*] [**key** *key-id*] [**minpoll** *interval*] [**maxpoll** *interval*] [**source** *type interface-path-id*] [**prefer**] [**burst**] [**iburst**]
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# server 172.16.22.44`
	`  minpoll 8 maxpoll 12`
		Forms a server association with another system. This step can be repeated as necessary to form associations with multiple devices.

	Command or Action	Purpose

Step 4	**peer** *ip-address* [**version** *number*] [**key** *key-id*] [**minpoll** *interval*] [**maxpoll** *interval*] [**source** *type interface-path-id*] [**prefer**]
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# peer 192.168.22.33`
	`  minpoll 8 maxpoll 12 source tengige 0/0/0/1`
		Forms a peer association with another system. This step can be repeated as necessary to form associations with multiple systems.
		Note To complete the configuration of a peer-to-peer association between the router and the remote device, the router must also be configured as a peer on the remote device.

Step 5	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# end`
	or
	`RP/0/RSP0/CPU0:router(config-ntp)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		  • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		  • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		  • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Broadcast-Based NTP Associates

In a broadcast-based NTP association, an NTP server propagates NTP broadcast packets throughout a network. Broadcast clients listen for the NTP broadcast packets propagated by the NTP server and do not engage in any polling.

Broadcast-based NTP associations should be used when time accuracy and reliability requirements are modest and if your network is localized and has a large number of clients (more than 20). Broadcast-based NTP associations also are recommended for use on networks that have limited bandwidth, system memory, or CPU resources. Time accuracy is marginally reduced in broadcast-based NTP associations because information flows only one way.

Use the **broadcast client** command to set your networking device to listen for NTP broadcast packets propagated through a network. For broadcast client mode to work, the broadcast server and its clients must be located on the same subnet. The time server that is transmitting NTP broadcast packets must be enabled on the interface of the given device using the **broadcast** command.

Use the **broadcast** command to set your networking device to send NTP broadcast packets.

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

Note If you enable NTP broadcast on the physical interface, subinterface or bundle interface, then it breaks the inter-VRF Poll-Based association between client and server. As these interfaces also handle NTP unicast traffic, the interface designated as broadcast, rejects service unicast clients on it. So, NTP broadcast and NTP unicast are not allowed on the same interface.

SUMMARY STEPS

1. **configure**
2. **ntp**
3. (Optional) **broadcastdelay** *microseconds*
4. **interface** *type interface-path-id*
5. **broadcast client**
6. **broadcast** [**destination** *ip-address*] [**key** *key-id*] [**version** *number*]
7. Use one of the following commands:
   - **end**
   - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ntp** **Example:** `RP/0/RSP0/CPU0:router(config)# ntp`	Enters NTP configuration mode.
Step 3	(Optional) **broadcastdelay** *microseconds* **Example:** `RP/0/RSP0/CPU0:router(config-ntp)# broadcastdelay 5000`	Adjusts the estimated round-trip delay for NTP broadcasts.

	Command or Action	Purpose
Step 4	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-ntp)# interface POS 0/1/0/0`	Enters NTP interface configuration mode.
Step 5	**broadcast client** **Example:** `RP/0/RSP0/CPU0:router(config-ntp-int)# broadcast client`	Configures the specified interface to receive NTP broadcast packets. **Note** Go to next step to configure the interface to send NTP broadcast packets.
Step 6	**broadcast** [**destination** *ip-address*] [**key** *key-id*] [**version** *number*] **Example:** `RP/0/RSP0/CPU0:router(config-ntp-int)# broadcast destination 10.50.32.149`	Configures the specified interface to send NTP broadcast packets. **Note** Go to previous step to configure the interface to receive NTP broadcast packets.

Step 7	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp-int)# end`
	or
	`RP/0/RSP0/CPU0:router(config-ntp-int)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring NTP Access Groups

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

The access list-based restriction scheme allows you to grant or deny certain access privileges to an entire network, a subnet within a network, or a host within a subnet.

The access group options are scanned in the following order, from least restrictive to most restrictive:

1. **peer**—Allows time requests and NTP control queries and allows the system to synchronize itself to a system whose address passes the access list criteria.
2. **serve**—Allows time requests and NTP control queries, but does not allow the system to synchronize itself to a system whose address passes the access list criteria.
3. **serve-only**—Allows only time requests from a system whose address passes the access list criteria.
4. **query-only**—Allows only NTP control queries from a system whose address passes the access list criteria.

If the source IP address matches the access lists for more than one access type, the first type is granted. If no access groups are specified, all access types are granted to all systems. If any access groups are specified, only the specified access types are granted.

For details on NTP control queries, see RFC 1305 (NTP version 3).

SUMMARY STEPS

1. **configure**
2. **ntp**
3. **access-group** {**peer** | **query-only** | **serve** | **serve-only**} *access-list-name*
4. Use one of the following commands:
   - **end**
   - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ntp** **Example:** `RP/0/RSP0/CPU0:router(config)# ntp`	Enters NTP configuration mode.

	Command or Action	Purpose
Step 3	**access-group**{**peer** | **query-only** | **serve** | **serve-only**} *access-list-name* **Example:** `RP/0/RSP0/CPU0:router(config-ntp)# access-group peer access1`	Creates an access group and applies a basic IPv4 or IPv6 access list to it.

Step 4	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# end`
	or
	`RP/0/RSP0/CPU0:router(config-ntp)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring NTP Authentication

This task explains how to configure NTP authentication.

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

The encrypted NTP authentication scheme should be used when a reliable form of access control is required. Unlike the access-list-based restriction scheme that is based on IP addresses, the encrypted authentication scheme uses authentication keys and an authentication process to determine if NTP synchronization packets sent by designated peers or servers on a local network are deemed as trusted, before the time information that it carries along is accepted.

The authentication process begins from the moment an NTP packet is created. A message authentication code (MAC) is computed using the MD5 Message Digest Algorithm and the MAC is embedded into an NTP synchronization packet. The NTP synchronization packet together with the embedded MAC and key number are transmitted to the receiving client. If authentication is enabled and the key is trusted, the receiving client

computes the MAC in the same way. If the computed MAC matches the embedded MAC, the system is allowed to sync to the server that uses this key in its packets.

After NTP authentication is properly configured, your networking device only synchronizes with and provides synchronization to trusted time sources.

SUMMARY STEPS

1. **configure**
2. **ntp**
3. **authenticate**
4. **authentication-key** *key-number* **md5** [**clear** | **encrypted**] *key-name*
5. **trusted-key** *key-number*
6. Use one of the following commands:
   - **end**
   - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ntp** **Example:** `RP/0/RSP0/CPU0:router(config)# ntp`	Enters NTP configuration mode.
Step 3	**authenticate** **Example:** `RP/0/RSP0/CPU0:router(config-ntp)# authenticate`	Enables the NTP authentication feature.

Step 4	**authentication-key** *key-number* **md5** [**clear** | **encrypted**] *key-name*
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# authentication-key 42 md5 clear key1`
		Defines the authentication keys.
		• Each key has a key number, a type, a value, and, optionally, a name. Starting from Cisco IOS-XR Release 7.5.1 the following authentication types are supported:
		  • cmac CMAC authentication
		  • md5 MD5 authentication
		  • sha1 SHA1 authentication

	Command or Action	Purpose
		• sha2 SHA2 authentication
Step 5	**trusted-key** *key-number* **Example:** `RP/0/RSP0/CPU0:router(config-ntp)# trusted-key 42`	`Defines trusted authentication keys.` • If a key is trusted, this router only synchronizes to a system that uses this key in its NTP packets.

Step 6	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# end`
	or
	`RP/0/RSP0/CPU0:router(config-ntp)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Disabling NTP Services on a Specific Interface

NTP services are disabled on all interfaces by default.

NTP is enabled globally when any NTP commands are entered. You can selectively prevent NTP packets from being received through a specific interface by turning off NTP on a given interface.

SUMMARY STEPS

1. **configure**
2. **ntp**
3. Use one of the following commands:
   - **no interface** *type interface-path-id*
   - **interface** *type interface-path-id* **disable**
4. Use one of the following commands:

- **end**
- **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ntp** **Example:** `RP/0/RSP0/CPU0:router(config)# ntp`	Enters NTP configuration mode.

Step 3	Use one of the following commands:
	• **no interface** *type interface-path-id*
	• **interface** *type interface-path-id* **disable**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# no interface pos 0/0/0/1`
	or
	`RP/0/RSP0/CPU0:router(config-ntp)# interface POS 0/0/0/1 disable`
		Disables NTP services on the specified interface.

Step 4	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# end`
	or
	`RP/0/RSP0/CPU0:router(config-ntp)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

	Command or Action	Purpose
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring the Source IP Address for NTP Packets

By default, the source IP address of an NTP packet sent by the router is the address of the interface through which the NTP packet is sent. Use this procedure to set a different source address.

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

SUMMARY STEPS

1. **configure**
2. **ntp**
3. **source** *type interface-path-id*
4. Use one of the following commands:
   - **end**
   - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ntp** **Example:** `RP/0/RSP0/CPU0:router(config)# ntp`	Enters NTP configuration mode.
Step 3	**source** *type interface-path-id* **Example:**	Configures an interface from which the IP source address is taken. **Note**

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-ntp)# source POS 0/0/0/1`	This interface is used for the source address for all packets sent to all destinations. If a source address is to be used for a specific association, use the **source** keyword in the **peer** or **server** command shown in Configuring Poll-Based Associations, on page 8.

Step 4	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# end`
	or
	`RP/0/RSP0/CPU0:router(config-ntp)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring the System as an Authoritative NTP Server

You can configure the router to act as an authoritative NTP server, even if the system is not synchronized to an outside time source.

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

SUMMARY STEPS

1. **configure**
2. **ntp**
3. **master** *stratum*
4. Use one of the following commands:
   - **end**
   - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ntp** **Example:** `RP/0/RSP0/CPU0:router(config)# ntp`	Enters NTP configuration mode.
Step 3	**master** *stratum* **Example:** `RP/0/RSP0/CPU0:router(config-ntp)# master 9`	`Makes the router an authoritative NTP server.` **Note** Use the **master** command with caution. It is very easy to override valid time sources using this command, especially if a low stratum number is configured. Configuring multiple machines in the same network with the **master** command can cause instability in time keeping if the machines do not agree on the time.

Step 4	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# end`
	or
	`RP/0/RSP0/CPU0:router(config-ntp)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		  • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		  • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		  • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring NTP-PTP Interworking

Use this task to configure NTP to use PTP as the time source.

Before you begin

PTP must be supported and enabled on the router before NTP-PTP interworking can be configured. If PTP is not enabled, you receive an error message similar to the following when you try to commit the configuration:

```
RP/0/RSP0/CPU0:router(config)# ntp master primary-reference-clock
RP/0/RSP0/CPU0:router(config)# commit

% Failed to commit one or more configuration items. Please issue
'show configuration failed' from this session to view the errors

RP/0/RSP0/CPU0:router(config)# show configuration failed
[:::]
ntp
 master primary-reference-clock
!!% 'ip-ntp' detected the 'fatal' condition 'PTP is not supported on this platform'
!
end
```

Refer to the Configuring PTP, on page 91 module for more information.

SUMMARY STEPS

1. **configure**
2. **ntp**
3. **master primary-reference-clock**
4. Use one of the following commands:
   - **end**
   - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ntp** **Example:** `RP/0/RSP0/CPU0:router(config)# ntp`	Enters NTP configuration mode.

	Command or Action	Purpose
Step 3	**master primary-reference-clock** **Example:** `RP/0/RSP0/CPU0:router(config-ntp)# master primary-reference-clock`	Specifies PTP to be the NTP time source.

Step 4	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# end`
	or
	`RP/0/RSP0/CPU0:router(config-ntp)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Updating the Hardware Clock

On devices that have hardware clocks (system calendars), you can configure the hardware clock to be periodically updated from the software clock. This is advisable for devices using NTP, because the time and date on the software clock (set using NTP) is more accurate than the hardware clock. The time setting on the hardware clock has the potential to drift slightly over time.

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

SUMMARY STEPS

1. **configure**
2. **ntp**
3. **update-calendar**
4. Use one of the following commands:

- **end**
- **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ntp** **Example:** `RP/0/RSP0/CPU0:router(config)# ntp`	Enters NTP configuration mode.
Step 3	**update-calendar** **Example:** `RP/0/RSP0/CPU0:router(config-ntp)# update-calendar`	Configures the router t o update its system calendar from the software clock at periodic intervals.

Step 4	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# end`
	or
	`RP/0/RSP0/CPU0:router(config-ntp)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		  • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		  • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		  • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Verifying the Status of the External Reference Clock

This task explains how to verify the status of NTP components.

Note The commands can be entered in any order.

SUMMARY STEPS

1. **show ntp associations** [**detail**] [**location** *node-id*]
2. **show ntp status** [**location** *node-id*]

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**show ntp associations** [**detail**] [**location** *node-id*] **Example:** `RP/0/RSP0/CPU0:router# show ntp associations`	Displays the status of NTP associations.
Step 2	**show ntp status** [**location** *node-id*] **Example:** `RP/0/RSP0/CPU0:router# show ntp status`	Displays the status of NTP.

Examples

The following is sample output from the **show ntp associations** command:

```
RP/0/RSP0/CPU0:router# show ntp associations

      address         ref clock     st  when  poll reach  delay  offset    disp
+~127.127.1.1      127.127.1.1       5     5  1024   37     0.0    0.00   438.3
*~172.19.69.1      172.24.114.33     3    13  1024    1     2.0   67.16     0.0
 * master (synced), # master (unsynced), + selected, - candidate, ~ configured
```

The following is sample output from the **show ntp status** command:

```
RP/0/RSP0/CPU0:router# show ntp status

Clock is synchronized, stratum 4, reference is 172.19.69.1
nominal freq is 1000.0000 Hz, actual freq is 999.9988 Hz, precision is 2**26
reference time is C54C131B.9EECF6CA (07:26:19.620 UTC Mon Nov 24 2008)
clock offset is 66.3685 msec, root delay is 7.80 msec
root dispersion is 950.04 msec, peer dispersion is 3.38 msec
```

Configuration Examples for Implementing NTP

Configuring Poll-Based Associations: Example

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

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

  server 172.19.69.1
```

Configuring Broadcast-Based Associations: Example

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

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

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

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

Configuring NTP Access Groups: Example

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

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

```
ntp
  peer 10.1.1.1
```

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

Configuring NTP Authentication: Example

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

- NTP authentication is enabled.
- Two authentication keys are configured (key 2 and key 3).
- The router is configured to allow its software clock to be synchronized with the clock of the peer (or vice versa) at IP address 10.3.32.154 using authentication key 2.
- The router is configured to allow its software clock to be synchronized with the clock by the device at IP address 10.32.154.145 using authentication key 3.
- The router is configured to synchronize only to systems providing authentication key 3 in their NTP packets.

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

Disabling NTP on an Interface: Example

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

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

Configuring the Source IP Address for NTP Packets: Example

The following example shows an NTP configuration in which Ethernet management interface 0/0/CPU0/0 is configured as the source address for NTP packets:

```
ntp
  authentication-key 2 md5 encrypted 06120A2D40031D1008124
  authentication-key 3 md5 encrypted 1311121E074110232621
  authenticate
  trusted-key 3
  server 10.3.32.154 key 3
  peer 10.32.154.145 key 2
  source MgmtEth0/0/CPU0/0
```

Configuring the System as an Authoritative NTP Server: Example

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

```
ntp
  master 6
```

Updating the Hardware Clock: Example

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

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

FQDN for NTP Server

Table 3: Feature History Table

Feature Name	Release Information	Feature Description
FQDN for NTP Server on Non-default VRF	Release 7.9.1	You can now specify a Fully Qualified Domain Name (FQDN) as the hostname for NTP server configuration over nondefault VRFs. FQDNs are easy to remember compared to numeric IP addresses. Service migration from one host to another can cause a change in IP address leading to outages. Prior releases allowed FQDN handling in only default VRFs.

NTP on Cisco IOS XR Software supports configuration of servers and peers using their Fully Qualified Domain Names (FQDN). While configuring, the FQDN is resolved via DNS into its corresponding IPv4 or IPv6 address and is stored in the running-configuration of the system. NTP supports FQDN for both IPv4 and IPv6 protocols. You can configure FQDN on default vrf.

Starting Cisco IOS XR Software Release 7.9.1 you can configure FQDN in nondefault vrf also.

Configure FQDN for NTP server

Prerequisites for configuring FQDN in a nondefault VRF

- Configuration must exist for DNS resolution over that specific VRF.
- The server must be reachable.

Configuration Example for FQDN on NTP Server on Default VRF

Use the **ntp server** command with the FQDN name to configure FQDN on default VRF. You dont need to specify VRF name. In the following example, time.cisco.com is the FQDN.

```
Router#configure
Router(config)#ntp server time.cisco.com
Router(config)#commit
```

Note When you are configuring FQDN over default VRF, you don't need to specify VRF name.

Running Configuration

Use the **show running-config ntp** command to see the ntp running configuration.

```
Router#show running-config ntp
ntp
 server 10.48.59.212
!
```

Verification

Use the **show ntp associations** command to verify that an NTP association has come up.

```
Router#show ntp associations

      address         ref clock     st  when  poll reach  delay  offset    disp
 ~10.48.59.212     173.38.201.67     2    42   128    3  196.06  -14.25  3949.4
 * sys_peer, # selected, + candidate, - outlayer, x falseticker, ~ configured
```

Configuration Example for FQDN on NTP Server on Nondefault VRF

FQDN must be reachable from the router to configure it as an NTP server or peer. You can use the **ping** command and verify that FQDN is reachable. In the following example, time.cisco.com is the FQDN and vrf_1 is the VRF over which it is reachable.

```
Router#ping time.cisco.com vrf vrf_1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.0.2.1 timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 171/171/172 ms
```

When you have confirmed that FQDN is pingable, you can configure FQDN to be used as an NTP server/peer. The following example shows how to configure an NTP server using its FQDN over a nondefault vrf.

```
Router#configure
Router(config)#ntp server vrf vrf_1 time.cisco.com minpoll 4 maxpoll 4 iburst
Router(config)#commit
```

Note If the FQDN you're trying to configure isn't reachable, the CLI treats it as invalid input.

Running Configuration

Use the **show running-config ntp** command to see the ntp running configuration.

```
Router#show running-config ntp
 ntp
  server vrf vrf_1 192.0.2.1 minpoll 4 maxpoll 4 iburst
 !
```

Verification

Use the **show ntp associations** command to verify that an NTP association has come up.

```
Router#show ntp associations
 address         ref clock     st  when  poll reach  delay  offset    disp
~192.0.2.1 vrf vrf_1
                 173.38.201.115    2    14    16   37  179.10  13.492  16.680
* sys_peer, # selected, + candidate, - outlayer, x falseticker, ~ configured
```

Configuring NTP server inside VRF interface

This task explains how to configure NTP server inside VRF interface.

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

SUMMARY STEPS

1. **configure**
2. **ntp**
3. **vrf** *vrf-name*
4. **source** *interface-type interface-instance*
5. Use one of the following commands:
   - **end**
   - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ntp** **Example:** `RP/0/RSP0/CPU0:router(config)# ntp`	Enters NTP configuration mode.
Step 3	**vrf** *vrf-name* **Example:** `RP/0/RSP0/CPU0:router(config)# ntp vrf Customer_A`	Specify name of a VRF (VPN- routing and forwarding) instance to configure.
Step 4	**source** *interface-type interface-instance* **Example:** `RP/0/RSP0/CPU0:router(config)# ntp vrf Customer_A source bvi 70`	Configures an interface from which the IP source address is taken. This allows IOS-XR to respond to NTP queries on VRF interfaces, in this case the source is BVI. **Note** This interface is used for the source address for all packets sent to all destinations. If a source address is to be used for a specific association, use the **source** keyword in the

	Command or Action	Purpose
		peer or **server** command shown in Configuring Poll-Based Associations, on page 8.

Step 5	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-ntp)# end`
	or
	`RP/0/RSP0/CPU0:router(config-ntp)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Additional References

The following sections provide references related to implementing NTP on Cisco IOS XR software.

Related Documents

Related Topic	Document Title
Cisco IOS XR clock commands	*Clock Commands on the Cisco ASR 9000 Series Router* module of *System Management Command Reference for Cisco ASR 9000 Series Routers*
Cisco IOS XR NTP commands	*NTP Commands on* module of *System Management Command Reference for Cisco ASR 9000 Series Routers*
Information about getting started with Cisco IOS XR Software	*Cisco ASR 9000 Series Aggregation Services Router Getting Started Guide*
Cisco IOS XR master command index	*Cisco ASR 9000 Series Aggregation Services Router Commands Master List*

Related Topic	Document Title
Information about user groups and task IDs	*Configuring AAA Services on the Cisco ASR 9000 Series Router* module of *System Security Configuration Guide for Cisco ASR 9000 Series Routers*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

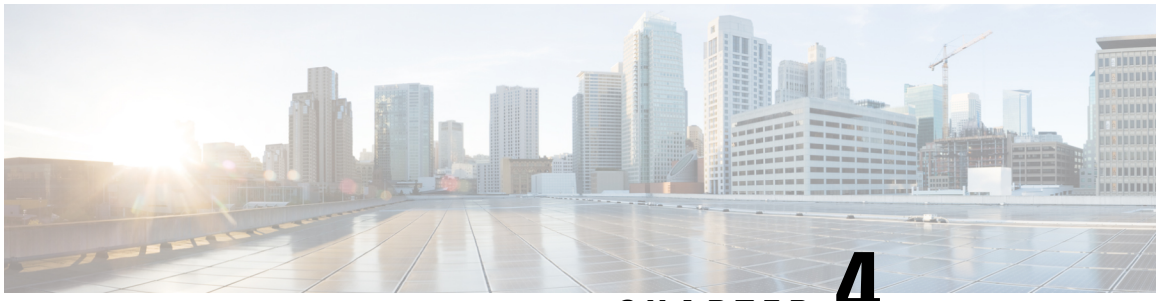
MIBs	MIBs Link
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at the following URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
RFC 1059	*Network Time Protocol, Version 1: Specification and Implementation*
RFC 1119	*Network Time Protocol, Version 2: Specification and Implementation*
RFC 1305	*Network Time Protocol, Version 3: Specification, Implementation, and Analysis*

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/cisco/web/support/index.html



CHAPTER 4

Configuring Network Configuration Protocol

This module provides details of the Network Configuration Protocol. For relevant commands, see *System Security Command Reference for Cisco ASR 9000 Series Routers*.

Release	Modification
Release 5.3.0	This feature was introduced.
Release 5.3.1	Support extended for more Yang models.
Release 6.0	Support extended for the Netconf subsystem configuration to be vrf aware. The configuration of the netconf port is no longer sufficient to start the Netconf subsystem support. At least one vrf needs to be configured. The configuration of the port is now optional.

- The Network Configuration Protocol, on page 33
- Netconf and Yang , on page 35
- Supported Yang Models , on page 36
- Denial of Services Defence for Netconf-Yang, on page 36
- Dynamic Loading of Operational Yang Models, on page 37
- Enabling NETCONF over SSH, on page 37
- Additional Reference , on page 40

The Network Configuration Protocol

The Network Configuration Protocol (Netconf) provides mechanisms to install, manipulate, and delete the configuration of network devices. It uses an Extensible Markup Language (XML)-based data encoding for the configuration data as well as the protocol messages. Yang is a data modeling language used with Netconf.

Netconf uses a simple RPC-based (Remote Procedure Call) mechanism to facilitate communication between a client and a server. The client can be a script or application typically running as part of a network manager. The server is typically a network device.

The configuration of features need not be done the traditional way (using CLIs), the client application (controller) reads the Yang model and communicates with the Netconf server (IOS XR) accordingly.

Note Following are the deviations from IETF-NACM YANG, where the system does not support:

- The *ordered-by-user* functionality for rule-lists and rules. rule-lists & rules are sorted based on name.
- The *enable-nacm* leaf.
- The *notification* related leafs (notification-name & denied-notifications.)

Netconf Sessions and Operations

A Netconf session is the logical connection between a network configuration application and a network device. A device should be capable of supporting multiple sessions and atleast one Netconf session.

Characteristics of a netconf session:

- Netconf is connection-oriented - SSH is the underlying transport.
- The netconf client establishes session with the server.
- Netconf sessions are established with the *hello* message. Features and capabilities are announced.
- Sessions can be terminated using the *close* or *kill* messages.

Basic Netconf operations:

- Get configuration <get-config>
- Get all information <get>
- Edit configuration <edit-config>
- Copy configuration <copy-config>

Note <copy-config> does not support source attribute with “data store” at present.

- <lock>, <unlock>
- <kill-session>
- <close-session>
- Commit configuration <commit>

The Yang data model

Each feature has a defined Yang Model which is synthesized from the schemas. A model is published in a tree format and includes:

- Top level nodes and their subtrees
- Subtrees that augment nodes in other yang models

```
Example: The aaa Yang model
module: Cisco-IOS-XR-aaa-lib-cfg
   +--rw aaa
      +--rw accountings
      |  +--rw accounting* [type listname]
      |     +--rw type                 xr:Cisco-ios-xr-string
      |     +--rw listname             xr:Cisco-ios-xr-string
      |     +--rw rp-failover?         Aaa-accounting-rp-failover
      |     +--rw broadcast?           Aaa-accounting-broadcast
      |     +--rw type-xr?             Aaa-accounting
      |     +--rw method*              Aaa-method
      |     +--rw server-group-name*   string
      +--rw authorizations
      |  +--rw authorization* [type listname]
      |     +--rw type                 xr:Cisco-ios-xr-string
      |     +--rw listname             xr:Cisco-ios-xr-string
      |     +--rw method*              Aaa-method
      |     +--rw server-group-name*   string
      +--rw accounting-update!
      |  +--rw type                 Aaa-accounting-update
      |  +--rw periodic-interval?   uint32
      +--rw authentications
         +--rw authentication* [type listname]
            +--rw type                 xr:Cisco-ios-xr-string
            +--rw listname             xr:Cisco-ios-xr-string
            +--rw method*              Aaa-method
            +--rw server-group-name*   string
```

Advantages of using the Yang model are:

- Yang supports programmatic interfaces.
- Yang supports simplified network management applications.
- Yang supports interoperability that provides a standard way to model management data.

Netconf and Yang

The workflow displayed here, will help the user to understand how Netconf-Yang can configure and control the network with minimal user intervention. The required components:

- Cisco Router (ASR9000 series or CRS) with Netconf capability
- Netconf Client Application with connection to the router

S. No.	Device / component	Action
1	Cisco router (ASR 9000 or CRS router)	Login/ access the router.
2	Cisco router	Prerequisites for enabling Netconf. • k9sec pie must be installed. • Crypto keys must be generated.

S. No.	Device / component	Action
3	Cisco router	Enable Netconf agent. Use the **netconf-yang agent ssh** and **ssh server netconf** command. The port can be selected. By default, it is set as 830.
4	Cisco router	Yang models are a part of the software image. The models can be retrieved from the router , using the <get-schema> operation.
5	Netconf client (application) The application can be on any standalone application or a SDN controller supporting Netconf	Installs and processes the Yang models. The client can offer a list of supported yang models; else the user will have to browse and locate the required yang file. There is a yang model file for each configuration module; for instance if the user wants to configure CDP , the relevant yang model is Cisco-IOS-XR-cdp-cfg **Note** Refer the table which lists all the supported yang models. Supported Yang Models , on page 36
5	Netconf client	Sends Netconf operation request over SSH to the router. A configuration request could include Yang-based XML data to the router. Currently, SSH is the only supported transport method.
6	Cisco router	Understands the Yang-based XML data and the network is configured accordingly (in case of configuration request from the client).
		The interactions between the client and the router happens until the network is configured as desired.

Supported Yang Models

The Yang models can be downloaded from a prescribed location (ftp server) or can also be retrieved directly from the router using the get-schema operation.

For a feature, separate Yang models are available for configuring the feature and to get operational statistics (show commands). The **-cfg.yang** suffix denotes configuration and **-oper*.yang** is for operational data statistics. In some cases, **-oper** is followed by **-sub**, indicating that a submodule(s) is available.

For a list of supported Yang models, see https://github.com/YangModels/yang/tree/master/vendor/cisco/xr

Denial of Services Defence for Netconf-Yang

In case of a DoS (Denial of Service) attack on Netconf, wherein, Netconf receives numerous requests in a short span of time, the router may become irresponsive if Netconf consumes most of the bandwidth or CPU

processing time. This can be prevented, by limiting the traffic directed at the Netconf agent. This is achieved using the **netconf-yang agent rate-limit** and **netconf-yang agent session** commands.

If rate-limit is set, the Netconf processor measures the incoming traffic from the SSH server. If the incoming traffic exceeds the set rate-limit, the packets are dropped.

If session-limit is set, the Netconf processor checks for the number of open sessions. If the number of current sessions is greater than or equal to, the set limit, no new sessions are opened.

Session idle- timeout and absolute-timeout also prevent DoS attacks. The Netconf processor closes the sessions, even without user input or intervention, as soon at the time out session is greater than or equal to the set time limit.

The relevant commands are discussed in detail, in the *System Security Command Reference for Cisco ASR 9000 Series Routers*

Dynamic Loading of Operational Yang Models

Netconf is enhanced to pre-load only the configurational yang models in memory, when it starts. The operational yang models are loaded into memory only when a request is issued. This helps reduce consumption of the RAM memory.

Enabling NETCONF over SSH

This task enables NETCONF over SSH. SSH is currently the only supported transport method .

If the client supports, Netconf over ssh can utilize the multi-channeling capabilities of IOS XR ssh server. For additional details about Multi-channeling in SSH, see *Implementing Secure Shell* in *System Security Configuration Guide*.

Prerequisites:

- k9sec pie must be installed, otherwise the port configuration for the netconf ssh server cannot be completed. (The Netconf subsystem for SSH, as well as, SSH cannot be configured without the k9sec pie.)
- Crypto keys must be generated prior to this configuration.
- The Netconf-YANG feature is packaged in the mgbl pie, which must be installed before enabling the Netconf-YANG agent.

SUMMARY STEPS

1. **configure**
2. **netconf-yang agent ssh**
3. **ssh server netconf** [**vrf** *vrf-name* [**ipv4 access-list***ipv4 access list name*] [**ipv6 access-list** *ipv6 access list name*]]
4. **ssh server netconf port** *port-number*

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**netconf-yang agent ssh** **Example:** `RP/0/RSP0/CPU0:router (config) # netconf agent ssh`	Enables NETCONF agent over SSH connection. After NETCONF is enabled, the Yang model in the controllcker, can configure the relevant models. **Note** The Yang models can be retrieved from the router via NETCONF <get-schema> operation.
Step 3	**ssh server netconf** [**vrf** *vrf-name* [**ipv4 access-list***ipv4 access list name*] [**ipv6 access-list** *ipv6 access list name*]] **Example:** `RP/0/RSP0/CPU0:router (config) # ssh server netconf vrf netconfvrf ipv4 access-list InternetFilter`	Brings up the netconf subsytem support with SSH server using a specified VRF of up to 32 characters. If no VRF is specified, the default VRF is used. To stop the SSH server from receiving any further connections for the specified VRF, use the **no** form of this command. Optionally ACLs for IPv4 and IPv6 can be used to restrict access to the netconf subsystem of the ssh server before the port is opened. **Note** The netconf subsystem support with SSH server can be configured for use with multiple VRFs .
Step 4	**ssh server netconf port** *port-number* **Example:** `RP/0/RSP0/CPU0:router (config) # ssh server netconf port 830`	Configures a port for the netconf ssh server. This command is optional. If no port is specified, port 830 is uses by default. **Note** 830 is the IANA-assigned TCP port for NETCONF over SSH, but it can be changed using this command.

What to do next

The **show netconf-yang statistics** command and **show netconf-yang clients** command can be used to verify the configuration details of the netconf agent.

The **clear netconf-yang agent session** command clears the specified Netconf session (on the Netconf server side).

Examples: Netconf over SSH

This section illustrates some examples relevant to Netconf:

Enabling netconf-yang for ssh transport and netconf subsystem for default vrf with default port (830)

```
config
netconf-yang agent ssh
ssh server netconf vrf default
  !
!
```

Enabling netconf-yang for ssh transport and netconf subsystem for vrf *green* and vrf *red* with netconf port (831)

```
config
netconf-yang agent ssh
!
ssh server netconf vrf green
ssh server netconf vrf red
ssh server netconf port 831
  !
!
```

Show command outputs

```
show netconf-yang statistics
Summary statistics        requests|             total time|   min time per request|   max
time per request|   avg time per request|
other                              0|       0h  0m  0s   0ms|       0h  0m  0s   0ms|
 0h  0m  0s   0ms|       0h  0m  0s   0ms|
close-session                      4|       0h  0m  0s   3ms|       0h  0m  0s   0ms|
 0h  0m  0s   1ms|       0h  0m  0s   0ms|
kill-session                       0|       0h  0m  0s   0ms|       0h  0m  0s   0ms|
 0h  0m  0s   0ms|       0h  0m  0s   0ms|
get-schema                         0|       0h  0m  0s   0ms|       0h  0m  0s   0ms|
 0h  0m  0s   0ms|       0h  0m  0s   0ms|
get                                0|       0h  0m  0s   0ms|       0h  0m  0s   0ms|
 0h  0m  0s   0ms|       0h  0m  0s
get-config                         1|       0h  0m  0s   1ms|       0h  0m  0s   1ms|
 0h  0m  0s   1ms|       0h  0m  0s   1ms|
edit-config                        3|       0h  0m  0s   2ms|       0h  0m  0s   0ms|
 0h  0m  0s   1ms|       0h  0m  0s   0ms|
commit                             0|       0h  0m  0s   0ms|       0h  0m  0s   0ms|
 0h  0m  0s   0ms|       0h  0m  0s   0ms|
cancel-commit                      0|       0h  0m  0s   0ms|       0h  0m  0s   0ms|
 0h  0m  0s   0ms|       0h  0m  0s   0ms|
lock                               0|       0h  0m  0s   0ms|       0h  0m  0s   0ms|
 0h  0m  0s   0ms|       0h  0m  0s   0ms|
unlock                             0|       0h  0m  0s   0ms|       0h  0m  0s   0ms|
 0h  0m  0s   0ms|       0h  0m  0s   0ms|
discard-changes                    0|       0h  0m  0s   0ms|       0h  0m  0s   0ms|
 0h  0m  0s   0ms|       0h  0m  0s   0ms|
validate                           0|       0h  0m  0s   0ms|       0h  0m  0s   0ms|
 0h  0m  0s   0ms|       0h  0m  0s   0ms|

show netconf-yang clients
client session ID|   NC version|    client connect time|        last OP time|        last
OP type|    <lock>|
22969|                1.1|         0d  0h  0m  2s|             11:11:24|
close-session|        No|
15389|                1.1|        0d  0h  0m  1s|            11:11:25|         get-config|
          No|
```

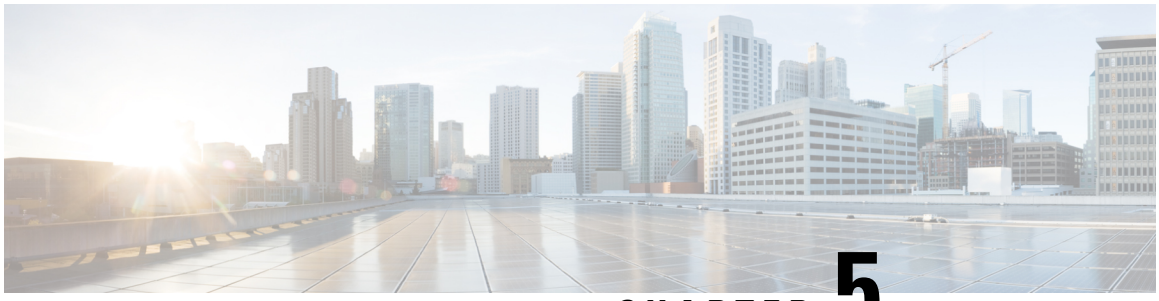
Additional Reference

Table 4: Related Documents

Related Topic	Document Title
Netconf-Yang	For related commands, see *System Security Command Reference for Cisco ASR 9000 Series Routers*

Table 5: Standards

Component	RFCs
YANG	6020
NETCONF	6241
NETCONF over SSH	6242



CHAPTER 5

Configuring Frequency Synchronization

Frequency Synchronization is used to distribute precision frequency around a network. Frequency is synchronized accurately using Synchronized Ethernet (SyncE) in devices connected by Ethernet in a network.

This module describes the concepts around this and details the various configurations involved. For information on SyncE commands, see *System Management Command Reference for Cisco ASR 9000 Series Routers*.

This module contains the following topics:

- Overview, on page 41
- Clocking Support for nV Cluster , on page 46
- Configuring Frequency Synchronization, on page 48
- Class C Timing Support, on page 65

Overview

Frequency or timing synchronization is the ability to distribute precision frequency around a network. In this context, timing refers to precision frequency, not an accurate time of day. Precision frequency is required in next generation networks for applications such as circuit emulation.

To achieve compliance to ITU specifications for TDM, differential method circuit emulation must be used, which requires a known, common precision frequency reference at each end of the emulated circuit. The incumbent example of frequency synchronization is provided by SDH equipment. This is used in conjunction with an external timing technology to provide synchronization of precision timing across the network.

SDH equipments are widely replaced by Ethernet equipments and synchronized frequency is required over such Ethernet ports. Synchronous Ethernet (SyncE) is used to accurately synchronize frequency in devices connected by Ethernet in a network. SyncE provides level frequency distribution of known common precision frequency references to a physical layer Ethernet network.

To maintain SyncE links, a set of operational messages are required. These messages ensure that a node is always deriving timing information from the most reliable source and then transfers the timing source quality information to clock the SyncE link. In SDH networks, these are known as Synchronization Status Messages (SSMs). SyncE uses Ethernet Synchronization Message Channel (ESMC) to provide transport for SSMs.

Source and Selection Points

Frequency Synchronization implementation involves Sources and Selection Points.

A Source inputs frequency signals into a system or transmits them out of a system. There are four types of sources:

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

Each source has a Quality Level (QL) associated with it which gives the accuracy of the clock. This QL information is transmitted across the network using ESMC or SSMs contained in the SDH frames. This provides information about the best available source the devices in the system can synchronize to. To define a predefined network synchronization flow and prevent timing loops, you can assign priority values to the sources on each router. The combination of QL information and user-assigned priority levels allow each router to choose a source to synchronize its SyncE or SDH interfaces, as described in the ITU standard G.781.

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

The input signals to the selection points can be:

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

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

- To drive the signals sent out of a set of interfaces.
- As input into another selection point on a card.
- As input into a selection point on an another card.

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

Note

- We recommend you to configure, and enable Frequency Synchronization selection input on two interfaces per line card.
- For link aggregation, you must configure and enable Frequency Synchronization selecction input on a single bundle member.

SyncE Hardware Support Matrix

This table provides details on the harware that supports SyncE:

Note The table also contains support details of upcoming releases. You can read this table in context of the current release and see relevant *Release Notes* for more information on supported features and hardware.

Table 6: Feature History Table

Feature Name	Release Information	Feature Description
SyncE Support on ASR 9000 5th Generation 400G Ethernet Line Card	Release 25.2.1	Frequency Synchronization is now supported on the following line card: • A99-4HG-FLEX-X-SE Route Processor: • A9K-RSP5-X-SE/TR • A9K-RSP5-SE/TR • A99-RP3-X-SE/TR • A99-RP3-SE/TR
SyncE Support on ASR 9000 5th Generation 400G Ethernet Line Card	Release 25.1.1	Frequency Synchronization is now supported on the following line card: • A9K-4HG-FLEX-X-SE Route Processor: • A9K-RSP5-X-SE • A9K-RSP5-X-TR
SyncE Support on 5th Generation 10-Port 400 Gigabit Ethernet Line Cards: • A99-10X400GE-X-SE • A99-10X400GE-X-TR	Release 7.3.2	Frequency Synchronization is used to distribute precision frequency around a network. Frequency is synchronized accurately using Synchronized Ethernet (SyncE) in devices connected by Ethernet in a network. SyncE is now supported on the line cards: • A99-10X400GE-X-SE • A99-10X400GE-X-TR

Hardware Variant	Cisco IOS XR	Cisco IOS XR 64 bit
A9K-8X100GE-L-SE/TR (10GE and 100GE)	5.3.0	6.1.1
A9K-RSP880-SE/TR	5.3.0	6.1.1
A9K-8X100GE-L-SE/TR (40-GE)	6.0.1	6.1.1
A9K-4X100GE-SE/TR A9K-8X100GE-SE/TR	5.3.2 (100G LAN only) 6.0.1	6.1.1
A9K-MOD400-SE/TR A9K-MOD200-SE/TR with MPA 20x10GE and Legacy MPAs	6.0.1	6.2.2
A9K-MOD400-SE/TR A9K-MOD200-SE/TR with MPAs 2x100 and 1x100	6.1.3	6.2.2
A9K-400G-DWDM-TR	5.3.3 6.0.1	
A9K-24X10GE-1G-SE/TR A9K-48X10GE-1G-SE/TR	6.2.1	6.3.2
A99-RSP-SE/TR (Cisco ASR 9910 Series Routers)	6.1.4	6.3.2
RSP880-LT-SE/TR	6.2.2	6.4.1
A9K-RSP440-TR/SE Enhanced Ethernet Linecards A99-RP-SE	4.3.4	
A99-RP2-TR/SE	5.3.0	6.3.2 6.4.1
Cisco ASR 9001 Series Routers	4.3.4	
Cisco ASR 9901 Series Routers	NA	6.4.1
A99-RSP-SE/TR (Cisco ASR 9906 Series Routers)	6.3.1	6.3.2
A9K-RSP5-SE/TR	NA	6.5.15
A99-RP3-SE/TR	NA	6.5.15
A9K-8X100GE-X-TR	NA	6.5.15

Hardware Variant	Cisco IOS XR	Cisco IOS XR 64 bit
A9K-16X100GE-TR	NA	6.5.15
A9K-32X100GE-TR	NA	6.5.15
A99-32X100GE-X-TR	NA	7.1.15
A9K-8HG-FLEX-SE/TR	NA	7.1.15
A9K-20HG-FLEX-SE/TR	NA	7.1.15
ASR-9903	NA	7.1.3
A9903-20HG-PEC	NA	7.1.3
A99-10X400GE-X-SE/TR	NA	7.3.2
A99-12X100GE	NA	7.4.1
A9K-4X100GE	NA	7.4.1
ASR-9902	NA	7.4.1
A9K-4HG-FLEX-SE/TR	NA	7.4.1
A99-4HG-FLEX-SE/TR	NA	7.4.1
A9K-4HG-FLEX-X-SE	NA	25.1.1
A99-4HG-FLEX-X-SE	NA	25.2.1

SyncE Restrictions

This section lists a few restrictions in configuring frequency synchronization. They are:

- On SyncE line interfaces, you can configure multiple interfaces for SyncE input. However, only one interface from each PHY gets selected as best source and programmed as SyncE input (there is no restriction on SyncE output) on the A9K-24X10GE-1G-SE/TR and A9K-48X10GE-1G-SE/TR line cards.
- *clock-interface timing-mode independent* configuration is not supported on Cisco A9K-RSP5-X-TR, A9K-RSP5-X-SE, A99-RP3-X-TR and A99-RP3-X-SE.

SyncE and extended ESMC

The Ethernet Synchronization Message Channel (ESMC) protocol is specified in the ITU-T G.8262.1. It enables frequency synchronization across a network over Ethernet ports with the ability to select enhanced quality levels. Enhanced quality levels lead to improved bandwidth, frequency accuracy, and holdover along with reduced noise generation in a network.

Table 7: Feature History Table

Feature name	Release Information	Feature Description
SyncE and extended ESMC	Release 25.2.1	ITU-T G.8262.1 recommendation defines the requirements for timing devices used in synchronizing network equipment. For example, bandwidth, frequency accuracy, holdover, and noise generation. With enhanced SyncE (eSyncE) and extended ESMC (eESMC) support, the routers are capable of handling the following SyncE clocks on the network: • Enhanced Primary Reference Clock (ePRC) • Enhanced Primary Reference Timing Clock (ePRTC)

As part of the ESMC protocol, Synchronization Status Messages (SSMs) distributes the Quality Level (QL) of timing signals. The updated G.8262.1 standard provides a new and enhanced Quality Level (QL) of Type Length Value (TLV) that allows more precise quality to provide accurate clocks.

The new and enhanced QL of TLV that is part of the updated G.8262.1 standard is known as **enhanced SyncE (eSyncE)**. The enhanced QL of TLV enables support for more QL values. You can configure a router to send or receive the enhanced TLV. The enhanced QL of TLV results in more precise synchronization of clocks across a network.

Restrictions of extended ESMC

These restrictions must be observed on the routers for usage of extended ESMC:

- Router that do not support eSyncE do not support extended ESMC.
- Router that does not support eSyncE ignores any enhanced TLVs it receives and hence does not support enhanced quality to provide accurate clocks.
- Router that does not support eSyncE at ingress nodes drop the QL TLV received from the previous node supporting eSyncE.
- The extended QL TLV is newly applied only at the subsequent node that supports enhanced ESMC.

Clocking Support for nV Cluster

ASR9K cluster consists of two chassis connected together to provide redundancy and to meet higher bandwidth requirements. RSP440 provides two ICS (Inter-Chassis Synchronization) interfaces on the front plate. Clocking functionality support is added to the ICS interfaces. The ICS interfaces could be used for clocking, in the

absence of other methods to synchronize frequency and Time-of-day information between the two cluster racks

nV Cluster Limitations

The limitations for the frequency synchronization support for cluster are:

- This feature is supported only on RSP440.
- The two chassis of the cluster have to be co-located. The length of the cable used for the ICS link should be less than 10 meters. This is needed to ensure the phase delay added due the length of the cable is within limits.
- SSM and QL is not supported on ICS links. SSM messages are not exchanged over the ICS interface. Hence, QL value needs to be configured under ICS clock interface configuration.
- The selection of an input clock source is based on the configuration of priority, QL as well as the clock quality. For SyncE, the ICS interfaces are similar to the SyncE line interfaces as far as input clock selection is concerned.
- All Input clock sources to cluster setup has to be redundant.
- No support for 1588 BC on LAG interfaces with member links across racks.

Inter-Chassis Synchronization (ICS)

ICS-Frequency Synchronization

Frequency synchronization is provided using Inter-Chassis Synchronization links (ICS). These are dedicated interfaces on the RSP used to synchronize the time and frequency.

The ICS link between the Primary DSC and Backup DSC carries the clock. There is no transfer of QL information from Primary DSC to Backup DSC.The clock direction is always from Primary DSC to Backup DSC. The Primary DSC transmits the clock and Backup DSC receives the clock.

The ICS clock interface (sync 2 or sync 3) is a clock input on the Backup DSC. The clock selection algorithm for SyncE is independent on each RSP. So, output clock from the rack which has Primary DSC is the outcome of the clock selection on the Primary DSC. The output clock from the rack which has Backup DSC is the outcome of the clock selection on the Backup DSC. If the ICS clock interface configuration is such that it is the selected clock on the Backup DSC, then the output clocks from the Primary rack and Backup rack are synchronised.

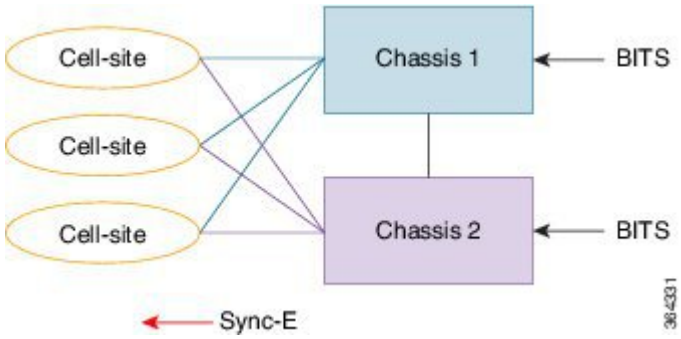
ICS-Time-of-Day

The ICS links also carry Time of Day (ToD) information when the ICS clock interfaces are configured for the same. Only the Backup DSC can synchronise with ToD from the Primary DSC and not vice versa. The 1588 clock information transmitted on all 1588 interfaces in the cluster (including interfaces on Backup rack) is of the clock selected at the Primary DSC. Thus, it is important that ICS clock interface on Backup DSC is configured such that it is the clock which is selected for ToD on the Backup DSC.

Recommended ICS Interface Connections

No inter-chassis frequency or time synchronization support:

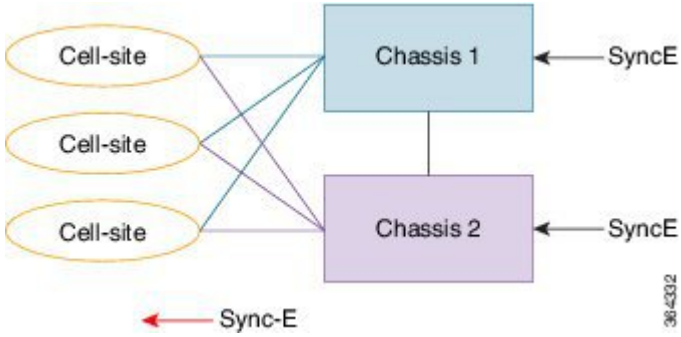
Figure 1: No inter-chassis frequency support



SyncE is used from the ASR9K cluster to provide precision frequency to mobile cell sites. A BITS clock is connected to each chassis of the cluster, meaning that the frequencies of both chassis are synchronized and the cell sites will all be synchronized, regardless of which chassis they synchronize to. In most deployments redundant BITS connections would be made to each chassis, to prevent against failure of any single BITS link.

With inter-chassis synchronization support:

Figure 2: With inter-chassis synchronization support



SyncE is used to synchronize the frequency of an ASR9k cluster to an upstream device. To provide redundancy in the case of one of the external SyncE inputs going down, the frequencies of the different cluster chassis must somehow be synchronized; else cell sites which select links from different chassis to synchronize may be out of sync if one of the SyncE links goes down.

Configuring Frequency Synchronization

Enabling Frequency Synchronization on the Router

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

Important **Frequency synchronization** configuration is mandatory to enable any type of frequency or time source on the router. This includes SyncE, clock-interfaces, Precision Time Protocol (PTP) or internal oscillator.

Note If timing mode system is not configured, the major alarm `T4 PLL is in FREERUN mode` is raised. This alarm has no functional impact to the system behavior.

SUMMARY STEPS

1. **configure**
2. **frequency synchronization**
3. **clock-interface timing-mode** {**independent** | **system**
4. **quality itu-t option** {**1** | **2 generation** {**1** | **2**}}
5. **log selection** {**changes** | **errors**}
6. Use one of these commands:
   - **end**
   - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**frequency synchronization** **Example:** `RP/0/RSP0/CPU0:router(config)# frequency synchronization`	Enables frequency synchronization on the router.
Step 3	**clock-interface timing-mode** {**independent**	**system** **Example:** `RP/0/RSP0/CPU0:router(config-freqsync)# clock-interface timing-mode system`	Configures the type of timing sources that can be used to drive the output from a clock interface. If this command is not used, the default quality mode is used. In the default mode, the clock interface output is driven only by input from line interfaces and the internal oscillator; it is never driven by input from another clock interface. In addition, some heuristic tests are run to detect if the signal being sent out of one clock interface can be looped back by some external box and sent back in via the same, or another clock interface. • **independent**—Specifies that the output of clock interfaces is driven only by the line interfaces (SyncE and SONET/SDH), as in the default mode. Loopback detection is disabled.

	Command or Action	Purpose
		• **system**—Specifies that the output of a clock interface is driven by the system-selected timing source (the source used to drive all SyncE and SONET/SDH interfaces), including clock interfaces. Loopback detection is disabled.

Step 4	**quality itu-t option** {**1** | **2 generation** {**1** | **2**}}
	Example:
	`RP/0/RSP0/CPU0:router(config-freqsync)# quality itu-t`
	`option 2 generation 1`
		(Optional) Specifies the quality level for the router. The default is **option 1**.
		• **option 1**—Includes PRC, SSU-A, SSU-B, SEC and DNU.
		• **option 2 generation 1**—Includes PRS, STU, ST2, ST3, SMC, ST4, RES and DUS.
		• **option 2 generation 2**—Includes PRS, STU, ST2, ST3, TNC, ST3E, SMC, ST4, PROV and DUS.
		Note
		The quality option configured here must match the quality option specified in the **quality receive** and **quality transmit** commands in interface frequency synchronization configuration mode.

Step 5	**log selection** {**changes** | **errors**} **Example:** `RP/0/RSP0/CPU0:router(config-freqsync)# log selection changes`	Enables logging to frequency synchronization. • **changes**—Logs every time there is a change to the selected source, in addition to errors. • **errors**—Logs only when there are no available frequency sources, or when the only available frequency source is the internal oscillator.

Step 6	Use one of these commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-freqsync)# end`
	or
	`RP/0/RSP0/CPU0:router(config-freqsync)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.

	Command or Action	Purpose
		• Use the **commit** command to save the configuration changes to the running configuration file, and remain within the configuration session.

What to do next

Configure frequency synchronization on any interfaces that should participate in frequency synchronization.

Configuring Frequency Synchronization on an Interface

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

Before you begin

You must enable frequency synchronization globally on the router.

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id*
3. **frequency synchronization**
4. **selection input**
5. **priority** *priority-value*
6. **wait-to-restore** *minutes*
7. **ssm disable**
8. **time-of-day-priority** *priority*
9. **quality transmit** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option*
10. **quality receive** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option*
11. Use one of these commands:
    - **end**
    - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/1/1/0`	Enters interface configuration mode.
Step 3	**frequency synchronization** **Example:** `RP/0/RSP0/CPU0:router(config-if)# frequency synchronization`	Enables frequency synchronization on the interface and enters interface frequency synchronization mode to configure the various options. By default, this causes the system selected frequency signal to be used for clocking transmission, but does not enable the use of the interface as an input.
Step 4	**selection input** **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# selection input`	(Optional) Specifies the interface as a timing source to be passed to the selection algorithm.
Step 5	**priority** *priority-value* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# priority 100`	(Optional) Configures the priority of the frequency source on a controller or an interface. Values can range from 1 (highest priority) to 254 (lowest priority). The default value is 100. This command is used to set the priority for an interface or clock interface. The priority is used in the clock-selection algorithm to choose between two sources that have the same quality level (QL). Lower priority values are preferred.
Step 6	**wait-to-restore** *minutes* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# wait-to-restore 300`	(Optional) Configures the wait-to-restore time, in minutes, for frequency synchronization on an interface. This is the amount of time after the interface comes up before it is used for synchronization. Values can range from 0 to 12. The default value is 5.
Step 7	**ssm disable** **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# ssm disable`	(Optional) Disables Synchronization Status Messages (SSMs) on the interface. • For SyncE interfaces, this disables sending ESMC packets, and ignores any received ESMC packets. • For SONET and clock interfaces, this causes DNUs to be sent, and ignores any received QL value.
Step 8	**time-of-day-priority** *priority* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# time-of-day-priority 50`	(Optional) Specifies the priority of this time source as the time-of-day (ToD) source. The priority is used as the first criterion when selecting between sources for a time-of-day selection point. Values can range from 1 (highest priority) to 254 (lowest priority); the default value is 100.
Step 9	**quality transmit** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option*	(Optional) Adjusts the QL that is transmitted in SSMs.

	Command or Action	Purpose
	Example: `RP/0/RSP0/CPU0:router(config-clk-freqsync)# quality transmit highest itu-t option 1 prc`	• **exact** *ql*—Specifies the exact QL to send, unless DNU would otherwise be sent. • **highest** *ql*—Specifies an upper limit on the QL to be sent. If the selected source has a higher QL than the QL specified here, this QL is sent instead. • **lowest** *ql*—Specifies a lower limit on the QL to be sent. If the selected source has a lower QL than the QL specified here, DNU is sent instead. The quality option specified in this command must match the globally-configured quality option in the **quality itu-t option** command. **Note** For clock interfaces that do not support SSM, only the lowest QL can be specified. In this case, rather than sending DNU, the output is squelched, and no signal is sent.
Step 10	**quality receive** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option* **Example:** `RP/0/RSP0/CPU0:router(config-clk-freqsync)# quality receive highest itu-t option 1 prc`	(Optional) Adjusts the QL value that is received in SSMs, before it is used in the selection algorithm. • **exact** *ql*—Specifies the exact QL regardless of the value received, unless the received value is DNU. • **highest** *ql*—Specifies an upper limit on the received QL. If the received value is higher than this specified QL, this QL is used instead. • **lowest** *ql*—Specifies a lower limit on the received QL. If the received value is lower than this specified QL, DNU is used instead. The quality option specified in this command must match the globally-configured quality option in the **quality itu-t option** command. **Note** For clock interfaces that do not support SSM, only the exact QL can be specified.
Step 11	Use one of these commands: • **end** • **commit** **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# end` or	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-if-freqsync)# commit`	configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file, and remain within the configuration session.

Configuring Frequency Synchronization on a Clock Interface

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

Note The configuration on clock interfaces must be the same for corresponding clock interfaces across all RSPs to avoid changes in frequency synchronization behavior in the event of an RSP switchover.

SUMMARY STEPS

1. **configure**
2. **clock-interface sync** *port-no* **location** *node-id*
3. **port-parameters** {**bits-input** *mode* | **bits-output** *mode* | **dti**}
4. **ics**
5. **frequency synchronization**
6. **selection input**
7. **priority** *priority-value*
8. **wait-to-restore** *minutes*
9. **ssm disable**
10. **time-of-day-priority** *priority*
11. **quality transmit** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option*
12. **quality receive** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option*
13. Use one of these commands:
    - **end**
    - **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**clock-interface sync** *port-no* **location** *node-id* **Example:** `RP/0/RSP0/CPU0:router(config)# clock-interface sync 2 location 0/2/0`	Enters clock interface configuration mode to configure the clock interface.
Step 3	**port-parameters** {**bits-input** *mode* | **bits-output** *mode* | **dti**} **Example:** `RP/0/RSP0/CPU0:router(config-clock-if)# port-parameters dti`	Specifies the type of external clock source for the clock interface. Options are BITS RX, BITS TX or DTI. The possible *mode* values for BITS interfaces are **2m**, **6m-output-only**, **e1** or **t1**.
Step 4	**ics** **Example:** `RP/0/RSP0/CPU0:router(config)# ics`	Enables chassis synchronization.

Step 5	**frequency synchronization**
	Example:
	`RP/0/RSP0/CPU0:router(config-clock-if)# frequency synchronization`
	`RP/0/RSP0/CPU0:router(config-clk-freqsync)#`
		Enters clock interface frequency synchronization mode to configure frequency synchronization parameters.
		Note
		The remaining steps in this task are the same as those used to configure the interface frequency synchronization.

Step 6	**selection input** **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# selection input`	(Optional) Specifies the interface as a timing source to be passed to the selection algorithm.
Step 7	**priority** *priority-value* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# priority 100`	(Optional) Configures the priority of the frequency source on a controller or an interface. Values can range from 1 (highest priority) to 254 (lowest priority). The default value is 100. This command is used to set the priority for an interface or clock interface. The priority is used in the clock-selection algorithm to choose between two sources that have the same quality level (QL). Lower priority values are preferred.

	Command or Action	Purpose
Step 8	**wait-to-restore** *minutes* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# wait-to-restore 300`	(Optional) Configures the wait-to-restore time, in minutes, for frequency synchronization on an interface. This is the amount of time after the interface comes up before it is used for synchronization. Values can range from 0 to 12. The default value is 5.
Step 9	**ssm disable** **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# ssm disable`	(Optional) Disables Synchronization Status Messages (SSMs) on the interface. • For SyncE interfaces, this disables sending ESMC packets, and ignores any received ESMC packets. • For SONET and clock interfaces, this causes DNUs to be sent, and ignores any received QL value.
Step 10	**time-of-day-priority** *priority* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# time-of-day-priority 50`	(Optional) Specifies the priority of this time source as the time-of-day (ToD) source. The priority is used as the first criterion when selecting between sources for a time-of-day selection point. Values can range from 1 (highest priority) to 254 (lowest priority); the default value is 100.
Step 11	**quality transmit** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option* **Example:** `RP/0/RSP0/CPU0:router(config-clk-freqsync)# quality transmit highest itu-t option 1 prc`	(Optional) Adjusts the QL that is transmitted in SSMs. • **exact** *ql*—Specifies the exact QL to send, unless DNU would otherwise be sent. • **highest** *ql*—Specifies an upper limit on the QL to be sent. If the selected source has a higher QL than the QL specified here, this QL is sent instead. • **lowest** *ql*—Specifies a lower limit on the QL to be sent. If the selected source has a lower QL than the QL specified here, DNU is sent instead. The quality option specified in this command must match the globally-configured quality option in the **quality itu-t option** command. **Note** For clock interfaces that do not support SSM, only the lowest QL can be specified. In this case, rather than sending DNU, the output is squelched, and no signal is sent.
Step 12	**quality receive** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option* **Example:** `RP/0/RSP0/CPU0:router(config-clk-freqsync)# quality receive highest itu-t option 1 prc`	(Optional) Adjusts the QL value that is received in SSMs, before it is used in the selection algorithm. • **exact** *ql*—Specifies the exact QL regardless of the value received, unless the received value is DNU. • **highest** *ql*—Specifies an upper limit on the received QL. If the received value is higher than this specified QL, this QL is used instead.

	Command or Action	Purpose
		• **lowest** *ql*—Specifies a lower limit on the received QL. If the received value is lower than this specified QL, DNU is used instead. The quality option specified in this command must match the globally-configured quality option in the **quality itu-t option** command. **Note** For clock interfaces that do not support SSM, only the exact QL can be specified.

Step 13	Use one of these commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-if-freqsync)# end`
	or
	`RP/0/RSP0/CPU0:router(config-if-freqsync)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file, and remain within the configuration session.

Configuring Clock Interface with DTI input

This procedure describes the steps involved to configure a Clock interface with DTI input.

1. To configure a clock interface, use **clock-interface sync** *value* **location** *node* command in the configuration mode.

```
RP/0/RSP0/CPU0:router(config)# clock-interface sync 1 location 0/RSP0/CPU0
```

2. To configure port parameters for the given clock interface, use **port-parameters dti** command in the clock-interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-clock-if)# port-parameters dti
```

3. To enable frequency synchronization, use **frequency synchronization** command in the clock-interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-clock-if)# frequency synchronization
```

4. To configure selection input for the given clock interface, use **selection input** command in the frequency-synchronization clock-configuration mode.

```
RP/0/RSP0/CPU0:router(config-clk-freqsync)# selection input
```

5. To configure priority for the clock interface, use **priority** *number* command in the frequency-synchronization clock-configuration mode.

```
RP/0/RSP0/CPU0:router(config-clk-freqsync)# priority 1
```

6. To configure wait-to-restore time for the clock interface, use **wait-to-restore** *number* command in the frequency-synchronization clock-configuration mode.

```
RP/0/RSP0/CPU0:router(config-clk-freqsync)# wait-to-restore 0
```

7. To disable SSM packets for the clock interface, use **ssm disable** command in the frequency-synchronization clock-configuration mode.

```
RP/0/RSP0/CPU0:router(config-clk-freqsync)# ssm disable
```

8. To configure quality settings for the clock interface, use **quality receive exact itu-t option** *number* **generation** *number* **PRS** command in the frequency-synchronization clock-configuration mode.

```
RP/0/RSP0/CPU0:router(config-clk-freqsync)# quality receive exact itu-t option 2
generation 2 PRS
```

Verification

To display the current running configuration of an interface, use **show run clock-interface** command.

```
RP/0/RSP0/CPU0:router# show run clock-interface sync 1 location 0/RSP0/CPU0

clock-interface sync 1 location 0/RSP0/CPU0
port-parameters
  dti
!
frequency synchronization
  selection input
  priority 1
  wait-to-restore 0
  ssm disable
  quality receive exact itu-t option 2 generation 2 PRC
!
!RP/0/RSP0/CPU0:router#
```

Configuring GPS Settings for a sync2 interface

This procedure describes the steps involved to configure GPS settings for a sync2 interface.

1. To configure a clock interface, use **clock-interface sync** *port-number* **location** *interface-location* command in the configuration mode.

```
RP/0/RSP0/CPU0:router(config)# clock-interface sync 2 location 0/RSP0/CPU0
```

2. To configure port parameters for the given clock interface, use **port-parameters** command in the clock-interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-clock-if)# port-parameters
```

3. To configure GPS input parameters, use **gps-input tod-format gprmc pps-input ttl** command.

```
RP/0/RSP0/CPU0:router(config-clk-parms)# gps-input tod-format
gprmc pps-input ttl
```

4. To return to the clock-interface configuration mode, use **exit** command.

```
RP/0/RSP0/CPU0:router(config-clk-parms)# exit
```

5. To enable frequency synchronization, use **frequency synchronization** command in the clock-interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-clock-if)# frequency synchronization
```

6. To configure selection input for the given clock interface, use **selection input** command in the frequency-synchronization clock-configuration mode.

```
RP/0/RSP0/CPU0:router(config-clk-freqsync)# selection input
```

7. To configure priority for the clock interface, use **priority** *number* command in the frequency-synchronization clock-configuration mode.

```
RP/0/RSP0/CPU0:router(config-clk-freqsync)# priority 10
```

8. To configure wait-to-restore time for the clock interface, use **wait-to-restore** *number* command in the frequency-synchronization clock-configuration mode.

```
RP/0/RSP0/CPU0:router(config-clk-freqsync)# wait-to-restore 0
```

9. To disable SSM packets for the clock interface, use **ssm disable** command in the frequency-synchronization clock-configuration mode.

```
RP/0/RSP0/CPU0:router(config-clk-freqsync)# ssm disable
```

10. To configure quality settings for the clock interface, use **quality receive exact itu-t option** *number* **generation** *number* **PRS** command in the frequency-synchronization clock-configuration mode.

```
RP/0/RSP0/CPU0:router(config-clk-freqsync)# quality receive exact itu-t option 2
generation 2 PRS
```

Verification

To verify the configured GPS parameters , use **show run clock-interface** command.

```
RP/0/RSP0/CPU0:router# show run clock-interface sync 2 location 0/RSP0/CPU0

clock-interface sync 2 location 0/RSP0/CPU0
port-parameters
gps-input tod-format gprmc pps-input ttl
!
```

GPS ToD Support for NMEA

National Marine Electronics Associations (NMEA) 0183 is a standard protocol used by GPS receivers to transmit data and is responsible for creating a standard uniform interface for digital data exchange between different marine electronic products. NMEA provides protocol strings to send out GPS updates. GPRMC is one such NMEA string that provides exact data and time (Greenwich time), latitude, longitude, heading, and speed. Router receives GPS ToD messages in serial ASCII stream through the RS422 interface in three formats - NTP Type 4, Cisco, and GPRMC. The timing data is extracted from this stream.

Note Cisco ASR 9000 Series Routers can support ToD in NMEA or GPRMC format. Currently, this is supported only on RS422.

Note You can refer to the below support information in context of the current release and see relevant *Release Notes* for more information on supported features and hardware.

Supported hardware are:

- A9K-RSP440-SE/TR
- A9K-RSP880-SE/TR
- A99-RP2-SE/TR
- A9K-RSP880-LT-SE/TR
- A99-RSP-SE/TR

Configuring ICS

This task enables inter-chassis synchronization for interfaces.

SUMMARY STEPS

1. **configure**
2. **clock-interface sync** *port-no* **location** *node-id*
3. **port-parameters ics**
4. **frequency synchronization**
5. **selection input**
6. **priority** *priority-value*
7. **wait-to-restore** *minutes*

8. **time-of-day-priority** *priority*
9. **quality receive { exact | highest | lowest} itu-t option** *option*

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**clock-interface sync** *port-no* **location** *node-id* **Example:** `RP/0/RSP0/CPU0:router(config)# clock-interface sync 2 location 1/RSP0/CPU0`	Enters clock interface configuration mode to configure the clock interface.
Step 3	**port-parameters ics** **Example:** `RP/0/RSP0/CPU0:router(config-clock-if)# port-parameters ics`	Enables inter-chassis synchronization.

Step 4	**frequency synchronization**
	Example:
	`RP/0/RSP0/CPU0:router(config-clock-if)# frequency synchronization`
	`RP/0/RSP0/CPU0:router(config-clk-freqsync)#`
		Enters clock interface frequency synchronization mode to configure frequency synchronization parameters.
		Note
		The remaining steps in this task are the same as those used to configure the interface frequency synchronization.

Step 5	**selection input** **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# selection input`	(Optional) Specifies the interface as a timing source to be passed to the selection algorithm.
Step 6	**priority** *priority-value* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# priority 100`	(Optional) Configures the priority of the frequency source on a controller or an interface. Values can range from 1 (highest priority) to 254 (lowest priority). The default value is 100. This command is used to set the priority for an interface or clock interface. The priority is used in the clock-selection algorithm to choose between two sources that have the same quality level (QL). Lower priority values are preferred.
Step 7	**wait-to-restore** *minutes* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# wait-to-restore 300`	(Optional) Configures the wait-to-restore time, in minutes, for frequency synchronization on an interface. This is the amount of time after the interface comes up before it is used for synchronization. Values can range from 0 to 12. The default value is 5.

	Command or Action	Purpose
Step 8	**time-of-day-priority** *priority* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# time-of-day-priority 50`	(Optional) Specifies the priority of this time source as the time-of-day (ToD) source. The priority is used as the first criterion when selecting between sources for a time-of-day selection point. Values can range from 1 (highest priority) to 254 (lowest priority); the default value is 100.
Step 9	**quality receive { exact | highest | lowest} itu-t option** *option* **Example:** `RP/0/RSP0/CPU0:router (config-clk-freqsync) # quality receive exact itu-t option 1 PRC`	

Verifying the Frequency Synchronization Configuration

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

SUMMARY STEPS

1. **show frequency synchronization configuration-errors**
2. **show frequency synchronization interfaces brief**
3. **show frequency synchronization interfaces** *node-id*
4. **show processes fsyncmgr location** *node-id*

DETAILED STEPS

Procedure

Step 1 **show frequency synchronization configuration-errors**

Example:

```
RP/0/RSP0/CPU0:router# show frequency synchronization configuration-errors

Node 0/2/CPU0:
==============
  interface GigabitEthernet0/2/0/0 frequency synchronization
    * Frequency synchronization is enabled on this interface, but isn't enabled globally.

  interface GigabitEthernet0/2/0/0 frequency synchronization quality transmit exact itu-t option 2
generation 1 PRS
    * The QL that is configured is from a different QL option set than is configured globally.
```

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

- Frequency Synchronization is configured on an interface (line interface or clock-interface), but is not configured globally. Refer to Enabling Frequency Synchronization on the Router, on page 48

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

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

Step 2 **show frequency synchronization interfaces brief**

Example:

```
RP/0/RSP0/CPU0:router# show frequency synchronization interfaces brief

Flags:  > - Up                D - Down              S - Assigned for selection
        d - SSM Disabled      x - Peer timed out    i - Init state

Fl  Interface                QLrcv QLuse Pri QLsnt Source
=== ======================== ===== ===== === ===== ========================
>Sx GigabitEthernet0/2/0/0   Fail  Fail  100 DNU   None
Dd  GigabitEthernet0/2/0/1   n/a   Fail  100 n/a   None

RP/0/RSP0/CPU0:router# show frequency synchronization clock-interfaces brief

Flags:  > - Up                D - Down              S - Assigned for selection
        d - SSM Disabled      s - Output squelched  L - Looped back

Node 0/0/CPU0:
==============
  Fl    Clock Interface     QLrcv  QLuse  Pri QLsnd  Source
  ===== =================== ====== ====== === ====== ========================
  >S    Sync0               PRC    Fail   100 SSU-B  Internal0 [0/0/CPU0]
  >     Sync1               SSU-A  Fail   100 SSU-B  Internal0 [0/0/CPU0]
  >S    Internal0           n/a    SSU-B  255 n/a    None

Node 0/1/CPU0:
==============
  Fl    Clock Interface     QLrcv  QLuse  Pri QLsnd  Source
  ===== =================== ====== ====== === ====== ========================
  D     Sync0               None   Fail   100 SSU-B  Internal0 [0/1/CPU0]
  D     Sync1               None   Fail   100 SSU-B  Internal0 [0/1/CPU0]
  >S    Internal0           n/a    SSU-B  255 n/a    None
```

Verifies the configuration. Note the following points:

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

  Note
  Internal oscillators are always eligible as inputs.

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

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

Step 3 **show frequency synchronization interfaces** *node-id*

Example:

```
RP/0/RSP0/CPU0:router# show frequency synchronization interfaces GigabitEthernet0/2/0/2

Interface GigabitEthernet0/2/0/2 (shutdown)
  Assigned as input for selection
  SSM Enabled
  Input:
    Down
    Last received QL: Failed
    Effective QL:     Failed, Priority: 100
  Output:
    Selected source:    Sync0 [0/0/CPU0]
    Selected source QL: Opt-I/PRC
    Effective QL:       Opt-I/PRC
  Next selection points: LC_INGRESS

RP/0/RSP0/CPU0:router# show frequency synchronization clock-interfaces location 0/1/CPU0

Node 0/1/CPU0:
==============
  Clock interface Sync0 (Down: mode not configured)
    SSM supported and enabled
    Input:
      Down
      Last received QL: Opt-I/PRC
      Effective QL:     Failed, Priority: 100
    Output:
      Selected source:    Internal0 [0/1/CPU0]
      Selected source QL: Opt-I/SSU-B
      Effective QL:       Opt-I/SSU-B
  Next selection points: RP_SYSTEM

  Clock interface Sync1 (Down: mode not configured)
    SSM supported and enabled
    Input:
      Down
      Last received QL: Opt-I/PRC
      Effective QL:     Failed, Priority: 100
    Output:
      Selected source:    Internal0 [0/1/CPU0]
      Selected source QL: Opt-I/SSU-B
      Effective QL:       Opt-I/SSU-B
  Next selection points: RP_SYSTEM

  Clock interface Internal0 (Up)
    Assigned as input for selection
    Input:
      Default QL:   Opt-I/SSU-B
      Effective QL: Opt-I/SSU-B, Priority: 255
  Next selection points: RP_SYSTEM RP_CLOCK_INTF
```

Investigates issues within individual interfaces. If the clock interface is down, a reason is displayed. This may be because there is missing or conflicting platform configuration on the clock interface.

Step 4 **show processes fsyncmgr location** *node-id*

Example:

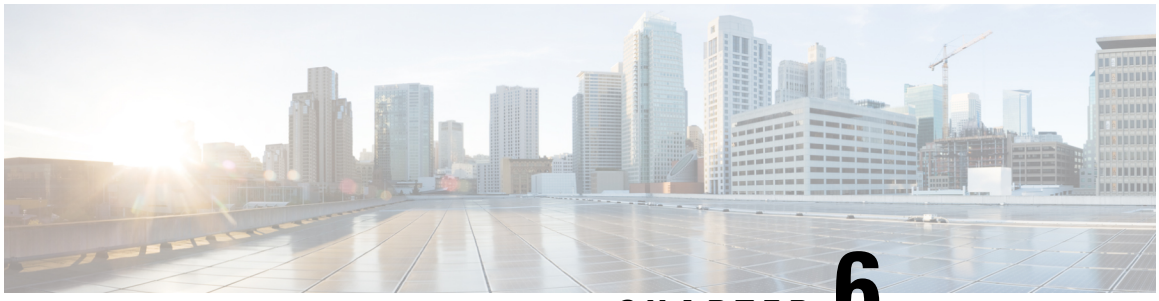
```
RP/0/RSP0/CPU0:router# show processes fsyncmgr location 0/0/CPU0
```

```
                Job Id: 134
                   PID: 30202
       Executable path: /pkg/bin/fsyncmgr
            Instance #: 1
            Version ID: 00.00.0000
               Respawn: ON
         Respawn count: 1
Max. spawns per minute: 12
          Last started: Mon Mar  9 16:30:43 2009
         Process state: Run
         Package state: Normal
     Started on config: cfg/gl/freqsync/g/a/enable
                  core: MAINMEM
              Max. core: 0
             Placement: None
          startup_path: /pkg/startup/fsyncmgr.startup
                 Ready: 0.133s
      Process cpu time: 1730768.741 user, -133848.-361 kernel, 1596920.380 total
-------------------------------------------------------------------------------
```

Verifies that the fsyncmgr process is running on the appropriate nodes.

Class C Timing Support

To Configure Class C mode, see Class C Timing Mode.



CHAPTER 6

Configuring Precision Time Protocol

Precision Time Protocol (PTP) is a protocol that defines a method to distribute time around a network. PTP support is based on the IEEE 1588-2008 standard.

This module describes the concepts around this protocol and details the various configurations involved. For information on PTP commands, see *System Management Command Reference for Cisco ASR 9000 Series Routers*.

This module contains the following topics:

- Overview, on page 67
- ITU-T Telecom Profiles for PTP, on page 87
- Configuring PTP, on page 91
- Configuring PTP Delay Asymmetry, on page 108
- Double Failure Clock Class Over-ride, on page 110
- PTP Holdover Traceability suppression, on page 111
- Configuration Examples, on page 112

Overview

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 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 and are referred to as members. Constantly-exchanged timing messages ensure continued synchronization. PTP ensures that the best available clock is selected as the source of time (the grandmaster clock) for the network and that other clocks in the network are synchronized to the grandmaster.

Table 8: PTP Clocks

Network Element	Description
Grandmaster (GM)	A network device physically attached to the primary time source. All clocks are synchronized to the grandmaster clock.

Network Element	Description
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. • 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.
Boundary Clock (BC)	The device participates in selecting the best server clock and can act as the server clock if no better clocks are detected. Boundary clock starts its own PTP session with a number of downstream clients. The boundary clock mitigates the number of network hops and results in packet delay variations in the packet network between the Grandmaster and client.
Transparent Clock (TC)	A transparent clock is a device or a switch that calculates the time it requires to forward traffic and updates the PTP time correction field to account for the delay, making the device transparent in terms of time calculations.

PTP consists of two parts:

- The port State machine and Best Master Clock Algorithm: This provides a method to determine the ports in the network that will remain passive (neither server nor client), run as a server (providing time to other clocks in the network), or run as clients (receiving time from other clocks in the network).
- Delay-Request/Response mechanism and a Peer-delay mechanism: This provides a mechanisms for client ports to calculate the difference between the time of their own clocks and the time of their server clock.

Note Cisco ASR 9000 Series routers do not support Peer-delay mechanism.

The implementation of PTP on Cisco IOS XR software is designed to operate effectively in Telecommunication networks, which are different from the networks for which PTP was originally designed.

PTP is supported on Gigabit Ethernet interfaces and subinterfaces (1G, 10G, 40G, and 100G), and Bundle Ethernet main interfaces. PTP is not supported on Bundle Ethernet subinterfaces.

Frequency and Time Selection

The selection of the source to synchronize the backplane clock frequency is made by frequency synchronization, and is outside of the scope of PTP. The Announce, Sync, and Delay-request frequencies must be the same on the server and client.

Delay-Response Mechanism

The Delay Request-response mechanism (defined in section 11.3 of IEEE Std 1588-2008) lets a client port estimate the difference between its own clock-time and the clock-time of its server. The following options are supported:

- One-step mechanism - The timestamp for a Sync message is sent in the Sync message itself.
- Two-step mechanism - The timestamp for a Sync message is sent later in a Follow-up message.

When running a port in client state, a router can send Delay-request messages and handle incoming Sync, Follow-up, and Delay-response messages. The timeout periods for both Sync and Delay-response messages are individually configurable.

Hybrid Mode

Your router allows the ability to select separate sources for frequency and time-of-day (ToD). Frequency selection can be between any source of frequency available to the router, such as: BITS, GPS, SyncE or IEEE 1588 PTP. The ToD selection is between the source selected for frequency and PTP, if available (ToD selection is from GPS, DTI or PTP). This is known as hybrid mode, where a physical frequency source (BITS or SyncE) is used to provide frequency synchronization, while PTP is used to provide ToD synchronization.

Frequency selection uses the algorithm described in ITU-T recommendation G.871, and is described in the *Configuring Frequency Synchronization* module in this document. The ToD selection is controlled using the time-of-day priority configuration. This configuration is found under the source interface frequency synchronization configuration mode and under the global PTP configuration mode. It controls the order for which sources are selected for ToD. Values in the range of 1 to 254 are allowed, with lower numbers indicating higher priority.

Port States

State machine indicates the behavior of each port. The possible states are:

State	Description
INIT	Port is not ready to participate in PTP.
LISTENING	First state when a port becomes ready to participate in PTP: In this state, the port listens to PTP servers for a (configurable) period of time.
PRE-MASTER	Port is ready to enter the Server state.
MASTER	Port provides timestamps for any client or boundary clocks that are listening.
UNCALIBRATED	Port receives timestamps from a server clock but, the router’s clock is not yet synchronized to the server.

State	Description
SLAVE	Port receives timestamps from a server clock and the router's clock is synchronized to the server.
PASSIVE	Port is aware of a better clock than the one it would advertise if it was in server state and is not a client clock to that server clock.

Leap Seconds

In prior releases, IOS-XR only offered a static and time-consuming solution to manage leap seconds. For every upcoming leap second inclusion, the number of leap seconds had to be hard-coded into a Software Maintenance Update (SMU) and also installed on the router for the same. It is a prolonged and tedious process to provide and install a SMU each time a new leap second is announced.

From Release 6.4.1 onward, Cisco IOS-XR supports leap-second configuration instead of SMU installations or reloads.

Time is measured using a common timescale. Leap second factor is used to adjust the current time to compensate for any drift from the common timescale. Leap seconds are introduced to dynamically adjust the UTC offset in response to leap second events. The two most relevant timescales are:

- **TAI - International Atomic Time** : This is a notional passage of time determined by weighted average of readings across a large number of atomic clocks.
- **UTC - Universal Coordinated Time** : This differs from TAI by an integer number of seconds to remain in synchronization with mean solar time. UTC is related to a notion of time called **UT1**, which represents the mean solar time at 0° longitude. Leap seconds are periodically inserted to ensure UTC and UT1 are never more than 0.9 seconds apart.

PTP uses TAI timescale. UTC time is derived using UTC offset. UTC offset and the number of seconds in the last minute of the current UTC day are sent in the PTP header of Announce messages.

UTC is calculated as: **UTC = TAI - offset**.

IOS-XR PTP implementation uses the following sources (in order of decreasing precedence) to determine the current UTC offset value:

- The current grandmaster clock, if present.
- UTC offset configuration, if present.
- The previous grandmaster clock, if one exists.
- The hardware (e.g. a locally connected GPS receiver), if available.
- Zero, indicating that no UTC offset information is available.

If any upcoming leap second (being advertised at the time synchronization with a grandmaster) is lost, that too will be applied at the appropriate time while in holdover

Note

- Leap seconds are generally added by including an extra second (23:59:60), either on June 30th or on December 31st.
- UTC offset is + 37 seconds, as of 01 Jan 2017.

Multiple PTP Profile Interoperability

Communication between two different profiles was not possible previously due to various factors like, incompatible domain numbers, BMCA, or clock-class leading to drop in packets. Also, you cannot compare devices running different profiles in such configurations. For example, the domain number for G.8275.1 profile (24) is incompatible with the domain number for G.8275.2 profile (44).

Multiple PTP Profile Interoperability feature lets you develop a configuration to communicate with a peer device running a different PTP profile than the profile that is configured on the source router. This means that multiple profiles can interoperate on a single device in this implementation.

Interoperation is achieved by converting packets on ingress/egress so that it is acceptable to the profile configured on the receiving device. This prevents packet loss and allows comparison of different profiles. You can configure the interoperation using the **interop** command. Configuration details are described in a later section in this chapter. For command details, refer to Precision Time Protocol (PTP) Commands chapter in the *System Management Command Reference for Cisco ASR 9000 Series Routers* guide.

Note

- Multiple ingress conversions are performed for interfaces configured with multiple servers.
- Only G.8275.1 and G.8275.2 profiles can be configured to interoperate.

Class C Timing Mode

Table 9: Feature History Table

Feature Name	Release Information	Feature Description
Class C Timing Mode	Release 7.6.2	We now support the enhanced timing mode, Class C, as per the revised version of G.8273.2 by ITU-T. You can now switch to this Class C mode to avail high-accuracy clocks in the telecom networks having precise timing requirements, such as 5G networks. Class C mode reduces the Maximum Absolute Time Error (Max|TE|) and enhances synchronization of Telecom Boundary Clock (T-BC) and Telecom Time Secondary Clock (T-TSC). Class C timing support is available for both PTP and Frequency Synchronization. Class C timing mode is supported only on the routers with the combination of following Route Switch Processors (RSPs) and Fifth generation of the ASR 9000 Series Ethernet line cards except A99-32X100GE-X-TR/SE: • A9K-RSP5-X-TR/SE • A99-RP3-X-TR/SE This feature introduces the timing-accuracy enhanced command.

The advent of 5G technology demands strict timing requirements. To satisfy the strict timing requirements, ITU-T has introduced Class C or Enhanced timing accuracy mode under G8273.2 profile. Class B or Legacy mode is the default mode. The Max|TE| for Class B is 70 ns, whereas for Class C it is 40 ns. Reduced Max|TE| error indicates reduced noise transfer and improved timing accuracy between T-BC and T-SC.

Restrictions

- Class C timing support is not available on A99-32X100GE-X-TR/SE Lightspeed-plus-based line card.
- Class C is not supported on the following line cards:
  - Third generation of the ASR 9000 Series Ethernet Line Cards

- BITS-output clock does not work with Cisco IOS XR Software Release 7.6.2 image. You must install Software Maintenance Updates (SMU) for the same.
- If the **timing-accuracy enhanced** command is applied on the router with unsupported line cards, the timing functionality stops working on those line cards.

  The following system log appears on the router console when Class C configuration is applied on the routers containing unsupported hardware that does not support Class C mode.

```
LC/0/1/CPU0:Sep 2 15:51:50.791 UTC: sync_agent[325]:
%PLATFORM-FSYNC-4-CLOCK_ACCURACY_UNSUPPORTED : This line card does not support enhanced
 accuracy mode
```

To configure Class C mode, see Configuring Class C Timing Mode, on page 107.

PTP Support Information

This table lists different types of support information related to PTP:

Transport Media	• UDP over IPv4 • Ethernet • IPv6
Messages	• Signaling • Announce • Sync • Follow-up • Delay-request • Delay-response • Management
Transport Modes	• Unicast: This is the default mode. All packets are sent as unicast messages. • Mixed: Announce and Sync messages are sent as multicast messages. Signaling, Delay-request, and Delay-response messages are sent as unicast messages. • Multicast: All packets are sent as multicast messages.

PTP hardware support matrix

Table 10: Feature History Table

Feature Name	Release Information	Feature Description
Precision time protocol on ASR 9000 5th generation 400G Ethernet line card	Release 25.2.1	Support for IEEE-1588 PTP is extended to the following line card: • A99-4HG-FLEX-X-SE Class B performance is supported on all ports 1G, 10G, 25G, 40G and 100G. Route processors: • A9K-RSP5-SE/TR • A99-RP3-SE/TR Class C performance is supported on all ports 1G, 10G, 25G, 40G and 100G. Route processors: • A9K-RSP5-X-SE/TR • A99-RP3-X-SE/TR
Precision time protocol on ASR 9000 5th generation 400G Ethernet line card	Release 25.1.1	Support for IEEE-1588 PTP is extended to the following line card: • A9K-4HG-FLEX-X-SE Class C performance is supported on all ports 1G, 10G, 25G, 40G and 100G. Route Processor: • A9K-RSP5-X-SE • A9K-RSP5-X-TR

Feature Name	Release Information	Feature Description
Precision time protocol on 12-port 100 Gigabit Ethernet line cards, ASR 9000 5th generation 400G line cards, ASR 9902 Series Routers, and 0.8T PEC	Release 7.4.1	Support for IEEE-1588 PTP is extended to the following routers and line cards: • A99-12X100GE • A9K-4X100GE • ASR-9902 • A9K-8HG-FLEX-SE/TR • A9K-4HG-FLEX-SE • A9K-4HG-FLEX-TR • A99-4HG-FLEX-SE • A99-4HG-FLEX-TR
PTP support on 5th generation 10-Port 400 Gigabit Ethernet line cards: • A99-10X400GE-X-SE • A99-10X400GE-X-TR	Release 7.3.2	Support for IEEE-1588 PTP is extended to the following line cards: • A99-10X400GE-X-SE • A99-10X400GE-X-TR

Note The table also contains support details of upcoming releases. You can read this table in context of the current release and see relevant *Release Notes* for more information on supported features and hardware.

This table provides a detailed information on the supported hardware:

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
A9K-8X100GE-L-SE/TR (10GE and 100GE)	Default & G.8265.1	5.3.3	6.3.2 6.4.1	PTP over Ethernet does not work on 100G ports on Cisco IOS XR until 6.4.1. Support was introduced in 6.4.1.
	G.8275.1 & G.8275.2	6.2.1	6.3.2 6.4.1	
	G.8273.2	6.2.1	6.3.2	
	PTP Multiprofile	6.5.1	6.5.1	

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
A9K-RSP880-SE/TR	1588/PTP Default & G.8265.1	5.3.3	6.3.2 6.4.1	-
	1588/PTP G.8275.1 & G.8275.2	6.2.1	6.3.2 6.4.1	
	1588/PTP G.8273.2	6.2.1	6.3.2 6.4.1	
	PTP Multiprofile	6.5.1	6.5.1	
A9K-8X100GE-L-SE/TR (40-GE)	1588/PTP Default & G.8265.1	6.0.1	6.3.2 6.4.1	-
	1588/PTP G.8275.1 & G.8275.2	6.2.1	6.3.2 6.4.1	
	1588/PTP G.8273.2	NA	NA	
	PTP Multiprofile	6.5.1	6.5.1	
A9K-4X100GE-SE/TR A9K-8X100GE-SE/TR	1588/PTP Default & G.8265.1	6.2.1	6.4.1	PTP over Ethernet does not work on 100G ports on Cisco IOS XR until 6.4.1. Support was introduced in 6.4.1. In 6.2.1, only G.8275.1 PTP profile is supported on the cards; No support for G.8273.2 PTP profile.
	1588/PTP G.8275.1 & G.8275.2	6.2.1	6.4.1	
	1588/PTP G.8273.2	6.4.1	6.4.1	
	PTP Multiprofile	6.5.1	6.5.1	

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
A9K-MOD400-SE/TR & A9K-MOD200-SE/TR with Legacy MPAs	1588/PTP Default & G.8265.1	6.1.3	6.4.1	-
	1588/PTP G.8275.1 & G.8275.2	6.2.2	6.4.1	-
	1588/PTP G.8273.2	-	-	-
	PTP Multiprofile	6.5.1	6.5.1	-
A9K-MOD400-SE/TR & A9K-MOD200-SE/TR with MPA 20x10GE , A9K-MPA-1X100GE and A9K-MPA-2X100GE	1588/PTP Default & G.8265.1	6.1.3	6.4.1	PTP over Ethernet does not work on 100G ports on Cisco IOS XR until 6.4.1. Support was introduced in 6.4.1. In 6.2.2, only G.8275.1 PTP profile is supported on the cards. No support for G.8273.2 PTP profile until 6.5.1.
	1588/PTP G.8275.1 & G.8275.2	6.2.2	6.4.1	
	1588/PTP G.8273.2	6.5.1	6.5.1	
	PTP Multiprofile	6.5.1	6.5.1	
A9K-24X10GE-1G-SE/TR A9K-48X10GE-1G-SE/TR	1588/PTP Default & G.8265.1	6.2.2 6.3.1	6.3.2	-
	1588/PTP G.8275.1 & G.8275.2	6.2.2 6.3.1	6.3.2	
	1588/PTP G.8273.2	6.3.1	6.3.2	
	PTP Multiprofile	6.5.1	6.5.1	

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
A99-RSP-SE/TR (Cisco ASR 9910 Series Routers)	1588/PTP Default & G.8265.1	6.3.1	6.3.2	-
	1588/PTP G.8275.1 & G.8275.2	6.3.1	6.3.2	
	1588/PTP G.8273.2	6.4.1	6.3.2	
	PTP Multiprofile	6.5.1	6.5.1	
A9K-RSP880-LT-SE/TR	1588/PTP Default & G.8265.1	6.2.2	6.4.1	-
	1588/PTP G.8275.1 & G.8275.2	6.2.2	6.4.1	
	1588/PTP G.8273.2	6.4.1	6.4.1	
	PTP Multiprofile	6.5.1	6.5.1	
A9K-RSP440-TR/SE A99-RP-SE Enhanced Ethernet Linecards	1588/PTP Default & G.8265.1	4.3.4	NA	Enhanced Ethernet linecards do not support G.8273.2 with G.8275.1 PTP profile. .
	1588/PTP G.8275.1 & G.8275.2	NA	NA	
	1588/PTP G.8273.2	NA	NA	
A99-RP2-TR/SE	1588/PTP Default & G.8265.1	5.3.3	6.3.2 6.4.1	-
	1588/PTP G.8275.1 & G.8275.2	6.2.1	6.3.2 6.4.1	
	1588/PTP G.8273.2	NA	NA	

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
Cisco ASR 9001 Series Routers	1588/PTP Default & G.8265.1	4.3.4	NA	Enhanced Ethernet based hardware does not support G.8273.2 with G.8275.1 PTP profile.
	1588/PTP G.8275.1 & G.8275.2	NA	NA	
	1588/PTP G.8273.2	NA	NA	
Cisco ASR 9901 Series Routers	1588/PTP Default & G.8265.1	NA	6.4.1	-
	1588/PTP G.8275.1 & G.8275.2	NA	6.4.1	
	1588/PTP G.8273.2	NA	6.6.1	
	PTP Multiprofile	NA	6.5.1	
A99-RSP-SE/TR (Cisco ASR 9906 Series Routers)	1588/PTP Default & G.8265.1	6.3.1	6.3.2	-
	1588/PTP G.8275.1 & G.8275.2	6.3.1	6.3.2	
	1588/PTP G.8273.2	6.4.1	6.3.2	
	PTP Multiprofile	6.5.1	6.5.1	
A9K-RSP5-SE	1588/PTP Default & G.8265.1	NA	6.5.15	-
	1588/PTP G.8275.2	NA	6.5.15	
	1588/PTP G.8275.1 & G.8273.2	NA	6.6.1	
	PTP Multiprofile	NA	6.5.15	

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
A9K-RSP5-TR	1588/PTP Default & G.8265.1	NA	6.5.15	-
	1588/PTP G.8275.2	NA	6.5.15	
	1588/PTP G.8275.1 & G.8273.2	NA	6.6.1	
	PTP Multiprofile	NA	6.5.15	
A99-RP3-SE	1588/PTP Default & G.8265.1	NA	6.5.15	-
	1588/PTP G.8275.2	NA	6.5.15	
	1588/PTP G.8275.1 & G.8273.2	NA	6.6.1	
	PTP Multiprofile	NA	6.5.15	
A99-RP3-TR	1588/PTP Default & G.8265.1	NA	6.5.15	-
	1588/PTP G.8275.2	NA	6.5.15	
	1588/PTP G.8275.1 & G.8273.2	NA	6.6.1	
	PTP Multiprofile	NA	6.5.15	
A9K-8X100GE-X-TR	1588/PTP Default & G.8265.1	NA	6.5.15	-
	1588/PTP G.8275.2	NA	6.5.15	
	1588/PTP G.8275.1 & G.8273.2	NA	6.6.1	
	PTP Multiprofile	NA	6.5.15	
A9K-16X100GE-TR	1588/PTP Default & G.8265.1	NA	6.5.15	NA
	1588/PTP G.8275.2	NA	6.5.15	
	1588/PTP G.8275.1 & G.8273.2	NA	6.6.1	
	PTP Multiprofile	NA	6.5.15	

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
A99-16X100GE-X-SE A99-32X100GE-TR/CM	1588/PTP Default & G.8265.1	NA	6.6.1	NA
	1588/PTP G.8275.2	NA	6.6.1	
	1588/PTP G.8275.1 & G.8273.2	NA	6.6.1	
	PTP Multiprofile	NA	6.6.1	
A9K-32X100GE-TR	1588/PTP Default & G.8265.1	NA	6.5.15	-
	1588/PTP G.8275.2	NA	6.5.15	
	1588/PTP G.8275.1 & G.8273.2	NA	6.6.1	
	PTP Multiprofile	NA	6.5.15	
Cisco ASR 9903 Series Routers	1588/PTP Default & G.8265.1	NA	7.1.3	Card supports 'one-step' clock operation only and must have one-step configuration on PTP master interface to operate.
	1588/PTP G.8275.2	NA	7.1.3	
	1588/PTP G.8275.1 & G.8273.2	NA	7.1.3	
	PTP Multiprofile	NA	7.1.3	
A9903-20HG-PEC	1588/PTP Default & G.8265.1	NA	7.1.3	
	1588/PTP G.8275.2	NA	7.1.3	
	1588/PTP G.8275.1 & G.8273.2	NA	7.1.3	
	PTP Multiprofile	NA	7.1.3	
A99-32X100GE-X-SE/TR	1588/PTP Default & G.8265.1	NA	7.1.15	
	1588/PTP G.8275.2	NA	7.1.15	
	1588/PTP G.8275.1 & G.8273.2	NA	7.1.15	
	PTP Multiprofile	NA	7.1.15	

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
A9K-8HG-FLEX-SE/TR	1588/PTP Default & G.8265.1	NA	7.1.15	Card supports 'one-step' clock operation only and must have one-step configuration on PTP master interface to operate.
	1588/PTP G.8275.2	NA	7.1.15	
	1588/PTP G.8275.1 & G.8273.2	NA	7.1.15	
	PTP Multiprofile	NA	7.1.15	
A9K-20HG-FLEX-SE/TR	1588/PTP Default & G.8265.1	NA	7.1.15	Card supports 'one-step' clock operation only and must have one-step configuration on PTP master interface to operate.
	1588/PTP G.8275.2	NA	7.1.15	
	1588/PTP G.8275.1 & G.8273.2	NA	7.1.15	
	PTP Multiprofile	NA	7.1.15	
A99-10X400GE-X-SE/TR	1588/PTP Default & G.8265.1	NA	7.3.2	Card supports 'one-step' clock operation only and must have one-step configuration on PTP master interface to operate. Class B Performance (Applicable to 1588/PTP G.8275.1 & G.8273.2)
	1588/PTP G.8275.2	NA	7.3.2	
	1588/PTP G.8275.1 & G.8273.2	NA	7.3.2	
	PTP Multiprofile	NA	7.3.2	
A99-12x100GE A99-12X100GE-CM	1588/PTP Default & G.8265.1	NA	7.4.1	
	1588/PTP G.8275.2	NA	7.4.1	
	1588/PTP G.8275.1 & G.8273.2	NA	7.4.1	Class B Performance
	PTP Multiprofile	NA	7.4.1	
A99-8X100GE-SE/TR/CM A9K-8X100GE-CM A9K-8X100G-LB-SE/TR A9K-400G-DWDM-TR A99-48X10GE-1G-SE/TR	1588/PTP Default & G.8265.1	6.2.2	6.2.2	
	1588/PTP G.8275.2	6.2.2	6.2.2	
	1588/PTP G.8275.1 & G.8273.2	6.2.2	6.2.2	
	PTP Multiprofile	6.2.2	6.2.2	

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
A9K-4X100GE	1588/PTP Default & G.8265.1	NA	7.4.1	
	1588/PTP G.8275.2	NA	7.4.1	
	1588/PTP G.8275.1 & G.8273.2	NA	7.4.1	Class B Performance
	PTP Multiprofile	NA	7.4.1	
A9K-400GE-SE/TR	1588/PTP Default & G.8265.1	NA	7.4.1	
	1588/PTP G.8275.2	NA	7.4.1	
	1588/PTP G.8275.1 & G.8273.2	NA	7.4.1	Class B Performance
	PTP Multiprofile	NA	7.4.1	
A99-400GE-SE/TR	1588/PTP Default & G.8265.1	NA	7.4.1	
	1588/PTP G.8275.2	NA	7.4.1	
	1588/PTP G.8275.1 & G.8273.2	NA	7.4.1	Class B Performance
	PTP Multiprofile	NA	7.4.1	
ASR 9902	1588/PTP Default & G.8265.1	NA	7.4.1	Port 12 to Port 35 provides Class B Performance and requires two-step clock operation on PTP master interface Port 0 to port 11 and port 36 to port 47 provide Class C performance and requires one-step clock operation on PTP master interface.
	1588/PTP G.8275.2	NA	7.4.1	
	1588/PTP G.8275.1 & G.8273.2	NA	7.4.1	
	PTP Multiprofile	NA	7.4.1	

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
ASR-9903	1588/PTP Default & G.8265.1	NA	7.4.1	Card supports 'one-step' clock operation only and must have one-step configuration on PTP master interface to operate.
	1588/PTP G.8275.2	NA	7.4.1	
	1588/PTP G.8275.1 & G.8273.2	NA	7.4.1	
	PTP Multiprofile	NA	7.4.1	
A9K-4HG-FLEX-SE/TR	1588/PTP Default & G.8265.1	NA	7.4.1	Card supports 'one-step' clock operation only and must have one-step configuration on PTP master interface to operate.
	1588/PTP G.8275.2	NA	7.4.1	
	1588/PTP G.8275.1 & G.8273.2	NA	7.4.1	
	PTP Multiprofile	NA	7.4.1	
A99-4HG-FLEX-SE/TR	1588/PTP Default & G.8265.1	NA	7.4.1	Card supports 'one-step' clock operation only and must have one-step configuration on PTP master interface to operate.
	1588/PTP G.8275.2	NA	7.4.1	
	1588/PTP G.8275.1 & G.8273.2	NA	7.4.1	
	PTP Multiprofile	NA	7.4.1	
A9K-4HG-FLEX-X-SE	1588/PTP Default & G.8265.1	NA	25.1.1	Card supports 'one-step' clock operation only and must have one-step configuration on PTP master interface to operate. Class C performance is supported on all ports 1G, 10G, 25G, 40G and 100G. Route Processor: • A9K-RSP5-X-SE • A9K-RSP5-X-TR
	1588/PTP G.8275.2	NA	25.1.1	
	1588/PTP G.8275.1 & G.8273.2	NA	25.1.1	
	PTP Multiprofile	NA	25.1.1	

Hardware Variant	1588/PTP	Cisco IOS XR	Cisco IOS XR 64 bit	Comments
A99-4HG-FLEX-X-SE	1588/PTP Default & G.8265.1	NA	25.2.1	Card supports 'one-step' clock operation only and must have one-step configuration on PTP master interface to operate. Class B performance is supported on all ports 1G, 10G, 25G, 40G and 100G. Route processors: • A9K-RSP5-SE/TR • A99-RP3-SE/TR Class C performance is supported on all ports 1G, 10G, 25G, 40G and 100G. Route processors: • A9K-RSP5-X-SE/TR • A99-RP3-X-SE/TR
	1588/PTP G.8275.2	NA	25.2.1	
	1588/PTP G.8275.1 & G.8273.2	NA	25.2.1	
	PTP Multiprofile	NA	25.2.1	

Note The following 2nd generation line cards support all IEEE-1588 PTP telecom profiles (Default, G.8265.1, G.8275.2, G.8275.1, G.8273.2, and PTP Multiprofile) in Cisco IOS XR 32 bit:

Table 11: 2nd Generation Line Cards Supporting IEEE-1588 PTP

Hardware Variant	Hardware Variant	Hardware Variant
A9K-2X100GE-SE/TR	A9K-40GE-SE/TR	A9K-40GE-SE/TR
A9K-1X100GE-SE/TR	A9K-MOD160-SE/TR	A9K-VSM-500
A9K-36X10GE-SE/TR	A9K-MOD80-SE/TR	A9K-SIP-700
A9K-4T16GE-SE/TR	A9K-4T16GE-SE/TR	

Restrictions

- PTP Grandmaster (GM) is not supported with all the PTP profiles.

- RSP IEEE 1588 port on RSP/RP is not supported.
- If PTP clock operation CLI is not configured, the default clock operation is two-step on all ASR9000 hardware variants.
- Due to the difference in PTP timestamp unit, which involves the PHY injecting the timestamp instead of the NPU, you must configure PTP clock operation **one-step** on the PTP master interface of the line cards which are explicitly specified in the PTP hardware support matrix, on page 74. Rest of the line cards only support PTP clock operation **two-step** on the PTP master interface.
- PTP clock operation one-step or two-step restriction is only for PTP master interface. PTP slave interface can operate in either one-step or two-step.
- Cisco ASR 9000 Series Routers do not support Class B 1 Pulse Per Second (PPS) performance with Forward Error Correction (FEC) enabled optics.
- The upgrade of TimingIC-*X* firmware impacts timing functionality on the ASR 9902 and ASR 9903 Routers, and 5th Generation Line Cards. You must reload the linecard after upgrade of timing firmware for proper functioning of SyncE and PTP features. Interface flapping and traffic drops are expected during this process.
- G.8275.1 and G.8275.2 profiles are not supported on Cisco ASR 9001 chassis, Cisco ASR 9000 Ethernet line cards, Cisco ASR 9000 Enhanced Ethernet line cards, and A9K-400G-DWDM-SE/TR line cards.
- As recommended in Appendix VI of ITU-T G.8275.1 document, G.8275.1 profile is supported only on Bundle Link Aggregation (LAG) member links and not supported on a bundle interface.
- G.8273.2 Telecom Boundary Clock (T-BC) performance is not supported on 40G interfaces.
- The G.8273.2 Class B performance is observed when the same type of line card is used for both PTP server and PTP client ports. Class A performance is observed when different types of line cards are used for PTP server and PTP client on T-BC.
- G.8275.2 profile is supported on Cisco ASR 9000 Series Routers. However, the performance standards of this profile are not aligned with any of the ITU-T standards because performance specifications for G.8275.2 profile has not yet been made available by ITU-T.
- Transparent Clock (TC) is not supported.
- PTP Multiprofile is not supported for G.8273.2 Class B performance.
- Platform Fault Manager (PFM) alarms for the 10MHz port are not supported on A9K-RSP5-SE, A9K-RSP5-TR, A99-RP3-SE, and A99-RP3-TR.
- Select 5th generation line cards (A9K-20HG-FLEX-xx and A9K-8HG-FLEX-xx) will support PTP Telecom Profile G.8275.2 in combination with transit G.8265.1/G.8275.2 packets, in a future version of these cards.

Note Forwarding PTP packets as IP or MPLS isn't possible without the redirecting device not being PTP-aware. If each node across the PTP path isn't performing the T-BC function, timing accuracy can't be maintained.

ITU-T Telecom Profiles for PTP

Cisco IOS XR software supports ITU-T Telecom Profiles for PTP as defined in the ITU-T recommendation. A profile consists of PTP configuration options applicable only to a specific application.

Separate profiles can be defined to incorporate PTP in different scenarios based on the IEEE 1588-2008 standard. A telecom profile differs in several ways from the default behavior defined in the IEEE 1588-2008 standard and the key differences are mentioned in the subsequent sections.

The following sections describe the ITU-T Telecom Profiles that are supported for PTP.

G.8265.1 Profile

G.8265.1 profile fulfills specific frequency-distribution requirements in telecom networks. Features of G.8265.1 profile are:

- *Clock advertisement*: G.8265.1 profile specifies changes to values used in Announce messages for advertising PTP clocks. The clock class value is used to advertise the quality level of the clock, while the other values are not used.
- *Clock Selection*: G.8265.1 profile also defines an alternate Best Master Clock Algorithm (BMCA) to select port states and clocks is defined for the profile. This profile also requires to receive Sync messages (and optionally, Delay-Response messages) to qualify a clock for selection.
- *Port State Decision*: The ports are statically configured to be Master or Slave instead of using FSM to dynamically set port states.
- *Packet Rates*: The packet rates higher than rates specified in the IEEE 1588-2008 standard are used. They are:
  - Sync/Follow-Up Packets: Rates from 128 packets-per-second to 16 seconds-per-packet.
  - Delay-Request/Delay-Response Packets: Rates from 128 packets-per-second to 16 seconds-per-packet.
  - Announce Packets: Rates from 8 packets-per-second to 64 packets-per-second.
- *Transport Mechanism*: G.8265.1 profile only supports IPv4 PTP transport mechanism.
- *Mode*: G.8265.1 profile supports transport of data packets only in unicast mode.
- *Clock Type*: G.8265.1 profile only supports Ordinary Clock-type (a clock with only one PTP port).
- *Domain Numbers*: The domain numbers that can be used in a G.8265.1 profile network ranges from 4 to 23. The default domain number is 4.
- *Port Numbers*: All PTP port numbers can only be 1 because all clocks in a this profile network are Ordinary Clocks.

G.8265.1 profile defines an alternate algorithm to select between different master clocks based on the local priority given to each master clock and their quality levels (QL). This profile also defines Packet Timing Signal Fail (PTSF) conditions to identify the master clocks that do not qualify for selection. They are:

- PTSF-lossSync condition: Raised for master clocks that do not receive a reliable stream of Sync and Delay-Resp messages. Cisco IOS XR software requests Sync and Delay-Resp grants for each configured master clock to track the master clock with this condition.
- PTSF-lossAnnounce condition: Raised for master clocks that do not receive a reliable stream of Announce messages.
- PTSF-unusable condition: Raised for master clocks that receives a reliable stream of Announce, Sync, and Delay-Resp messages, but not usable by slave clocks. Cisco IOS XR software does not use this condition.

Hardware variant-specific behavior

The profile G8265.1 displays the following behavior on these hardware variants A9K-RSP5-SE, A9K-RSP5-TR, A99-RP3-SE, and A99-RP3-TR:

- Configuring either a master or slave clock type is mandatory.
- G.8265.1 is only a frequency synchronization profile and the servo state is displayed as FREQ_LOCKED and the PTP slave interface remains as slave. Phase synchronization is not supported.
- G.8265.1 profile supports only PTP pure mode and not PTP hybrid mode.

G.8273.2 Profile

The G.8273.2 profile allows distribution of time and phase synchronization across packet-based networks. Cisco's implementation supports the enhanced Class C timing mode.

Class C mode enables highly accurate clock synchronization crucial for telecom networks with stringent timing requirements, including 5G networks. This mode significantly reduces the Maximum Absolute Time Error (Max|TE|) and improves the synchronization of Telecom Boundary Clocks (T-BC) and Telecom Time Secondary Clocks (T-TSC).

Class C timing support is available for both PTP and Frequency Synchronization, ensuring comprehensive synchronization capabilities for your network.

For information on how to configure PTP, see Configuring PTP.

G.8275.1 Profile

G.8275.1 profile fulfills the time-of-day and phase synchronization requirements in telecom networks with all network devices participating in the PTP protocol. G.8275.1 profile with SyncE provides better frequency stability for the time-of-day and phase synchronization.

Features of G.8275.1 profile are:

- *Synchronization Model*: G.8275.1 profile adopts hop-by-hop synchronization model. Each network device in the path from master to slave synchronizes its local clock to upstream devices and provides synchronization to downstream devices.
- *Clock Selection*: G.8275.1 profile also defines an alternate BMCA that selects a clock for synchronization and port state for the local ports of all devices in the network is defined for the profile. The parameters defined as a part of the BMCA are:
  - Clock Class

- Clock Accuracy
- Offset Scaled Log Variance
- Priority 2
- Clock Identity
- Steps Removed
- Port Identity
- notSlave flag
- Local Priority

- *Port State Decision*: The port states are selected based on the alternate BMCA algorithm. A port is configured to a **master-only** port state to enforce the port to be a master for multicast transport mode.
- *Packet Rates*: The nominal packet rate for Announce packets is 8 packets-per-second and 16 packets-per-second for Sync/Follow-Up and Delay-Request/Delay-Response packets.
- *Transport Mechanism*: G.8275.1 profile only supports Ethernet PTP transport mechanism.
- *Mode*: G.8275.1 profile supports transport of data packets only in multicast mode. The forwarding is done based on forwardable or non-forwardable multicast MAC address.
- *Clock Type*: G.8275.1 profile supports the following clock types:
  - *Telecom Grandmaster (T-GM)*: Provides timing for other network devices and does not synchronize its local clock to other network devices.
  - *Telecom Time Slave Clock (T-TSC)*: A slave clock synchronizes its local clock to another PTP clock, but does not provide PTP synchronization to any other network devices.
  - *Telecom Boundary Clock (T-BC)*: Synchronizes its local clock to a T-GM or an upstream T-BC clock and provides timing information to downstream T-BC or T-TSC clocks.
- *Domain Numbers*: The domain numbers that can be used in a G.8275.1 profile network ranges from 24 to 43. The default domain number is 24.

Hardware variant-specific behavior

The profile G8275.1 displays the following behavior on these hardware variants A9K-RSP5-SE, A9K-RSP5-TR, A99-RP3-SE, and A99-RP3-TR:

- SyncE input is mandatory as only PTP hybrid mode is supported.
- The frequency is derived from the SyncE interface and phase adjustments are based on PTP.
- If you configure SyncE before you configure PTP, the Servo state is set to FREQ_LOCKED by default.
- After the Servo is in PHASE_LOCKED state, if the SyncE input is lost or removed, the Servo transitions to HOLDOVER state.
- After the Servo is in PHASE_LOCKED state, if the PTP input is lost or removed, the Servo transitions to FREQ_LOCKED state.

Note For the hardware variants A9K-8X100GE-X-TR, A9K-16X100GE-TR and A9K-32X100GE-TR you are not required to shut the 100 GE link to configure this profile.

G.8275.2 Profile

G.8275.2 profile fulfills the time-of-day and phase synchronization requirements in telecom networks with partial timing support from the network. Features of G.8275.2 profile are:

- *Clock Selection*: G.8275.2 profile also defines an alternate BMCA that selects a clock for synchronization and port state for the local ports of all devices in the network is defined for the profile. The parameters defined as a part of the BMCA are:
  - Clock Class
  - Clock Accuracy
  - Offset Scaled Log Variance
  - Priority 2
  - Clock Identity
  - Steps Removed
  - Port Identity
  - notSlave flag
  - Local Priority

Note See ITU-T G.8275.2 document to determine the valid values for Clock Class parameter.

- *Port State Decision*: The port states are selected based on the alternate BMCA algorithm. A port is configured to a **master-only** port state to enforce the port to be a master for unicast transport mode.
- *Packet Rates:*
  - Synchronization/Follow-Up—minimum is one packet-per-second and maximum of 128 packets-per-second.
  - Packet rate for Announce packets—minimum of one packet-per-second and maximum of eight packets-per-second.
  - Delay-Request/Delay-Response packets—minimum is one packet-per-second and maximum of 128 packets-per-second
- *Transport Mechanism*: G.8275.2 profile supports only IPv4 and IPv6 PTP transport mechanism.
- *Mode*: G.8275.2 profile supports transport of data packets only in unicast mode.
- *Clock Type*: G.8275.2 profile supports the following clock types:

- *Telecom Grandmaster (T-GM)*: Provides timing for other network devices and does not synchronize its local clock to other network devices.
- *Telecom Time Slave Clock (T-TSC)*: A slave clock synchronizes its local clock to another PTP clock, but does not provide PTP synchronization to any other network devices.
- *Telecom Boundary Clock (T-BC)*: Synchronizes its local clock to a T-GM or an upstream T-BC clock and provides timing information to downstream T-BC or T-TSC clocks.

- *Domain Numbers*: The domain numbers that can be used in a G.8275.2 profile network ranges from 44 to 63. The default domain number is 44.

Hardware variant-specific behavior

The profile G8275.2 displays the following behavior on these hardware variants A9K-RSP5-SE, A9K-RSP5-TR, A99-RP3-SE, and A99-RP3-TR:

- Hybrid PTP and pure PTP are supported on this profile.
- The physical-layer-frequency command must be used to configure Hybrid PTP.
- To switch from Hybrid PTP to Pure PTP, you must remove the physical-layer-frequency configuration and frequency synchronization configuration to remove SyncE inputs from line card interfaces and RSP clock-interfaces.

Configuring PTP

Prerequisite

You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

PTP Interface and Profile Configuration

When a global PTP profile is attached to an interface, its values are used as default settings for that interface. When additional settings are configured under an interface itself, these settings override the defaults in that profile. When no profile is attached to an interface, the configuration on the interface is used to determine the PTP settings for that interface.

When configuring PTP, use one of the following approaches:

- Create a profile (or multiple profiles) containing all the default settings to use on all PTP interfaces. Override any settings that differ for particular interfaces by using the interface configuration under the interfaces themselves.
- Configure all settings separately for each interface, without using any global profiles. Use this approach if the interfaces do not have consistent settings, or if you are configuring only a small number of PTP interfaces.

Configuring Frequency Synchronization and Quality Settings for PTP

This procedure describes the steps involved to configure frequecy and quality settings for PTP on a router.

1. To enable frequency synchronization on the router, use **frequency synchronization** command in the configuration mode.

```
RP/0/RSP0/CPU0:router(config)# frequency synchronization
```

2. To configure ITU-T quality parameters, use **quality itu-t option** *option* **generation** *number* command in the frequency synchronization configuration mode.
   - **option 1**: Includes PRC, SSU-A, SSU-B, SEC, and DNU. This is the default option.
   - **option 2 generation 1**: Includes PRS, STU, ST2, ST3, SMC, and DUS.
   - **option 2 generation 2**: Includes PRS, STU, ST2, ST3, TNC, ST3E, SMC, and DUS.

Note The **quality option** configured here must match the **quality option** specified in the **quality receive** and **quality transmit** commands.

```
RP/0/RSP0/CPU0:router(config-freqsync)# quality itu-t
option 2 generation 2
```

Verification

To display the frequency synchronization selection, use **show frequency synchronization selection** command.

```
RP/0/RSP0/CPU0:router# show frequency synchronization selection
Node 0/RSP1/CPU0:
==============
Selection point: T0-SEL-B (3 inputs, 1 selected)
  Last programmed 06:49:27 ago, and selection made 06:49:15 ago
  Next selection points
    SPA scoped    : None
    Node scoped   : T4-SEL-C CHASSIS-TOD-SEL
    Chassis scoped: LC_TX_SELECT
    Router scoped : None
  Uses frequency selection
  Used for local line interface output
  S  Input                     Last Selection Point         QL  Pri  Status
  == ========================  ========================  =====  ===  ==========
  1  Sync1 [0/RSP1/CPU0]       n/a                         PRC    1  Locked
     HundredGigE0/5/0/2        0/5/CPU0 ETH_RXMUX 1        PRC    1  Available
     Internal0 [0/RSP1/CPU0]   n/a                         SEC  255  Available

Selection point: T4-SEL-A (1 inputs, 1 selected)
  Last programmed 06:49:27 ago, and selection made 06:49:15 ago
  Next selection points
    SPA scoped    : None
    Node scoped   : T4-SEL-C
    Chassis scoped: None
    Router scoped : None
  Uses frequency selection
  S  Input                     Last Selection Point         QL  Pri  Status
```

```
  == ========================  ========================  =====  ===  ===========
  1  HundredGigE0/5/0/2        0/5/CPU0 ETH_RXMUX 1        PRC    1  Available

Selection point: T4-SEL-C (2 inputs, 1 selected)
  Last programmed 06:49:15 ago, and selection made 06:49:15 ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: None
    Router scoped : None
  Uses frequency selection
  Used for local clock interface output
  S  Input                     Last Selection Point         QL  Pri  Status
  == ========================  ========================  =====  ===  ===========
  1  Sync1 [0/RSP1/CPU0]       0/RSP1/CPU0 T0-SEL-B 1      PRC    1  Locked
     HundredGigE0/5/0/2        0/RSP1/CPU0 T4-SEL-A 1      PRC    1  Available

Selection point: CHASSIS-TOD-SEL (1 inputs, 1 selected)
  Last programmed 6d04h ago, and selection made 6d04h ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: None
    Router scoped : None
  Uses time-of-day selection
  S  Input                     Last Selection Point      Pri  Time  Status
  == ========================  ========================  ===  ====  ===========
  1  Sync1 [0/RSP1/CPU0]       0/RSP1/CPU0 T0-SEL-B 1    100  Yes   Available

Node 0/3/CPU0:
==============
Selection point: ETH_RXMUX (0 inputs, 0 selected)
  Last programmed 9w6d ago, and selection made 9w6d ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: T0-SEL-B T4-SEL-A
    Router scoped : None
  Uses frequency selection

Selection point: LC_TX_SELECT (1 inputs, 1 selected)
  Last programmed 9w6d ago, and selection made 9w6d ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: None
    Router scoped : None
  Uses frequency selection
  Used for local line interface output
  S  Input                     Last Selection Point         QL  Pri  Status
  == ========================  ========================  =====  ===  ===========
  24 Sync1 [0/RSP1/CPU0]       0/RSP1/CPU0 T0-SEL-B 1      PRC    1  Available

Node 0/5/CPU0:
==============
Selection point: ETH_RXMUX (1 inputs, 1 selected)
  Last programmed 06:49:27 ago, and selection made 06:49:27 ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: T0-SEL-B T4-SEL-A
    Router scoped : None
  Uses frequency selection
  S  Input                     Last Selection Point         QL  Pri  Status
```

```
  == ========================  ========================  =====  ===  ===========
  1  HundredGigE0/5/0/2        n/a                         PRC    1  Available

Selection point: LC_TX_SELECT (1 inputs, 1 selected)
  Last programmed 6d04h ago, and selection made 6d04h ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: None
    Router scoped : None
  Uses frequency selection
  Used for local line interface output
  S  Input                     Last Selection Point         QL  Pri  Status
  == ========================  ========================  =====  ===  ===========
  24 Sync1 [0/RSP1/CPU0]       0/RSP1/CPU0 T0-SEL-B 1      PRC    1  Available
```

Configuring Global Profile

This procedure describes the steps involved to create a global configuration profile for a PTP interface that can then be assigned to any interface as required.

Note Prior to Cisco IOS XR Software Release 6.3.3, the default PTP timers for G2875.1 were not set to standard values. This could lead to interoperability issues with other routers running the timers with updated values. Hence, to prevent such issues arising due to difference in packet rates, you must explicitly configure the **announce interval** value to 8, **sync frequency** value to 16 and **delay-request frequency** value to 16 while configuring global g.2875.1 profile.

1. To enter the PTP configuration mode, use **ptp** command in the configuration mode.

   ```
   RP/0/RSP0/CPU0:router(config)# ptp
   ```

2. To configure a PTP profile, use **profile** command in the ptp configuration mode.

   ```
   RP/0/RSP0/CPU0:router(config-ptp)# profile tp64
   ```

3. To configure frequency for a Sync message for the given PTP profile, use **sync frequency** *rate* command in the ptp-profile configuration mode.

   ```
   RP/0/RSP0/CPU0:router(config-ptp-profile)# sync frequency 16
   ```

4. To configure delay-request frequency for the given PTP profile, use **delay-request frequency** *rate* command in the ptp-profile configuration mode.

   ```
   RP/0/RSP0/CPU0:router(config-ptp-profile)# delay-request frequency 16
   ```

Verification

To display the configured PTP profile details, use **show run ptp** command.

```
RP/0/RSP0/CPU0:router# show run ptp

Wed Feb 28 11:16:05.943 UTC
```

```
ptp
clock
  domain 24
  profile g.8275.1 clock-type T-BC
!
profile slave
  transport ethernet
  sync frequency 16
  announce interval 1
  delay-request frequency 16
!
profile master
  transport ethernet
  sync frequency 16
  announce interval 1
  delay-request frequency 16
!
profile slave1
  transport ethernet
  sync frequency 64
  announce interval 1
  delay-request frequency 64
!
```

Configuring PTP Slave Interface

This procedure describes the steps involved to configure a PTP interface to be a Slave.

1. To configure an interface, use **interface** *type interface-path-id* command in the configuration mode.

   ```
   RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/1/0/5
   ```

2. To enter the PTP configuration mode for the given interface, use **ptp** command in the interface configuration mode.

   ```
   RP/0/RSP0/CPU0:router(config-if)# ptp
   ```

3. To configure a PTP profile (or specify a previously defined profile), use **profile** *name* command in the ptp interface configuration mode.

Note Any additional commands entered in ptp-interface configuration mode overrides the global profile settings.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# profile tp64
```

4. To configure the transport mode for all PTP messages in the given PTP profile, use **transport** *mode_type* command in the ptp interface configuration mode.

   ```
   RP/0/RSP0/CPU0:router(config-if-ptp)# transport ipv4
   ```

5. To configure timeout for PTP announce messages in the given PTP profile, use **announce interval** *interval-value* command in the ptp interface configuration mode.

   ```
   RP/0/RSP0/CPU0:router(config-if-ptp)# announce interval 1
   ```

6. To configure the port state, use **port state** command in the ptp interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# port state slave-only
```

7. To configure IPv4 or IPv6 address for PTP master, use **master ipv4|ipv6** *address* command in the ptp interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# master ipv4 192.168.2.1

RP/0/RSP0/CPU0:router(config-if-ptp)# master ipv6 2001:DB8::1
```

8. To return to the interface configuration mode, use **exit** command.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# exit
```

9. To configure a gateway for the given interface, use **ipv4 address** *address mask* command in the interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 1.7.1.2 255.255.255.0
```

Verification

To verify the port state details, use **show run interface** *interface-name* command.

```
RP/0/RSP0/CPU0:router# show run interface TenGigE 0/1/0/5

Fri Aug  3 19:57:14.184 UTC
interface TenGigE 0/1/0/5
 ptp
  profile tp64
  transport ipv4
  port state slave-only
  master ipv4 192.168.2.1
  !
  announce interval 1
  !
 ipv4 address 1.7.1.1 255.255.255.0
!
```

Configuring PTP Master Interface

This procedure describes the steps involved to configure a PTP interface to be a Master.

1. To configure an interface, use **interface** *type interface-path-id* command in the configuration mode.

```
RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/1/0/5
```

2. To enter the PTP configuration mode for the given interface, use **ptp** command in the interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-if)# ptp
```

3. To configure a PTP profile (or specify a previously defined profile), use **profile** *name* command in the ptp interface configuration mode.

Note Any additional commands entered in PTP interface configuration mode override settings in this profile.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# profile tp64
```

4. To configure the transport mode for all PTP messages in the given PTP profile, use **transport** *mode_type* command in the ptp interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# transport ipv4
```

5. To configure timeout for PTP announce messages in the given PTP profile, use **announce interval** *interval-value* command in the ptp interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# announce interval 1
```

6. To return to the interface configuration mode, use **exit** command.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# exit
```

7. To configure a gateway for the given interface, use **ipv4 address** *address mask* command in the interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 1.7.1.2 255.255.255.0
```

Verification

To verify the port state details, use **show run interface** *interface-name* command.

```
RP/0/RSP0/CPU0:router# show run interface TenGigE 0/1/0/5

Fri Aug  3 13:57:44.366 PST
interface TenGigE 0/1/0/5
 ptp
  profile tp64
  transport ipv4
  !
  announce interval 1
  !
  ipv4 address 1.7.1.2 255.255.255.0
 !
```

Configuring PTP Hybrid Mode

This procedure describes the steps involved to configure router in a hybrid mode. You can do this by selecting PTP for Time-of-Day (ToD) and another source for frequency.

Note Configure appropriate clock priorities when using synchronous Ethernet for frequency synchronization. This ensures the system selects the frequency source from the same interface as the PTP source. Aligning both frequency and time synchronization to the same interface helps maintain consistency and reduces configuration complexity.

1. To enable frequency synchronization on the router, use **frequency synchronization** command in the configuration mode.

```
RP/0/RSP0/CPU0:router(config)# frequency synchronization
```

2. To configure a SyncE source, create an interface to be a SyncE input. This can be configured using **interface** command in the configuration mode.

Note The time-of-day-priority setting specifies that SyncE to be used as a ToD source if there is no source available with a lower priority.

```
RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/1/0/0
RP/0/RSP0/CPU0:router(config-if)# frequency synchronization
RP/0/RSP0/CPU0:router(config-if-freqsync)# selection input
RP/0/RSP0/CPU0:router(config-if-freqsync)# time-of-day-priority 100
RP/0/RSP0/CPU0:router(config-if-freqsync)# commit
```

3. To configure PTP as the source for ToD, enable PTP on the router using **ptp** command in command in the configuration mode. ToD priority values can range from 1 (highest priority) to 254 (lowest priority).

```
RP/0/RSP0/CPU0:router(config)# ptp
RP/0/RSP0/CPU0:router(config-ptp)# time-of-day-priority 1
RP/0/RSP0/CPU0:router(config)# commit
```

4. To confiure a PTP interface, use **interface** command in configuration mode. To enable this interface as a PTP Master, use **master** command in ptp-interface configuration mode.

```
RP/0/RSP0/CPU0:router(config)# interface gigabitEthernet 0/1/0/1
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 10.0.0.1/24
RP/0/RSP0/CPU0:router(config-if)# ptp
RP/0/RSP0/CPU0:router(config-if-ptp)# master ipv4 10.0.0.2
RP/0/RSP0/CPU0:router(config-if-ptp)# commit
```

Verification

To display the frequency synchronization selection, use **show frequency synchronization selection** command.

```
RP/0/RSP0/CPU0:router# show frequency synchronization selection
Node 0/RSP1/CPU0:
==============
Selection point: T0-SEL-B (3 inputs, 1 selected)
  Last programmed 06:49:27 ago, and selection made 06:49:15 ago
```

```
  Next selection points
    SPA scoped    : None
    Node scoped   : T4-SEL-C CHASSIS-TOD-SEL
    Chassis scoped: LC_TX_SELECT
    Router scoped : None
  Uses frequency selection
  Used for local line interface output
  S  Input                     Last Selection Point         QL  Pri  Status
  == ========================  ========================  =====  ===  ===========
  1  Sync1 [0/RSP1/CPU0]       n/a                         PRC    1  Locked
     HundredGigE0/5/0/2        0/5/CPU0 ETH_RXMUX 1        PRC    1  Available
     Internal0 [0/RSP1/CPU0]   n/a                         SEC  255  Available

Selection point: T4-SEL-A (1 inputs, 1 selected)
  Last programmed 06:49:27 ago, and selection made 06:49:15 ago
  Next selection points
    SPA scoped    : None
    Node scoped   : T4-SEL-C
    Chassis scoped: None
    Router scoped : None
  Uses frequency selection
  S  Input                     Last Selection Point         QL  Pri  Status
  == ========================  ========================  =====  ===  ===========
  1  HundredGigE0/5/0/2        0/5/CPU0 ETH_RXMUX 1        PRC    1  Available

Selection point: T4-SEL-C (2 inputs, 1 selected)
  Last programmed 06:49:15 ago, and selection made 06:49:15 ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: None
    Router scoped : None
  Uses frequency selection
  Used for local clock interface output
  S  Input                     Last Selection Point         QL  Pri  Status
  == ========================  ========================  =====  ===  ===========
  1  Sync1 [0/RSP1/CPU0]       0/RSP1/CPU0 T0-SEL-B 1      PRC    1  Locked
     HundredGigE0/5/0/2        0/RSP1/CPU0 T4-SEL-A 1      PRC    1  Available

Selection point: CHASSIS-TOD-SEL (1 inputs, 1 selected)
  Last programmed 6d04h ago, and selection made 6d04h ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: None
    Router scoped : None
  Uses time-of-day selection
  S  Input                     Last Selection Point      Pri  Time  Status
  == ========================  ========================  ===  ====  ===========
  1  Sync1 [0/RSP1/CPU0]       0/RSP1/CPU0 T0-SEL-B 1    100  Yes   Available

Node 0/3/CPU0:
==============
Selection point: ETH_RXMUX (0 inputs, 0 selected)
  Last programmed 9w6d ago, and selection made 9w6d ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: T0-SEL-B T4-SEL-A
    Router scoped : None
  Uses frequency selection

Selection point: LC_TX_SELECT (1 inputs, 1 selected)
  Last programmed 9w6d ago, and selection made 9w6d ago
```

```
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: None
    Router scoped : None
  Uses frequency selection
  Used for local line interface output
  S  Input                     Last Selection Point         QL  Pri  Status
  == ========================  ========================  =====  ===  ===========
  24 Sync1 [0/RSP1/CPU0]       0/RSP1/CPU0 T0-SEL-B 1      PRC    1  Available

Node 0/5/CPU0:
==============
Selection point: ETH_RXMUX (1 inputs, 1 selected)
  Last programmed 06:49:27 ago, and selection made 06:49:27 ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: T0-SEL-B T4-SEL-A
    Router scoped : None
  Uses frequency selection
  S  Input                     Last Selection Point         QL  Pri  Status
  == ========================  ========================  =====  ===  ===========
  1  HundredGigE0/5/0/2        n/a                         PRC    1  Available

Selection point: LC_TX_SELECT (1 inputs, 1 selected)
  Last programmed 6d04h ago, and selection made 6d04h ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: None
    Router scoped : None
  Uses frequency selection
  Used for local line interface output
  S  Input                     Last Selection Point         QL  Pri  Status
  == ========================  ========================  =====  ===  ===========
  24 Sync1 [0/RSP1/CPU0]       0/RSP1/CPU0 T0-SEL-B 1      PRC    1  Available
```

Configuring Leap Seconds

This procedure describes the steps involved in leap second configuration. The configuration can be executed in two ways:

- By directly providing the **UTC offset value** in the command.
- By providing the path to a **file** in the command, where the UTC offset information is stored (or available).

1. To enter the PTP configuration mode, use **ptp** command in the configuration mode.

   ```
   RP/0/RSP0/CPU0:router(config)# ptp
   ```

2. To configure the UTC offset information by providing the offset value directly, use { **utc-offset** {**baseline** | *date* } { *offset-value* } } command in the ptp configuration mode.
   - Using the **baseline** keyword, enter a positive number for the *offset-value* (it is assumed that a negative UTC offset will not be required).

- **OR** provide a date (in YYYY-MM-DD format) and the *offset-value* . UTC offset used by PTP will be updated on this date. If you do not specify a date, the configuration is applied for the current day, at midnight.

Note In both cases, providing the UTC *offset-value* directly in the command is mandatory.

```
RP/0/RSP0/CPU0:router(config-ptp)# utc-offset baseline 37

RP/0/RSP0/CPU0:router(config-ptp)# utc-offset 2018-07-01 38
```

3. To configure UTC offset information by providing the path to a file containing the UTC offset information, use { **utc-offset leap-second-file** { *file-path* } } [**poll-frequency** *days*] command in the ptp configuration mode. Optionally, you can provide a polling frequency in days, at which to poll the file for changes. If a frequency for polling is not specified, the file will polled on the day the file is set to expire.

Note The format of this file must be based on the canonical list present at http://www.ietf.org/timezones/data/leap-seconds.list.

```
RP/0/RSP0/CPU0:router(config-ptp)# utc-offset leap-second-file http://<remote-url>

RP/0/RSP0/CPU0:router(config-ptp)# utc-offset leap-second-file file://<local-path>
poll-frequency 7
```

Verification

To display the current UTC offset value, use **show ptp utc-offset** command.

```
RP/0/RSP0/CPU0:router# show ptp utc-offset

Current offset: +36 seconds (not valid)
Pending leap seconds:
 From 2017-01-01 offset will be +37 seconds
 From 2018-07-01 offset will be +38 second
 From 2019-07-01 offset will be +39 seconds
Source: User-configured
```

To display the current UTC offset value and related details, use **show ptp utc-offset detail** command.

```
RP/0/RSP0/CPU0:router# show ptp utc-offset detail

Current offset: +36 seconds (valid)
Known leap seconds:
From 1996-01-01 offset was +30 seconds
From 1997-07-01 offset was +31 seconds
From 1999-01-01 offset was +32 seconds
From 2006-01-01 offset was +33 seconds
From 2009-01-01 offset was +34 seconds
From 2012-07-01 offset was +35 seconds
From 2015-07-01 offset was +36 seconds
```

```
From 2017-01-01 offset will be +37 seconds
Source: file:///test/xxxuser/leapsec/test/list-leap-seconds.list
Expiry date: 2017-12-28
```

Configuring Multiple PTP Profile Interoperability

This procedure describes the steps involved in configuring interoperability for PTP profiles.

1. To configure an interface and then enter the PTP configuration mode, use **interface** and **ptp** commands respectively.

```
RP/0/RSP0/CPU0:router(config)# interface tenGigE 0/0/0/9

RP/0/RSP0/CPU0:router(config-if)# ptp
```

2. To configure PTP profile, use **profile** command in the interface-ptp configuration mode.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# profile interop-slave
```

3. To configure interoperability, use **interop** command in the interface-ptp configuration mode.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# interop
```

4. To configure the Telecom profile and domain number to interoperate with, use **profile {profile-type}** and **domain** *domain-number* commands in the interface-ptp-interop configuration mode.

```
RP/0/RSP0/CPU0:router(config-if-ptp-interop)# profile g.8275.2

RP/0/RSP0/CPU0:router(config-if-ptp-interop)# domain 44
```

5. To enable conversion of packets on ingress, use **ingress-conversion** command in the interface-ptp-interop configuration mode. The **ingress-conversion** command, converts the packets received from the incoming Announce messages.

```
RP/0/RSP0/CPU0:router(config-if-ptp-interop)#
ingress-conversion
```

6. To explicitly configure the other related parameters, use the respective commands in the interop-ingress submode.

Note Default values are used for parameters that are not explicitly configured during ingress-conversion. For example, default values will be used for parameters like **ClockAccuracy** or **OffsetScaledLogVariance** if they are not explicitly configured.

```
RP/0/RSP0/CPU0:router(config-if-ptp-interop-ingress)#
priority1 10
priority2 10
```

7. To enable conversion of packets on egress, use **egress-conversion** command in the interface-ptp-interop configuration mode. The **egress-conversion** command converts the packets sent through the outgoing Announce messages. The configuration is the same as for ingress conversion.

```
RP/0/RSP0/CPU0:router(config-if-ptp-interop)#
egress-conversion
```

Verification

To display the interop conversions, use **show ptp interop** command.

```
RP/0/RSP0/CPU0:router# show ptp interop tenGigE 0/0/0/9
Egress Conversions:
    Profile:                    Default -> G.8275.2
    Domain:                           0 -> 10
    Priority1:                        1 -> 128
    Priority2:                      100 -> 100
    ClockClass:                      52 -> 140
    ClockAccuracy:                    0 -> 0x21
    OffsetScaledLogVariance:          0 -> 0x4e5d

  Ingress Conversions:
    Profile:                  G.8275.2 -> Default
    Domain:                         10 -> 0
    Master 51.51.51.51:
      Priority1:                      1 -> 100
      Priority2:                      2 -> 254
      ClockClass:                     3 -> 13
      ClockAccuracy:               0x20 -> 0x20
      OffsetScaledLogVariance:   0x4e5d -> 0x4e5d
```

Configuring PTP Telecom Profile Interface

This procedure describes the steps involved to create an interface for PTP ITU-T Telecom Profiles.

Note It is also possible to make these definitions within a global PTP profile and attach them to the interface using the profile command in PTP interface configuration mode.

1. To configure an interface, use **interface** *type interface-path-id* command in the configuration mode.

```
RP/0/RSP0/CPU0:router(config)# interface gigabitethernet 0/1/0/1
```

2. To enter the PTP configuration mode for the given interface, use **ptp** command in the interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-if)# ptp
```

3. To configure a PTP profile (or specify a previously defined profile), use **profile** *name* command in the ptp-interface configuration mode.

Note Any additional commands entered in ptp-interface configuration mode overrides the global profile settings.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# profile tele64
```

4. To configure frequency for Sync or Delay-request messages for the given ptp interface, use **sync frequency** *rate* command or **delay-request frequency** *rate* command appropriately in the ptp-interface configuration mode. The valid configurable values are **2, 4, 8, 16, 32, 64 or 128**.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# sync frequency 128

RP/0/RSP0/CPU0:router(config-if-ptp)# delay-request frequency 128
```

5. To configure duration for different PTP messages, use one of the following commands in the ptp-interface configuration mode: **announce grant-duration** *duration*, **sync grant-duration** *duration*, or **delay-response grant-duration** *duration*. The duration value can be between **60 and 1000 seconds**.

Note This duration value represents the length of grant that is requested for a port in Slave state and represents the maximum grant-duration allowed when the port is in Master state.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# announce grant-duration 120

RP/0/RSP0/CPU0:router(config-if-ptp)# sync grant-duration 120

RP/0/RSP0/CPU0:router(config-if-ptp)# delay-response grant-duration 120
```

6. To configure a timeout value, length of time by when a PTP message must be received (before PTSF-lossSync is raised), use one of the following commands in the ptp-interface configuration mode: **sync timeout** *timeout* or **delay-response timeout** *timeout*. The timeout value can be between **100 to 10000 micro seconds**.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# sync timeout 120

RP/0/RSP0/CPU0:router(config-if-ptp)# delay-response timeout 120
```

7. To configure a response for unicast-grant invalid-request, use **unicast-grant invalid-request {reduce | deny}** command. The response for requests with unacceptable parameters would either be denied or granted with reduced parameters.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# unicast-grant
invalid-request reduce
```

8. To configure IPv4 or IPv6 address for a PTP master, use **master {ipv4 | ipv6}** *ip-address* command in the ptp-interface configuration mode.

```
RP/0/RSP0/CPU0:router(config-if-ptp)# master ipv4 192.168.2.1

RP/0/RSP0/CPU0:router(config-if-ptp)# master ipv6 2001:DB8::1
```

9. To override the clock-class received in Announce messages from the specified Master, use **clock-class** *class* command in the ptp-master-interface configuration mode. The class values can range from **0 to 255**.

```
RP/0/RSP0/CPU0:router(config-if-ptp-master)# clock-class 2
```

Verification

To display the PTP interface details, use **show ptp interfaces brief** command.

```
RP/0/RSP0/CPU0:router# show ptp interfaces brief
Fri Feb  9 11:16:45.248 UTC
Intf              Port         Port                 Line
Name              Number       State        Encap   State         Mechanism
-------------------------------------------------------------------------------
BE1               1            Slave        IPv4    up            2-step DRRM
Gi0/0/0/40        2            Master       IPv4    up            2-step DRRM
```

To verify the configured profile details, use **show run interface** *interface-name* command.

```
RP/0/RSP0/CPU0:router# show run interface Gi0/0/0/33

Wed Feb 28 11:49:16.940 UTC
interface GigabitEthernet0/0/0/33
ptp
  profile slave
  multicast target-address ethernet 01-1B-19-00-00-00
  transport ethernet
  port state slave-only
  clock operation two-step
!
ipv4 address 21.1.1.2 255.255.255.0
frequency synchronization
  selection input
  priority 5
  wait-to-restore 0
!
```

Configuring PTP Telecom Profile Clock

This procedure describes the steps involved to configure PTP clock and its settings to be consistent with ITU-T Telecom Profiles for Frequency.

1. To enter the PTP configuration mode, use **ptp** command in the configuration mode.

```
RP/0/RSP0/CPU0:router(config)# ptp
```

2. To enter the PTP-clock configuration mode, use **clock** command in the ptp-configuration mode.

```
RP/0/RSP0/CPU0:router(config-ptp)# clock
```

3. To configure the domain-number for a PTP profile, use **domain** *number* command in the ptp-configuration mode. The allowed domain number range for G.8265.1 profile is between **4 and 23** and the range for G.8275.1 profile is between **24 and 43**.

```
RP/0/RSP0/CPU0:router(config-ptp)# domain 24
```

4. To configure timescale, use **timescale** *source* command in the ptp-clock configuration mode.

```
RP/0/RSP0/CPU0:router(config-ptp-clock)# timescale PTP
```

5. To configure the time-source that will be advertised in Announce messages, use **time-source** *source* command in the ptp-clock configuration mode. The allowed options are: atomic-clock, GPS, hand-set, internal-oscillator, NTP, other, PTP, and terrestrial-radio.

```
RP/0/RSP0/CPU0:router(config-ptp-clock)# time-source GPS
```

6. To exit the ptp-clock configuration mode, use **exit** command.

```
RP/0/RSP0/CPU0:router(config-ptp-clock)# exit
```

7. To configure the desired telecom profile and the clock type for the profile, use **clock profile { g.8265.1 | g.8275.1 | g.8275.2} clock-type {T-GM | T-BC | T-TSC}** command in the ptp configuration mode.

Note The **clock-selection telecom-profile** and **clock-advertisement telecom-profile** commands are deprecated from Release 6.1.2. They are replaced by the **clock profile** command.

```
RP/0/RSP0/CPU0:router(config-ptp)# clock profile g.8275.1 clock-type T-BC
```

Verification

To display the configured PTP clock profile details, use **show run ptp** command.

```
RP/0/RSP0/CPU0:router# show run ptp !
ptp
clock
  domain 24
  profile g.8275.1 clock-type T-BC
!
profile slave
  sync frequency 16
  announce frequency 8
  delay-request frequency 16
!
profile master
  sync frequency 16
  announce frequency 8
  delay-request frequency 16
!
log
  servo events
  best-master-clock changes
!
!
```

To verify that PTP has been enabled on the router and the device is in LOCKED Phase, use **show ptp platform servo** command.

```
RP/0/RSP0/CPU0:router # show ptp platform servo

Fri Feb  9 11:16:54.568 UTC
Servo status: Running
```

```
Servo stat_index: 2
Device status: PHASE_LOCKED
Servo log level: 0
Phase Alignment Accuracy: 1 ns
Sync timestamp updated: 111157
Sync timestamp discarded: 0
Delay timestamp updated: 111157
Delay timestamp discarded: 0
Previous Received Timestamp T1: 1518155252.263409770  T2: 1518155252.263410517  T3:
1518155252.287008362  T4: 1518155252.287009110
Last Received Timestamp T1: 1518155252.325429435  T2: 1518155252.325430194  T3:
1518155252.348938058  T4: 1518155252.348938796
Offset from master:  0 secs, 11 nsecs
Mean path delay   :  0 secs, 748 nsecs
setTime():2  stepTime():1  adjustFreq():10413 adjustFreqTime():0
Last setTime: 1.000000000 flag:1  Last stepTime:-736216, Last adjustFreq:465
```

Configuring Class C Timing Mode

Configuration Example

Use the **timing-accuracy enhanced** command to switch to Class C from Class B mode.

```
Router#configure
Router(config)#frequency synchronization
Router(config-freqsync)#timing-accuracy enhanced
Router(config-freqsync)#commit
```

Verification

Use the **show running-config frequency synchronization** command to verify that you have enhanced to Class C mode from Class B mode.

```
Router#show running-config frequency synchronization
frequency synchronization
 quality itu-t option 1
 clock-interface timing-mode system
 timing-accuracy enhanced
 !
```

System Log

The following system log informs you about the successful mode change from Class B to Class C:

```
RP/0/RSP0/CPU0:Sep 2 15:51:50.784 UTC: dao_tmp[119]:
%PLATFORM-CLKCTRL-5-CLOCK_ACCURACY_ENHANCED : System timing switching to enhanced accuracy
 mode
```

Configuring PTP Delay Asymmetry

Table 12: Feature History Table

Feature Name	Release Information	Description
PTP Delay Asymmetry	Release 7.3.1	Any delays on Precision Time Protocol (PTP) paths can impact PTP accuracy and in turn impact clock settings for all devices in a network. This feature allows you to configure the static asymmetry such that the delay is accounted for and the PTP synchronization remains accurate. The **delay-symmetry** command is introduced for this feature.

Configure PTP delay asymmetry to offset the static delays on a PTP path that occur due to different route selection for forward and reverse PTP traffic. Delays can also be due to any node having different delay for ingress or egress path. These delays can impact PTP accuracy due to the asymmetry in PTP. With this feature, you can enable a higher degree of accuracy in the PTP server performance leading to better synchronization between real-time clocks of the devices in a network. Better synchronization between the clocks of different devices in a network leads to a network that performs efficiently.

Configuration of this delay asymmetry provides an option to configure static delays on a client clock for every server clock. You can configure this value in microseconds and nanoseconds. Configured PTP delay asymmetry is also synchronized with the Servo.

Note If you configure multiple PTP delay asymmetries for the same PTP profile, the latest PTP delay asymmetry that you configure is applied to the PTP profile.

A positive value indicates that the server-to-client propagation time is longer than the client-to-server propagation time, and conversely for negative values.

Supported PTP Profiles

The following PTP profiles support the configuration of PTP delay asymmetry:

- PTP over IP (G8275.2 or default profile)
- PTP over L2 (G8275.1)

Restrictions

- PTP delay asymmetry can be configured only on the PTP port of the grandmaster clock, which can either be a boundary clock or an ordinary clock.

- For G875.1 and G875.2 PTP profiles, PTP delay asymmetry is supported for both, client port and dynamic port that act as a client.
- PTP delay asymmetry is supported for fixed cable delay compensation and not for variable delay in the network.
- PTP delay asymmetry can be configured within the range of 3 microseconds and -3 microseconds or 3000 nanoseconds and -3000 nanoseconds.
- Fixed delay can be measured by using any test and measurement tool. Fixed delay can be compensated by using the positive or negative values. For example, if the fixed delay is +10 nanoseconds, configure -10 nanoseconds to compensate the fixed delay.

Configuration

To configure PTP delay asymmetry:

1. Configure an interface with PTP.
2. Configure PTP delay asymmetry on the client side.

Configuration Example

```
/* Configure an interface with PTP. */
Router# configure
Router(config)# interface HundredGigE 0/1/0/0
Router(config-if)# ptp

/* Configure PTP delay asymmetry on the client side. */
Router(config-if-ptp-master)# delay-asymmetry 3 microseconds
Router(config-if-ptp-master)# commit
```

Running Configuration

```
interface preconfigure HundredGigE 0/1/0/0
 ptp
  delay-asymmetry 3 microseconds
```

Verification

To verify if PTP delay asymmetry delay is applied, use the **show ptp foreign-masters** command:

```
Router# show ptp foreign-masters
Sun Nov 1 10:19:21.874 UTC
Interface HundredGigE0/1/0/0 (PTP port number 1)
IPv4, Address 209.165.200.225, Unicast
Configured priority: 1
Configured clock class: None
Configured delay asymmetry: 3 microseconds <------ configured variable delay asymmetry value
Announce granted: every 2 seconds, 300 seconds
Sync granted: 16 per-second, 300 seconds
Delay-resp granted: 16 per-second, 300 seconds
Qualified for 2 minutes, 45 seconds
Clock ID: 80e01dfffe8ab73f
Received clock properties:
Domain: 0, Priority1: 128, Priority2: 128, Class: 6
Accuracy: 0x22, Offset scaled log variance: 0xcd70
Steps-removed: 1, Time source: GPS, Timescale: PTP
Frequency-traceable, Time-traceable
```

```
Current UTC offset: 37 seconds (valid)
Parent properties:
Clock ID: 80e01dfffe8ab73f
Port number: 1
```

To validate the approximate compensated delay value, use the **show ptp platform servo** command:

```
Router# show ptp platform servo
Sat Nov 1 15:17:14.611 UTC
Servo status: Running
Servo stat_index: 2
Device status: PHASE_LOCKED
Servo Mode: Non Hybrid
Servo log level: 0
Phase Alignment Accuracy: -3 ns
Sync timestamp updated: 54754
Sync timestamp discarded: 0
Delay timestamp updated: 55196
Delay timestamp discarded: 0
Previous Received Timestamp T1: 1563984472.036333938 T2: 1563984472.036334935 T3:
1563984472.077066895 T4: 1563984472.077067478
Last Received Timestamp T1: 1563984472.100355188 T2: 1563984472.100356182 T3:
1563984472.139059682 T4: 1563984472.139060266
Offset from master: 0 secs, 6 microsecs <--------------- compensated value, showing 6
microseconds because actual fixed delay is 3 microseconds, we configured 3 microseconds and
 router detected it as fixed delay and tries to compensate.
Mean path delay : 0 secs, 771 nsecs
setTime():1 stepTime():0 adjustFreq():4278
Last setTime: 1563981048.000000000 flag:0 Last stepTime:0 Last adjustFreq:51511
```

Double Failure Clock Class Over-ride

Table 13: Feature History Table

Feature Name	Release Information	Feature Description
PTP Double Failure Clock Class	Release 7.7.1	This feature enables you to configure a clock class that will over-ride the existing class during a state of double-failure where PTP and SyncE are lost. This feature introduces the **double-failure-clock-class** command.

PTP Holdover Traceability suppression

Table 14: Feature History Table

Feature Name	Release Information	Feature Description
PTP Holdover Traceability Suppression	Release 7.3.1	When a device which is configured as a Boundary clock (T-BC) loses synchronization with a quality Primary clock, to ensure that the downstream nodes continue to receive the configured clock class for a specified duration, and it's traceable you can configure this feature.

When the device loses synchronization with a quality Primary clock, to ensure the downstream nodes continue to receive the configured clock class, and it is traceable you can configure this feature.

This feature enables the device which is configured as a boundary clock (T-BC) with PTP Profiles G.8275.1 or G.8275.2 to send out the configured clock-class as holdover clock-class and the time traceability flag to be set as TRUE for the specified duration. This is to ensure the downstream nodes do not have an impact as this is a deviation from prescribed G.8275.1 ITU-T standards.

Note

- There will be PTP flaps during switchovers or ISSU as the PTP holdover timer is running on the active RSP.
- Once the configured holdover override duration has lapsed and the device is unable to receive quality Primary clock within this duration, the device will send the prescribed default clock class of 165 and the traceability flag will be set as FALSE to advertise loss of clock to downstream nodes.

Configuring PTP Holdover traceability suppression

This section describes how to configure the PTP holdover traceability suppression feature:

```
Router# config
Router(config)# ptp
Router(config-ptp)# holdover-spec-duration 1000
Router(config-ptp)# holdover-spec-clock-class 135
Router(config-ptp)# uncalibrated-traceable-override
Router(config-ptp)# holdover-spec-traceable-override
```

Configuration Examples

Slave Configuration Example

The following example shows a PTP slave configuration:

```
 interface TenGigE 0/1/0/5
 ptp
  profile tp64
  transport ipv4
  port state slave-only
  master ipv4 1.7.1.2
  !
  announce interval 1
  !
 ipv4 address 1.7.1.1 255.255.255.0
!
```

Master Configuration Example

This example shows a PTP master configuration:

```
 ptp
  profile tp64
  transport ipv4
  announce interval 1
 !
 ipv4 address 1.7.1.2 255.255.255.0
 !
```

PTP Hybrid Mode Configuration Example

This example shows the configuration of PTP hybrid mode:

```
ptp
 time-of-day priority 10
 !
interface GigabitEthernet0/1/1/0
 ptp
  transport ipv4
  port state slave-only
  master ipv4 192.168.52.38
  !
  sync frequency 64
  announce interval 1
  delay-request frequency 64
 !
interface GigabitEthernet 0/1/0/1
 ipv4 address 192.168.52.41 255.255.255.0
 speed 100
```

```
 frequency synchronization
  selection input
  priority 10
  wait-to-restore 0
  ssm disable
  time-of-day-priority 100
 !
```

ITU-T Telecom Profiles Configuration Examples

Master global configuration for the telecom profile:

```
-- For G.8265.1 profile --

ptp
 clock
 domain 4
 profile g.8265.1
 !
  profile master
  transport ipv4
  sync frequency 16
  announce interval 1
  delay-request frequency 16
interface gi 0/2/0/4
 ptp
  profile master
  transport ipv4
  clock operation two-step
 !
 ipv4 address 17.1.1.1/24

-- For G.8275.1 profile --

ptp
 clock
 domain 24
 profile g.8275.1
 !
  profile master
  transport ethernet
  sync frequency 16
  announce interval 1
  delay-request frequency 16
interface gi 0/2/0/4
 ptp
  profile master
  transport ethernet
  multicast target-address ethernet 01-1B-19-00-00-00
  clock operation two-step
 !
 ipv4 address 17.1.1.1/24
```

Slave global configuration for the telecom profile:

```
-- For G.8265.1 profile --
```

```
ptp
 clock
 domain 4
 profile g.8265.1
 !
  profile slave
  transport ipv4
  sync frequency 16
  announce interval 1
  delay-request frequency 16
interface gi 0/1/0/0
 ptp
  profile slave
  transport ipv4
  Master ipv4 18.1.1.1
  port state slave-only
  !
  clock operation two-step
  !
 ipv4 address 18.1.1.2/24
```

```
-- For G.8275.1 profile --

ptp
 clock
 domain 24
 profile g.8275.1 clock-type T-TSC
 !
  profile slave
  transport ethernet
  sync frequency 16
  announce interval 1
  delay-request frequency 16
interface gi 0/1/0/0
 ptp
  profile slave
  transport ethernet
  multicast target-address ethernet 01-1B-19-00-00-00
  !
  clock operation two-step
  !
 ipv4 address 18.1.1.2/24
```

```
-*- For G.8275.2 profile -*-


ptp
 clock
  domain 44
  profile g.8275.2 clock-type T-TSC
 !
 profile slave
  transport ipv6
  port state slave-only
  sync frequency 64
  announce frequency 8
  unicast-grant invalid-request deny
  delay-request frequency 64
 !
 log
  servo events
  best-master-clock changes
```

```
 !
!
interface GigabitEthernet0/2/0/12
 ptp
  profile slave
  master ipv6 30::2
  !
 !
 ipv6 address 30::1/64
!
```

Global configuration with clock type as T-Boundary Clock (**T-BC**) for the telecom profile:

```
-- For G.8275.1 profile --

ptp
 clock
 domain 24
 profile g.8275.1 clock-type T-BC
 !
  profile master
  transport ethernet
  sync frequency 16
  announce interval 1
  delay-request frequency 16
  exit
  profile slave
  transport ethernet
  sync frequency 16
  announce interval 1
  delay-request frequency 16
  exit
interface gi 0/2/0/4
 ptp
  profile slave
  transport ethernet
  multicast target-address ethernet 01-1B-19-00-00-00
  !
  clock operation two-step
  !
 ipv4 address 17.1.1.2/24
interface gi 0/2/0/0
 ptp
  profile master
  transport ethernet
  multicast target-address ethernet 01-1B-19-00-00-00
  clock operation two-step
  !
 ipv4 address 18.1.1.1/24
```

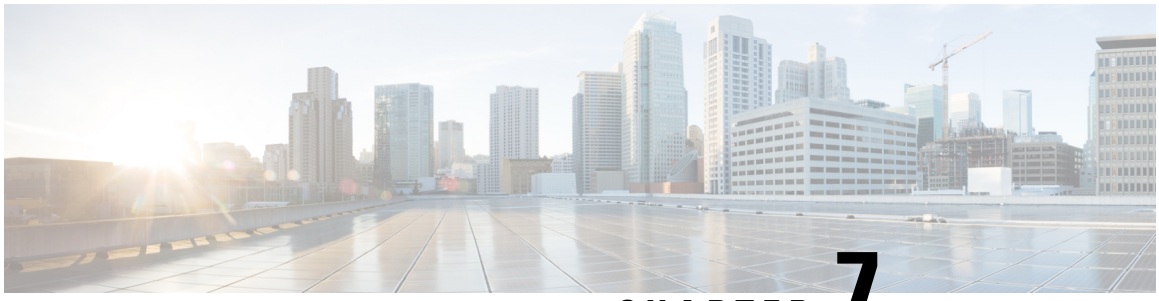
Note When G.8275.1 profile is configured on a 100G interface, keywords **commit replace** and **rollback config last 1** does not work and the router configuration rollback fails entirely. Use **rollback config last 1 best-effort** instead.

```
-*- For G.8275.2 profile -*-
ptp
```

```
 clock
  domain 44
  profile g.8275.2 clock-type T-BC
 !
 profile slave
  transport ipv6
  port state slave-only
  sync frequency 64
  announce frequency 8
  unicast-grant invalid-request deny
  delay-request frequency 64
 !
 profile master
  transport ipv6
  sync frequency 64
  announce frequency 8
  unicast-grant invalid-request deny
  delay-request frequency 64
 !
 log
  servo events
  best-master-clock changes
 !
!


interface GigabitEthernet0/2/0/11
 ptp
  profile master
 !
 ipv6 address 30::1/64
!

interface GigabitEthernet0/2/0/12
 ptp
  profile slave
  master ipv6 40::2
   !
 !
 ipv6 address 40::1/64
!
```



CHAPTER 7

Network Synchronization Design Best Practices

This chapter provides guidelines and best practices to follow when designing timing requirements for your network.

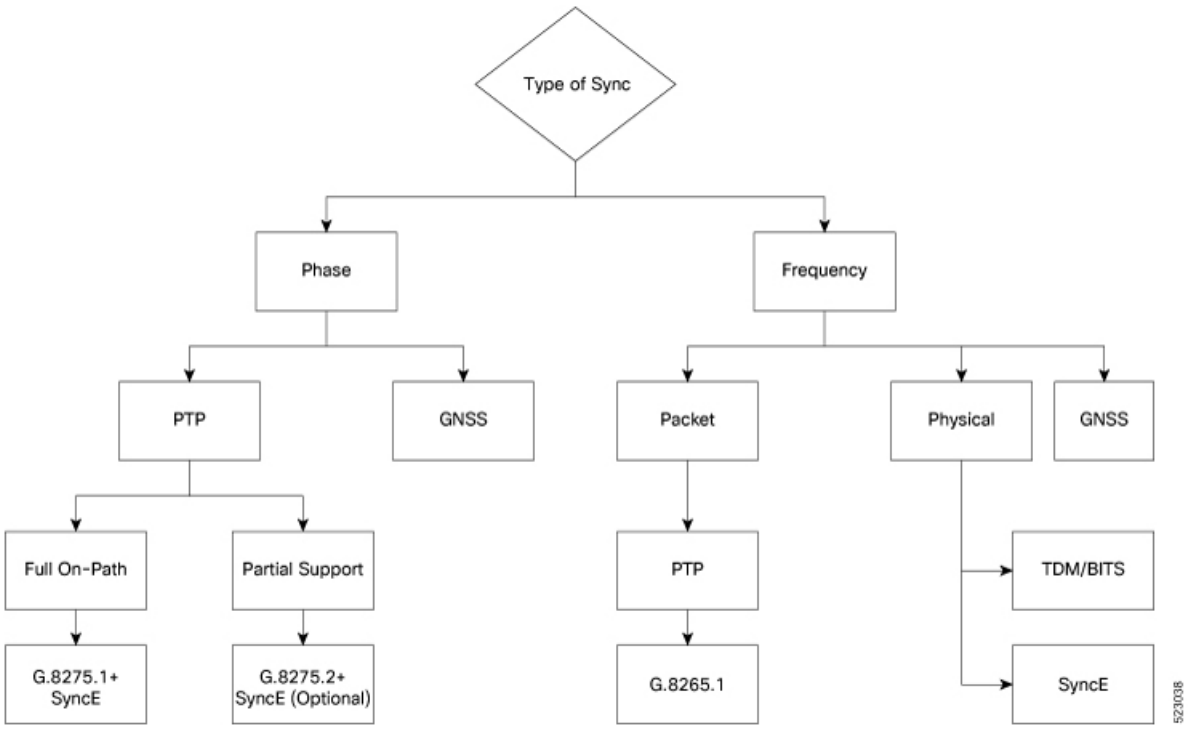
- Network Synchronization Design Best Practices, on page 117

Network Synchronization Design Best Practices

The synchronization of a network is essential for ensuring that all devices in a network run on the same clock time. It also ensures that the applications in the network function correctly. To design your network synchronization accurately, you must have a clear understanding of your network requirements, timing budget, application requirements, and the desired level of synchronization accuracy. This section describes some best practices to follow when designing your network synchronization.

Network Synchronization Decision Tree

Use the network synchronization decision tree for determining the appropriate synchronization solution for your network deployment. Network synchronization helps in ensuring that the network operates with accurate and synchronized time.



General Guidelines for Successful Synchronization Deployments

Network synchronization is crucial for maintaining reliable and efficient network operations, ensuring data integrity, complying with regulations, and facilitating troubleshooting and management tasks. The following guidelines help in deploying successful network synchronization for your network:

- Ensure that you use a standards-based solution designed for your need. For example, use the correct profile.
- Configure the appropriate clock source for your network. It can be Global Navigation Satellite System (GNSS) based such as a Global Positioning System (GPS) clock, or a Precision Time Protocol (PTP) grandmaster clock.
  - Frequency synchronization requires Building Integrated Timing Supply (BITS) or synchronous Ethernet, and Phase synchronization requires PTP and/or GNSS.
  - Use a combination of GNSS over the air and/or PTP or synchronous Ethernet over transport.

  For more information on SyncE and PTP, refer to *System Management Configuration Guide for Cisco ASR 9000 Series Routers*.
- Set up the synchronization protocols that are required, which includes PTP, Network Time Protocol (NTP), or synchronous Ethernet.
  - NTP uses the system clock for logging events in the system, or to show clock output, whereas PTP and GNSS work on the IEEE 1588 hardware clock in the system.
  - The NTP clock of a node can't be used to synchronize the downstream network using PTP. However, a node can synchronize its NTP clock with the available PTP or GNSS clock.

Note Most NTP implementations are software-based. Software-based time synchronization is less accurate than hardware-based synchronization, but it's still useful for applications where low levels of accuracy, such as 10's or 100's of milliseconds, are acceptable.

  - Use PTP for phase synchronization in the absence of a GNSS.
  - Synchronous Ethernet (SyncE) is a recommendation from ITU Telecommunication Standardization Sector (ITU-T) on how to deliver a frequency in a network. If you require a frequency-only synchronization solution, use SyncE instead of PTP.

- Configure the appropriate synchronization profiles and preferences for your network. It might include the accuracy, priority, and other parameters that determine how your network handles synchronization events.
- Design your network for phase synchronization with optimal time error budgets.
  - Use boundary clocks to reduce time error and to reset Packet Delay Variation (PDV).
  - Ensure that PTP awareness is implemented consistently throughout, including the transport system, and that boundary clocks accurately transmit time to minimize accumulated time error.
- For phase synchronization, use a hybrid clock that incorporates both SyncE and PTP.

  For more information on PTP Hybrid Mode, refer to *System Management Configuration Guide for Cisco ASR 9000 Series Routers*.
- Reduce the number of hops:
  - Distribute sources of time to meet the budget. If you have too many hops, install a GNSS receiver further out into the network.
  - Don't centralize two Primary Reference Time Clocks (PRTC) and Telecom Grandmasters (T-GM) in two different locations and try to run a synchronization signal accurately across the whole network.
- Minimize Packet Delay Variation (PDV) and jitter. Ensure that microwaves, Gigabit-capable Passive Optical Networks (GPON), Digital Subscriber Line (DSL), and Dense Wavelength Division Multiplexing (DWDM) are PTP aware.
- Monitor your synchronization deployment to ensure that it's functioning correctly and meeting your desired level of accuracy.

  For more information, refer to Verifying the Frequency Synchronization Configuration in the *System Management Configuration Guide for Cisco ASR 9000 Series Routers*.
- Be aware of any relevant industry standards and practices when deploying synchronization.

Guidelines for Phase Synchronization Deployments

Follow these guidelines for phase synchronization deployments.

- Set up the necessary network infrastructure to support phase synchronization. It includes installing timing devices such as GPS receivers, synchronous Ethernet interfaces, and timing servers.

- Configure the phase synchronization protocols such as setting up PTP as appropriate.
- As best practice, use the G.8275.1 telecommunication profile standard with complete on-path support, including Layer-2 multicast in combination with SyncE.
- Minimize phase time error by performing the following tasks:
  - Remove asymmetric routing issues.
  - Reduce the number of hops, unless telecommunication grandmaster (T-GM) clocks are deployed in the preaggregation network.
  - Decrease PDV or packet jitter.
- If you use IP protocols for PTP, you can run into issues with rerouting, asymmetric routing, Equal Cost Multi-Path (ECMP), bundles, and so on.
- If you need tight timing budgets over many hops, ensure that your hardware supports the highest levels of clock accuracy.
- For GNSS deployments:
  - Meet all the requirements for cable and antenna installations.
  - Consult with a professional if you don't have experience with GNSS installation and calibration.
- Make sure that your deployment is working as intended. Monitor it regularly to identify any potential issues.
- Consult with Cisco technical support if you encounter any issues or have questions.

Note When PTP is used with MACsec, achieving high accuracy can be challenging. PTP requires exact timestamping to maintain tight network synchronization. MACsec affixes and detaches a header that is between 24–32 bytes in size. This process can lead to significant inconsistencies in the time delays between where the link is connected and the location where the egress timestamps are applied.

PTP over IP Network Design

When using networks to carry frequency over Precision Time Protocol over Internet Protocol (PTPoIP), the goal is to minimize Packet Delay Variation (PDV) by reducing the number of hops. Use the following guidelines:

- The placement of the telecom grandmaster (T-GM) clock plays an important role in ensuring that the network operates within your timing budget. For example, place a pair of T-GM clocks in a centralized location only if the network has a small number of hops. In larger networks with multiple hops, it may be necessary to distribute T-GM clocks throughout the network to ensure proper timing management at each hop.
- Use a dedicated frequency synchronization protocol such as synchronous Ethernet or 1588v2, which is designed specifically to maintain precise frequency synchronization between devices.

- Use the G.8265.1 standard. Frequency synchronization using the G.8265.1 standard is a way to make sure multiple devices on a network are operating at the same frequency, allowing for more accurate and reliable communication.
- Configure Quality of Service (QoS) policies to prioritize network traffic and reduce delays. This can be done by using traffic shaping, traffic policing, and queue management.

Selecting the Correct Profile For Network Synchronization

G.8275.1 PTPoE

G.8275.1 is a technical specification standard for Precision Time Protocol over Ethernet (PTPoE). It defines how you can use the Precision Time Protocol (PTP) to synchronize clocks over Ethernet networks with layer 2 multicast. PTPoE is an extension of PTP that allows it to be used over Ethernet networks. It's used in applications where precise time synchronization is required.

For more information, refer to G.8275.1 in the *System Management Configuration Guide for Cisco ASR 9000 Series Routers*.

G.8275.2 PTPoIP

G.8275.2 is a technical specification standard for Precision Time Protocol over Internet Protocol (PTPoIP). It defines the use of the Precision Time Protocol (PTP) over packet-based networks such as Internet Protocol (IP) networks, to provide precise time synchronization of network devices.

For more information, refer to G.8275.2in the *System Management Configuration Guide for Cisco ASR 9000 Series Routers*.

Feature Adaptability on Each Profile

The following table lists the adaptability of features on each profile:

Feature	G.8275.1 PTPoE	G.8275.2 PTPoIP
Network Model	Full on-path support	Partial on-path support
IP Routing	Not applicable	Can cause issues in rings and asymmetry from a number of causes
Transit Traffic	Not allowed	Can result in jitter and asymmetry
Performance	Optimal	Variable
Configuration Model	Physical port	L3 device
PTP over Bundles	No issues	Work in progress for Telecom Boundary Clocks (T-BC)
Asymmetry	Reduced due to T-BC on every node	Optimal when deployed as a Partial Support Telecom Boundary Clock (T-BC-P)

Feature	G.8275.1 PTPoE	G.8275.2 PTPoIP
PDV/Jitter	Reduced due to T-BC on every node	Optimal when deployed as a T-BC-P

Reducing Asymmetry

Asymmetry occurs in a PTP unaware network for the following scenarios:

- When routing large networks, complex topologies, rings, and Equal-cost multi-path (ECMP)
- When using PTP unaware transit nodes, especially with varying traffic patterns
- In the transport layer such as Passive Optical Network (PON), cable, DWDM, and complex optics

Note Every 2 seconds of asymmetry results in 1 microsecond of time error.

To reduce asymmetry in a PTP unaware network:

- Use QoS: QoS can help reduce asymmetry in an unaware network.
- Implement Telecom Boundary Clocks (T-BC): T-BCs can handle asymmetry in the nodes when implemented correctly.

Reducing Packet Delay Variation

To reduce the effects of Packet Delay Variation (PDV) on PTP clock recovery, you must have a steady layer of packets that arrive in minimum time.

- Implement Telecom Boundary Clocks (T-BC) in the PTP unaware node. T-BC introduces a time reference to the PTP unaware node, which then synchronizes its clock with the T-BC.
- Use a high-quality network connection between the T-BC and the PTP unaware node. A high-quality network connection, such as a dedicated fiber link, can help reduce PDV due to network impairments.

Remediating Transport Asymmetry

Transport asymmetry occurs when data is transported at varying rates in different directions over a communication link, leading to an imbalance in transport. To correct this issue:

- Ensure that your transport layer is PTP aware.

  In optical devices, use a wavelength division multiplexing (WDM) technology such as Optical Service Channel (OSC) for managing your fiber optic infrastructure effectively.

Synchronizing Across Networks

To avoid synchronization issues when connecting to other mobile networks:

- Make sure to align all mobile networks to a common source of time. For example, align mobile networks to the Coordinated Universal Time (UTC) from a Global Navigation Satellite System (GNSS) such as Global Positioning System (GPS).
- Monitor your clocks at the interconnect points.

Note In 5G networks, using standalone GNSS receivers at every radio site may not provide the sub-100 nanosecond accuracy required for the timing requirements of Fronthaul radio systems.