

System Management Configuration Guide, Cisco Catalyst IE31xx Series Switches

First Published: 2020-08-10

Last Modified: 2025-05-15

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

© 2020–2025 Cisco Systems, Inc. All rights reserved.



CONTENTS

Full Cisco Trademarks with Software License ?

CHAPTER 1

Configuring Precision Time Protocol 1

Information About Precision Time Protocol 1

Why PTP? 1

Ethernet Switches and Delays 2

Message-Based Synchronization 2

PTP Event Message Sequences 3

Synchronizing with Boundary Clocks 3

Synchronizing with Peer-to-Peer Transparent Clocks 4

Synchronizing the Local Clock 5

Best Master Clock Algorithm 6

PTP Clocks 6

PTP Profiles 8

Default Profile Mode 8

Power Profile Mode 8

Tagging Behavior for PTP Packets 9

PTP Clock Modes Supported on the Switch 10

Configurable Boundary Clock Synchronization Algorithm 11

NTP to PTP Time Conversion 11

Grandmaster Boundary Clock Hybrid 14

Clock Manager 14

Prerequisites 15

Guidelines and limitations 16

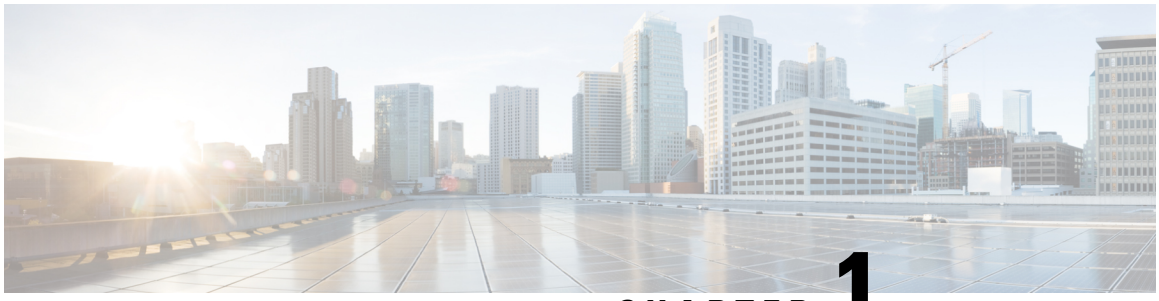
Default Settings 19

Configuring PTP on the Switch 19

Configuring PTP Power Profile Mode on the Switch 20
Configuring Default Profile Mode on the Switch 23
Verifying Configuration 27
Configuration Example 29
Configuring NTP to PTP Time Conversion 29
Verifying Configuration 32
Configuration Example 34
PTP Serviceability 34
Displaying PTP Message Counters 34
Displaying PTP Error Message Counters 36
Displaying PTP Offset and Delay 38
Debugging PTP 41
PTP alarms 42
Configure the PTP alarms 43
Feature History 44

CHAPTER 2 **Manage file systems and the Swap Drive** 45
Primary file system and swap drive 45
ROM Monitor variables and configuration 46
SD card operation 47
Insert or remove SD card 50
Insert the SD card into the Switch 50
Remove the SD card from the Switch 51
Enable the SD card 51
Disable the SD card 52
Configure automatic synchronization from internal flash to SD card 53
Setup switch using SD card 54
Format the SD card to load Cisco IOx 54
Emergency recovery for Cisco IOS XE image 55

CHAPTER 3 **Onboard Failure Logging** 57
Onboard Failure Logging 57
Feature History for Onboard Failure Logging 59



CHAPTER 1

Configuring Precision Time Protocol

- Information About Precision Time Protocol , on page 1
- NTP to PTP Time Conversion, on page 11
- Prerequisites, on page 15
- Guidelines and limitations, on page 16
- Default Settings, on page 19
- Configuring PTP on the Switch, on page 19
- Configuring NTP to PTP Time Conversion, on page 29
- PTP Serviceability, on page 34
- Feature History, on page 44

Information About Precision Time Protocol

Precision Time Protocol (PTP) is defined in IEEE 1588 as Precision Clock Synchronization for Networked Measurements and Control Systems, and was developed to synchronize the clocks in packet-based networks that include distributed device clocks of varying precision and stability. PTP is designed specifically for industrial, networked measurement and control systems, and is optimal for use in distributed systems because it requires minimal bandwidth and little processing overhead.

Note Cisco is moving from the traditional master/slave nomenclature. In this document, the terms *grandmaster clock (GMC)* or *time source* and *time recipient* are used instead.

Why PTP?

Smart grid power automation applications such as peak-hour billing, virtual power generators, and outage monitoring and management, require extremely precise time accuracy and stability. Timing precision improves network monitoring accuracy and troubleshooting ability.

In addition to providing time accuracy and synchronization, the PTP message-based protocol can be implemented on packet-based networks, such as Ethernet networks. The benefits of using PTP in an Ethernet network include:

- Low cost and easy setup in existing Ethernet networks

- Limited bandwidth is required for PTP data packets

Ethernet Switches and Delays

In an Ethernet network, switches provide a full-duplex communication path between network devices. Switches send data packets to packet destinations using address information contained in the packets. When a switch attempts to send multiple packets simultaneously, some of the packets are buffered by the switch so that they are not lost before they are sent. When the buffer is full, the switch delays sending packets. This delay can cause device clocks on the network to lose synchronization with one another.

Additional delays may occur when packets entering a switch are stored in local memory while the switch searches the MAC address table to verify the packet Cyclic Redundancy Check (CRC) fields. This process causes variations in packet-forwarding time latency, and these variations might result in asymmetrical packet-delay times.

Adding PTP to a network compensates for these latency and delay problems by correctly adjusting device clocks so that they stay synchronized with one another. PTP enables network switches to function as PTP devices, including boundary clocks and transparent clocks.

Note To learn more about PTP clock devices and their role in a PTP network, see PTP Clocks, on page 6.

Message-Based Synchronization

To ensure clock synchronization, PTP requires an accurate measurement of the communication path delay between the time source (grandmaster clock) and the time recipient. PTP sends messages between the time source and the time recipient to determine the delay measurement. Then, PTP measures the exact message transmit and receive times and uses these times to calculate the communication path delay. PTP then adjusts the current time information contained in network data for the calculated delay, resulting in more accurate time information.

This delay measurement principle determines path delay between devices on a network, and the local clocks are adjusted for this delay using a series of messages sent between the time source and the time recipient devices. The one-way delay time is calculated by averaging the path delay of the transmit and receive messages. This calculation assumes a symmetrical communication path. However, switched networks do not necessarily have symmetrical communication paths because of the buffering process.

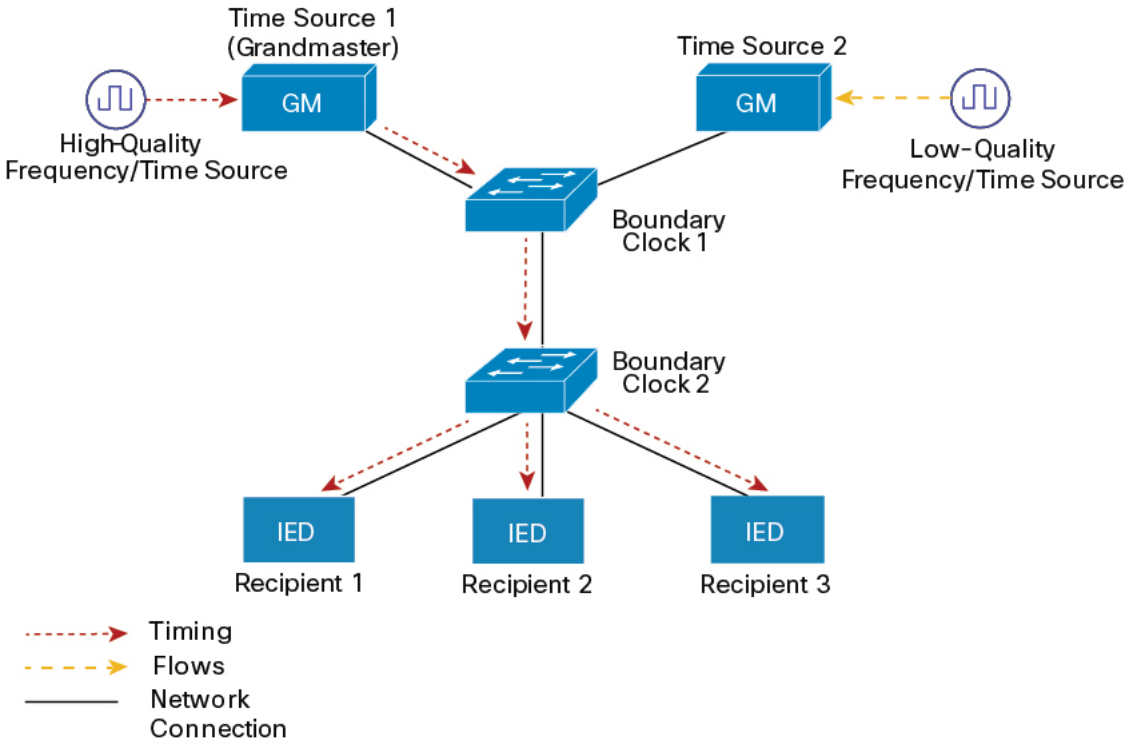
PTP provides a method—using transparent clocks—to measure and account for the delay in a time-interval field in network timing packets, making the switches temporarily transparent to the time source and the time recipient nodes on a network. An end-to-end transparent clock forwards all the messages in a network in the same way that a switch does.

Note The Cisco PTP implementation supports multicast PTP messages only.

To read a detailed description of synchronization messages, refer to PTP Event Message Sequences, on page 3. To learn more about how transparent clocks calculate network delays, see PTP Clocks, on page 6.

The following figure shows a typical 1588 PTP network that includes time source clocks, switches in boundary clock mode, and intelligent electronic devices (IEDs) such as a digital relays or protection devices. In this figure, Time Source 1 is the grandmaster clock. If Time Source 1 becomes unavailable, the time recipient boundary clocks switch to Time Source 2 for synchronization.

Figure 1: PTP Network



PTP Event Message Sequences

This section describes the PTP event message sequences that occur during synchronization.

Synchronizing with Boundary Clocks

The ordinary clocks and boundary clocks configured for the delay request-response mechanism use the following event messages to generate and communicate timing information:

- Sync
- Delay_Req
- Follow_Up
- Delay_Resp

These messages are sent in the following sequence:

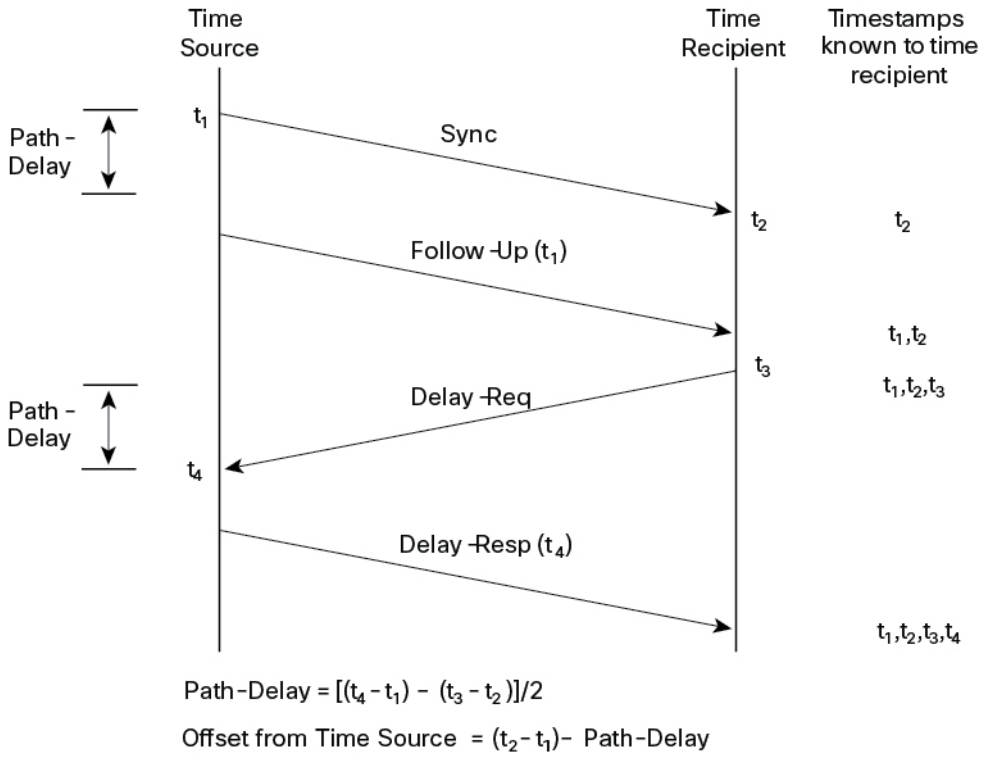
1. The time source sends a Sync message to the time recipient and notes the time (t1) at which it was sent.
2. The time recipient receives the Sync message and notes the time of reception (t2).

3. The time source conveys to the time recipient the timestamp t1 by embedding the timestamp t1 in a Follow_Up message.
4. The time recipient sends a Delay_Req message to the time source and notes the time (t3) at which it was sent.
5. The time source receives the Delay_Req message and notes the time of reception (t4).
6. The time source conveys to the time recipient the timestamp t4 by embedding it in a Delay_Resp message.

After this sequence, the time recipient possesses all four timestamps. These timestamps can be used to compute the offset of the time recipient clock relative to the time source, and the mean propagation time of messages between the two clocks.

The offset calculation is based on the assumption that the time for the message to propagate from the time source to the time recipient is the same as the time required from the time recipient to the time source. This assumption is not always valid on an Ethernet network because of asymmetrical packet delay times.

Figure 2: Detailed Steps—Boundary Clock Synchronization



Synchronizing with Peer-to-Peer Transparent Clocks

When a network includes multiple levels of boundary clocks in the hierarchy, with non-PTP-enabled devices between them, synchronization accuracy decreases.

The round-trip time is assumed to be equal to mean_path_delay/2. However, this is not always valid for Ethernet networks. To improve accuracy, the resident time of each intermediary clock is added to the offset in the end-to-end transparent clock. Resident time, however, does not take into consideration the link delay between peers, which is handled by peer-to-peer transparent clocks.

Peer-to-peer transparent clocks measure the link delay between two clock ports implementing the peer delay mechanism. The link delay is used to correct timing information in Sync and Follow_Up messages.

Peer-to-peer transparent clocks use the following event messages:

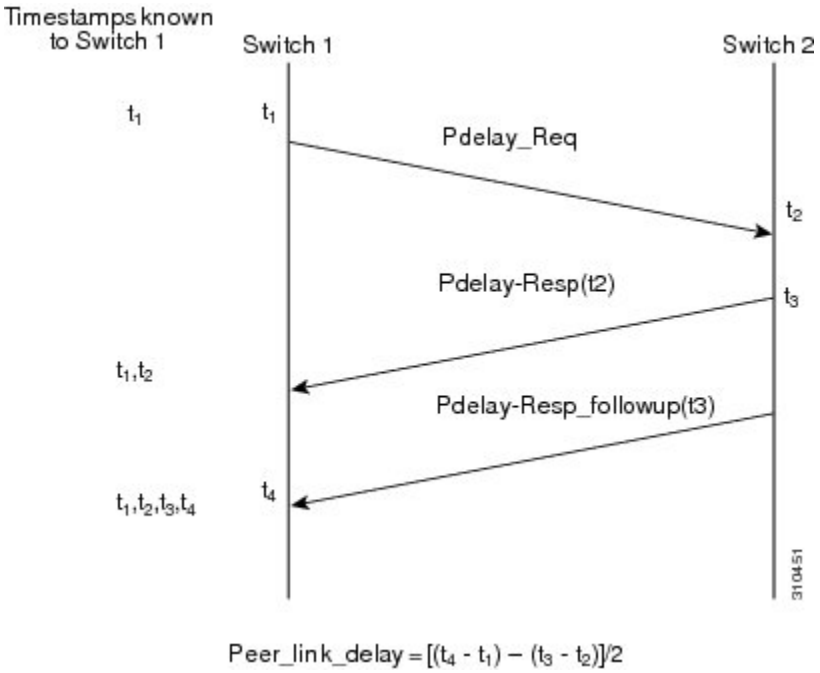
- Pdelay_Req
- Pdelay_Resp
- Pdelay_Resp_Follow_Up

These messages are sent in the following sequence:

1. Port 1 generates timestamp t1 for a Pdelay_Req message.
2. Port 2 receives and generates timestamp t2 for this message.
3. Port 2 returns and generates timestamp t3 for a Pdelay_Resp message.

   To minimize errors caused by frequency offset between the two ports, Port 2 returns the Pdelay_Resp message as quickly as possible after the receipt of the Pdelay_Req message.
4. Port 2 returns timestamps t2 and t3 in the Pdelay_Resp and Pdelay_Resp_Follow_Up messages respectively.
5. Port 1 generates timestamp t4 after receiving the Pdelay_Resp message. Port 1 then uses the four timestamps (t1, t2, t3, and t4) to calculate the mean link delay.

Figure 3: Detailed Steps—Peer-to-Peer Transparent Clock Synchronization



Synchronizing the Local Clock

In an ideal PTP network, the time source and the time recipient clocks operate at the same frequency. However, *drift* might occur on the network. Drift is the frequency difference between the time source and the time recipient clocks. You can compensate for drift by using the time stamp information in the device hardware

and follow-up messages (intercepted by the switch) to adjust the frequency of the local clock to match the frequency of the time source clock.

Best Master Clock Algorithm

The Best Master Clock Algorithm (BMCA) is the basis of PTP functionality. The BMCA specifies how each clock on the network determines the best time source clock in its subdomain of all the clocks it can see, including itself. The BMCA runs on the network continuously and quickly adjusts for changes in network configuration.

The BMCA uses the following criteria to determine the best time source clock in the subdomain:

- Clock quality, for example, GPS is considered the highest quality
- Clock accuracy of the clock's time base
- Stability of the local oscillator
- Closest clock to the grandmaster

In addition to identifying the best time source clock, the BMCA also ensures that clock conflicts do not occur on the PTP network by ensuring that:

- Clocks do not have to negotiate with one another.
- There is no misconfiguration, such as two time source clocks or no time source clocks, as a result of the time source clock identification process.

PTP Clocks

A PTP network is made up of PTP-enabled devices and devices that are not using PTP. The PTP-enabled devices typically consist of the following clock types.

Grandmaster Clock

Within a PTP domain, the grandmaster clock (GMC) is the primary source of time for clock synchronization using PTP. The GMC usually has a very precise time source, such as a GPS or atomic clock. When the network does not require any external time reference and only needs to be synchronized internally, the GMC can be free-running.

The switch can function as a hybrid grandmaster boundary clock using NTP as its source. For more information, see NTP to PTP Time Conversion, on page 11.

Ordinary Clock

An ordinary clock is a PTP clock with a single PTP port. It functions as a node in a PTP network. Ordinary clocks are the most common clock type on a PTP network because they are used as end nodes on a network that is connected to devices requiring synchronization. Ordinary clocks have various interfaces to external devices.

Boundary Clock

A boundary clock in a PTP network operates in place of a standard network switch or router. Boundary clocks have more than one PTP port, and each port provides access to a separate PTP communication path. Boundary

clocks provide an interface between PTP domains. They intercept and process all the PTP messages, and pass all other network traffic. The boundary clock uses the BMCA to select the best clock seen by any port. The selected port is then set to not be a time source. The time source port synchronizes the clocks connected downstream, while the port that is not a time source synchronizes with the upstream time source clock.

Transparent Clock

The role of transparent clocks in a PTP network is to update the time interval field that is a part of a PTP event message. This update compensates for switch delay and has an accuracy of within one picosecond.

There are two types of transparent clocks:

End-to-end (E2E) transparent clocks measure the PTP event message transit time (also known as *resident time*) for SYNC and DELAY_REQUEST messages. This measured transit time is added to a data field (correction field) in the corresponding messages:

- The measured transit time of a SYNC message is added to the correction field of the corresponding SYNC or the FOLLOW_UP message.
- The measured transit time of a DELAY_REQUEST message is added to the correction field of the corresponding DELAY_RESPONSE message.

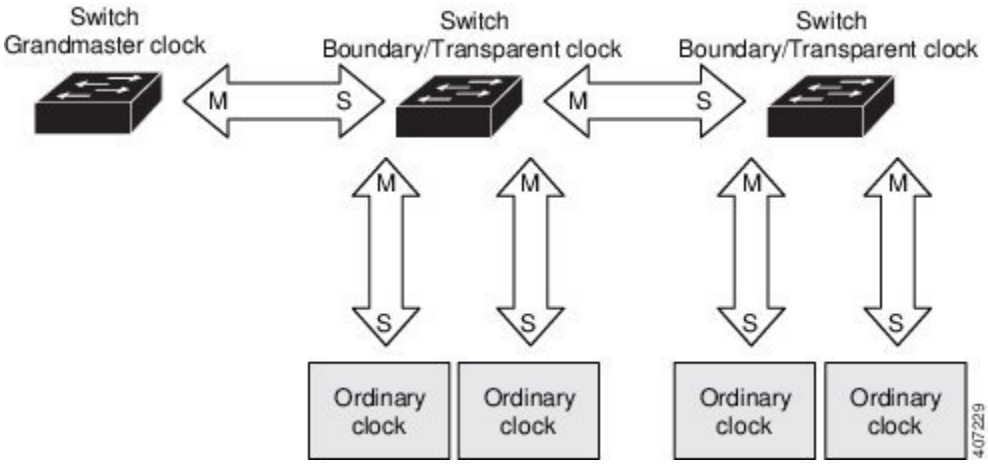
The time recipient uses this information when determining the offset between the time recipient's and the time source's time. E2E transparent clocks do not provide correction for the propagation delay of the link itself.

Peer-to-peer (P2P) transparent clocks measure PTP event message transit time in the same way E2E transparent clocks do, as described above. In addition, P2P transparent clocks measure the upstream link delay. The upstream link delay is the estimated packet propagation delay between the upstream neighbor P2P transparent clock and the P2P transparent clock under consideration.

These two times (message transit time and upstream link delay time) are both added to the correction field of the PTP event message. The correction field of the message received by the time recipient contains the sum of all link delays. In theory, this is the total end-to-end delay (from time source to time recipient) of a SYNC packet.

The following figure illustrates PTP clocks in a time source-time recipient hierarchy within a PTP network.

Figure 4: PTP Clock Hierarchy



PTP Profiles

This section describes the following PTP profiles available on the switch:

- Power Profile
- Default Profile

The Power Profile is defined in PC37.238-2011 - IEEE Draft Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications. The Cisco PTP implementation uses the terms Power Profile mode and Default Profile mode when referring to this IEEE 1588 profile and its associated configuration values.

The IEEE 1588 definition of a PTP profile is *the set of allowed PTP features applicable to a device*. A PTP profile is usually specific to a particular type of application or environment and defines the following values:

- BMCA options
- Configuration management options
- Path delay mechanisms (peer delay or delay request-response)
- Range and default values of all PTP configurable attributes and data set members
- Transport mechanisms that are required, permitted, or prohibited
- Node types that are required, permitted, or prohibited
- Options that are required, permitted, or prohibited

Default Profile Mode

The default PTP profile mode in the switch is Default Profile mode. In this mode:

- The PTP mode of transport is Layer 3.
- The supported transparent clock mode is end-to-end (E2E).

The Default profile uses L3 transport multicast address 224.0.1.129 (MAC address 01-00-5e-00-01-81) for all PTP messages.

See Power Profile Mode, on page 8 for a list of the configuration values for the switch in Default Profile and Power Profile modes.

Power Profile Mode

The IEEE Power Profile defines specific or allowed values for the PTP networks used in power substations. The defined values include the optimum physical layer, the higher level protocol for PTP messages, and the preferred BMCA. The Power Profile values ensure consistent and reliable network time distribution within substations, between substations, and across wide geographic areas.

The switch is optimized for PTP in these ways:

- Hardware: The switch uses FPGA and PHY for the PTP function. The PHY time stamps the Fast Ethernet and Gigabit Ethernet ports.
- Software: In Power Profile mode, the switch uses the configuration values defined in the IEEE 1588 Power Profile standard.

The following table lists the configuration values defined by the IEEE 1588 Power Profile and the values that the switch uses for each PTP profile mode.

Table 1: Configuration Values for the IEEE PTP Power Profile and Switch Modes

PTP Field	Power Profile Value	Switch Configuration Value	
		Power Profile Mode	**Default Profile Mode**
Message transmission	Ethernet 802.3 with Ethertype 0X88F7. PTP messages are sent as 802.1Q- tagged Ethernet frames with a default VLAN 0 and default priority 4.	**Access Ports**: Untagged Layer 2 packets. **Trunk Ports**: 802.1Q tagged Layer 2 packets with native VLAN on the port and default priority value of 4.	Layer 3 packets. By default, 802.1q tagging is disabled.
MAC address: Nonpeer delay messages	01-1B-19-00-00-00.	01-1B-19-00-00-00.	01-00-5e-00-01-81.
MAC address: Peer delay messages	01-80-C2-00-00-0E.	01-80-C2-00-00-0E.	Not applicable to this mode.
Domain number	0.	0.	0.
Path delay calculation	Peer-to-peer transparent clocks.	Peer-to-peer transparent clocks using the peer_delay mechanism.	End-to-end transparent clocks using the delay_request mechanism.
BMCA	Enabled.	Enabled.	Enabled.
Clock type	Two-step clocks are supported.	Two-step.	Two-step.
Time scale	Epoch.[1]	Epoch.	Epoch.
Grandmaster ID and local time determination	PTP-specific TLV (type, length, value) to indicate Grandmaster ID.	PTP-specific TLV to indicate Grandmaster ID.	PTP-specific type, length, and value to indicate Grandmaster ID.
Time accuracy over network hops	Over 16 hops, the time recipient device synchronization accuracy is within 1 usec (1 microsecond).	Over 16 hops, the time recipient device synchronization accuracy is within 1 usec (1 microsecond).	Not applicable in this mode.

[1] Epoch = Elapsed time since epoch start.

Tagging Behavior for PTP Packets

The following table describes the switch tagging behavior in Power Profile and Default Profile modes.

Table 2: Tagging Behavior for PTP Packets

Switch Port Mode	Configuration	Power Profile Mode		Default Profile Mode	
		Behavior	Priority	Behavior	Priority
Trunk Port	**vlan dot1q tag native** enabled	Switch tags packets	7	Switch tags packets	7
Trunk Port	**vlan dot1q tag native** disabled	PTP software tags packets	4	Untagged	None
Access Port	N/A	Untagged	None	Untagged	None

PTP Clock Modes Supported on the Switch

PTP synchronization behavior depends on the PTP clock mode that you configure on the switch. You can configure the switch for one of the global modes described below.

See Guidelines and limitations, on page 16 for guidelines to configure each of the clock modes.

Grandmaster-Boundary Clock Mode

The switch can function as a hybrid grandmaster boundary clock using NTP as its source. For more information, see NTP to PTP Time Conversion, on page 11.

Boundary Clock Mode

A switch configured for boundary clock mode participates in selecting the best time source clock on the subdomain, selecting from all the clocks it can see, including itself. If the switch does not detect a more accurate clock than itself, then the switch becomes the time source clock. If a more accurate clock is detected, then the switch synchronizes to that clock and becomes a time recipient clock.

After initial synchronization, the switch and the connected devices exchange PTP timing messages to correct the changes caused by clock offsets and network delays.

Forward Mode

A switch configured for forward mode passes incoming PTP packets as normal multicast traffic.

E2E Transparent Clock Mode

A switch configured for end-to-end transparent clock mode does not synchronize its clock with the time source clock. A switch in this mode does not participate in time source clock selection and uses the default PTP clock mode on all ports.

P2P Transparent Clock Mode

A switch configured for peer-to-peer transparent clock mode does not synchronize its clock with the time source clock. A switch in this mode does not participate in time source clock selection and uses the default PTP clock mode on all ports.

Configurable Boundary Clock Synchronization Algorithm

You can configure the BC synchronization algorithm to accommodate various PTP use cases, depending on whether you need to prioritize filtering of input time errors or faster convergence. A PTP algorithm that filters packet delay variation (PDV) converges more slowly than a PTP algorithm that does not.

By default, the BC uses a linear feedback controller (that is, a servo) to set the BC's time output to the next clock. The linear servo provides a small amount of PDV filtering and converges in an average amount of time. For improved convergence time, BCs can use the TC feedforward algorithm to measure the delay added by the network elements forwarding plane (the disturbance) and use that measured delay to control the time output.

While the feedforward BC dramatically speeds up the boundary clock, the feedforward BC does not filter any PDV. The adaptive PDV filter provides high quality time synchronization in the presence of PDV over wireless access points (APs) and enterprise switches that do not support PTP and that add significant PDV.

Three options are available for BC synchronization (all are compliant with IEEE 1588-2008):

- Feedforward—For very fast and accurate convergence; no PDV filtering.
- Adaptive—Filters as much PDV as possible, given a set of assumptions about the PDV characteristics, the hardware configuration, and the environmental conditions.

Note With the adaptive filter, the switch does not meet the time performance requirements specified in ITU-T G.8261.

- Linear—Provides simple linear filtering (the default).

Adaptive mode (**ptp transfer filter adaptive**) is not available in Power Profile mode.

For configuration information, see Configuring PTP on the Switch, on page 19.

NTP to PTP Time Conversion

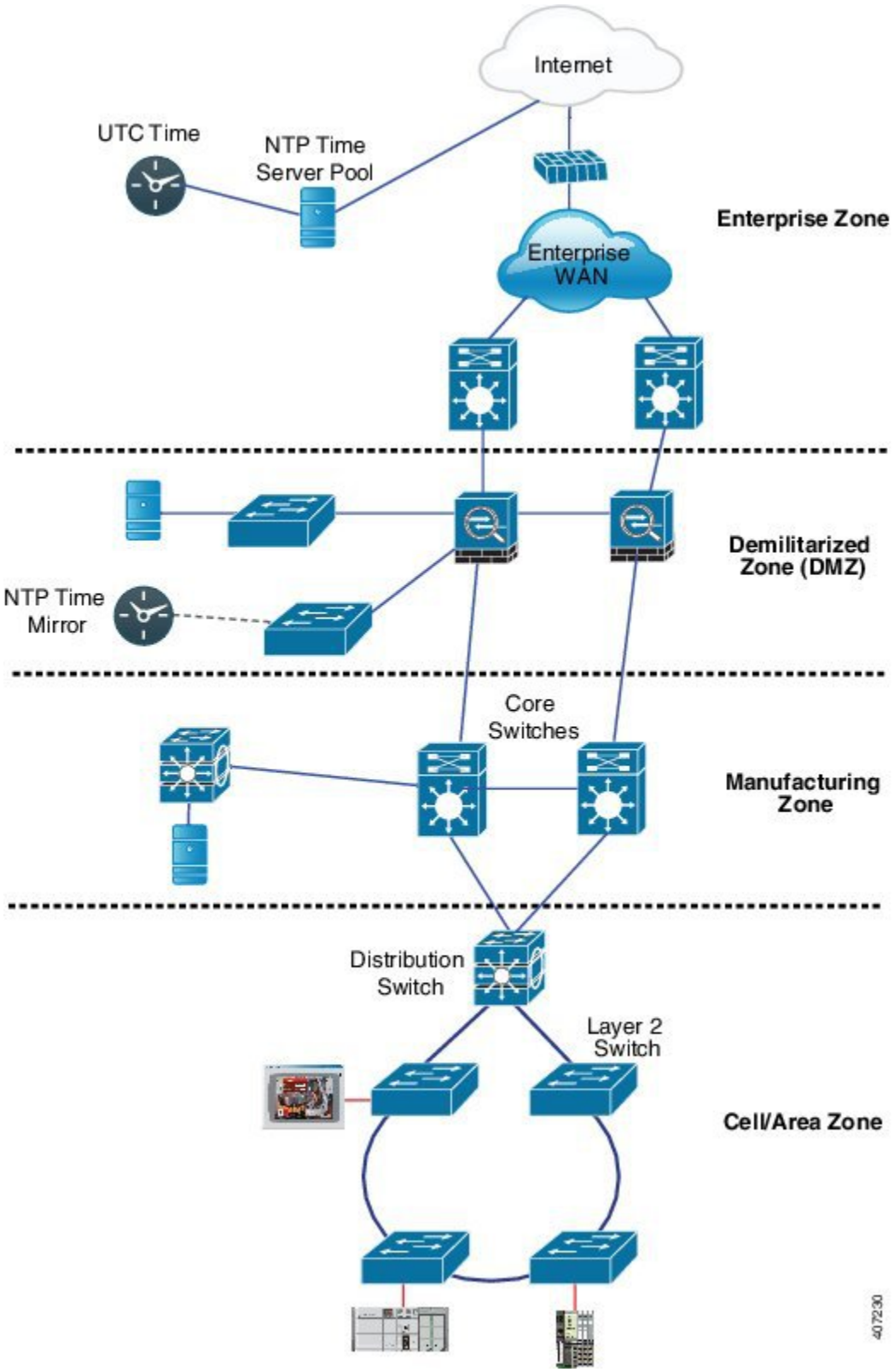
NTP to PTP time conversion allows you to use Network Time Protocol (NTP) as a time source for PTP. Customers who use PTP for very precise synchronization within a site can use NTP across sites, where precise synchronization is not required.

NTP is the traditional method of synchronizing clocks across packet based networks. NTP uses a two-way time transfer mechanism, between a time source and an end device. NTP is capable of synchronizing a device within a few 100 milliseconds across the Internet, and within a few milliseconds in a tightly controlled LAN. The ability to use NTP as a time source for PTP allows customers to correlate data generated in their PTP network with data in their enterprise data centers running NTP.

Note Beginning with the Cisco IOS XE Dublin 17.12.x release, Cisco Catalyst IE3100 Rugged Series Switches are supported for NTP to PTP time conversion.

The following figure shows an example of an industrial network based on the Industrial Automation and Control System Reference Model. The enterprise zone and demilitarized zone run NTP, and the manufacturing

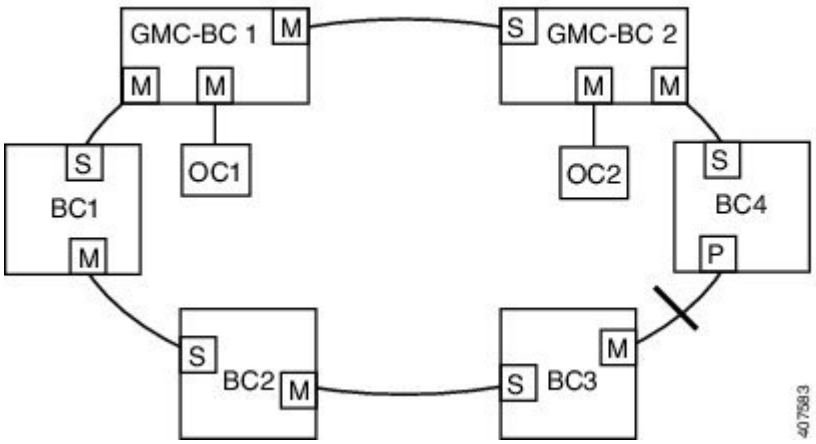
zone and cell/area zone run PTP with NTP as the time source. The switch with the NTP to PTP conversion feature can be either the Layer 2 Switch or the Distribution Switch in the Cell/Area Zone.


Internet
UTC Time
NTP Time
Server Pool
Enterprise Zone
Enterprise
WAN
Demilitarized
Zone (DMZ)
NTP Time
Mirror
Core
Switches
Manufacturing
Zone
Distribution
Switch
Layer 2
Switch
Cell/Area Zone
407230

Grandmaster Boundary Clock Hybrid

The NTP to PTP conversion feature adds grandmaster clock functionality to Cisco PTP, so the switch can be a time source as well as forward time. A new PTP clock type, grandmaster boundary clock (GMC-BC), provides the NTP time source for PTP. The GMC-BC acts like a BC, which is a multi-port device, with a single-port GMC connected to a virtual port on the BC. The GMC-BC switches between acting like a GMC when the GMC-BC is the primary GMC, and acting like a BC when the GMC-BC is a backup. This ensures that all devices on the PTP network remain synchronized in a failover scenario. The following figure shows a PTP network with redundant GMC-BCs. GMC-BC 1 is the grandmaster clock, and GMC-BC 2 is both backup GMC and BC.

Figure 5: Redundant GMC-BC Configuration



In a network with two GMC-BCs, the secondary GMC-BC can synchronize to both the NTP reference and the PTP reference at the same time, so the secondary GMC-BC can immediately take over when the primary GMC-BC fails. The GMC-BC instantly updates the time during a switchover.

Clock Manager

The clock manager is the component in the Cisco NTP to PTP software architecture that keeps track of the various time services and selects the clock that actively provides time. The clock manager notifies the time services of important changes, such as state changes, leap seconds, or daylight saving time.

The clock manager selects the NTP or manually-set clock first, followed by PTP and the real-time clock if NTP is not active. The following table shows the results of the clock selection process.

Table 3: Time Service Selection

NTP (Active) or Manually Set	PTP (Active)	Real-Time Clock	Selected Output
True	Don't care	Don't care	NTP or Manually Set
False	True	Don't care	PTP
False	False	True	Real-Time Clock

In general, the clock manager ensures that the time displayed in the Cisco IOS XE commands **show ptp clock** and **show clock** match. The **show clock** command always follows this priority, but there are two corner cases where the **show ptp clock** time may differ:

- The switch is either a TC or a BC, and there is no other active reference on the network. To preserve backwards compatibility, the TC and BC never take their time from the clock manager, only from the network's PTP GMC. If there is no active PTP GMC, then the time displayed in the **show clock** and the **show ptp clock** command output may differ.
- The switch is a syntonizing TC, a BC with a time recipient port, or a GMC-BC with time recipient port, and the time provided by the PTP GMC does not match the time provided by NTP or the user (that is, manually set). In this case, the PTP clock must forward the time from the PTP GMC. If the PTP clock does not follow the PTP GMC, then the PTP network will end up with two different time bases, which would break any control loops or sequence of event applications using PTP.

The following table shows how the Cisco IOS XE and PTP clocks behave given the various configurations. Most of the time, the two clocks match. Occasionally, the two clocks are different; those configurations are highlighted in the table.

Table 4: Expected Time Flow

IOS XE Clock Configuration	PTP Clock Configuration	IOS XE Clock Source	PTP Clock Source
Calendar	PTP BC, E2E TC, or GMC-BC in BC Mode	PTP	PTP
Manual	PTP BC, E2E TC, or GMC-BC in BC Mode	Manual	PTP
NTP	PTP BC, E2E TC, or GMC-BC in BC Mode	NTP	PTP
Calendar	GMC-BC in GM Mode	Calendar	Calendar
Manual	GMC-BC in GM Mode	Manual	Manual
NTP	GMC-BC in GM Mode	NTP	NTP

Prerequisites

- Review the Guidelines and limitations, on page 16.
- To use the NTP to PTP conversion feature, the switch must have an IP address for NTP to function.
- To use the NTP to PTP conversion feature, you must configure at least one NTP server. Configuring three or more NTP servers allows NTP to ignore bad clocks.

Note For information about configuring NTP, see Basic System Management Configuration Guide, Cisco IOS XE 17, Network Time Protocol.

Guidelines and limitations

PTP messages

- The Cisco PTP implementation supports only two-step clock operation in BC mode; one-step clock in not supported.
- In transparent clock mode, the switch converts any one-step Sync message received from the grandmaster clock into a two-step message.
- Cisco PTP supports multicast PTP messages only.

PTP mode and profile

- The switch and the grandmaster clock must be in the same PTP domain.
- When Power Profile mode is enabled, the switch drops the PTP announce messages that do not include these two Type, Length, Value (TLV) message extensions: *Organization_extension* and *Alternate_timescale* .

  If the grandmaster clock is not compliant with PTP and sends announce messages without these TLVs, configure the switch to process the announce message by entering the **ptp allow-without-tlv** command.

  Refer to Configuring PTP Power Profile Mode on the Switch, on page 20 for a complete description of this command.
- When the switch is in Power Profile mode, only the peer_delay mechanism is supported.

  To change to boundary clock mode and the peer_delay mechanism, enter the **ptp mode boundary pdelay-req** command.
- In Default Profile mode, only the delay_request mechanism is supported.

  To change to boundary clock mode with the delay_request mechanism, enter the **ptp mode boundary delay-req** command.

Note Refer to Configuring Default Profile Mode on the Switch, on page 23 for a complete description of commands.

Note PTP is not supported for GLC-T transceivers at 100 Mbps on Cisco Catalyst IE3x00 Rugged Series fiber ports.

Packet format

- The packet format for PTP messages can be 802.1q tagged packets or untagged packets.
- The switch does not support 802.1q QinQ tunneling.
- In switch Power Profile mode:

  - When the PTP interface is configured as an access port, PTP messages are sent as untagged, Layer 2 packets.
  - When the PTP interface is configured as a trunk port, PTP packets are sent as 802.1q tagged Layer 2 packets over the port native VLAN.

- Time recipient IEDs must support tagged and untagged packets.
- When PTP packets are sent on the native VLAN in E2E transparent clock mode, they are sent as untagged packets. To configure the switch to send them as tagged packets, enter the global **vlan dot1q tag native** command.

VLAN configuration

- Sets the PTP VLAN on a trunk port. The range is from 1 to 4094. The default is the native VLAN of the trunk port.
- In boundary mode, only PTP packets in PTP VLAN will be processed, PTP packets from other VLANs will be dropped.
- Before configuring the PTP VLAN on an interface, the PTP VLAN must be created and allowed on the trunk port.
- Most grandmaster clocks use the default VLAN 0. In Power Profile mode, the switch default VLAN is VLAN 1 and VLAN 0 is reserved. When you change the default grandmaster clock VLAN, it must be changed to a VLAN other than 0.
- When VLAN is disabled on the grandmaster clock, the PTP interface must be configured as an access port.

Clock configuration

- All PHY PTP clocks are synchronized to the grandmaster clock. The switch system clock is not synchronized as part of PTP configuration and processes.
- When VLAN is enabled on the grandmaster clock, it must be in the same VLAN as the native VLAN of the PTP port on the switch.
- Grandmaster clocks can drop untagged PTP messages when a VLAN is configured on the grandmaster clock. To force the switch to send tagged packets to the grandmaster clock, enter the global **vlan dot1q tag native** command.

Clock modes

- Boundary Clock Mode
  - You can enable this mode when the switch is in Power Profile mode (Layer 2) or in Default Profile mode (Layer 3).
- Forward Mode
  - You can enable this mode when the switch is in Power Profile mode (Layer 2) or in Default Profile mode (Layer 3).

    - When the switch is in Forward mode, the only global configuration available is the CLI command to switch to a different PTP mode (that is, boundary, e2etransparent, or p2ptransparent).

- E2E Transparent Clock Mode
    - You can enable this mode only when the switch is in Default Profile mode (Layer 3).
    - When the switch is in E2E Transparent mode, the only global configurations available from CLI commands are to switch to a different PTP mode (boundary, forward, or gmc-bc), and change the domain.
- P2P Transparent Clock Mode
    - You can enable this mode only when the switch is in Power Profile mode (Layer 2).
- GMC-BC Clock Mode
    - You can enable this mode when the switch is in Default Profile mode or in Power Profile mode.

PDV filtering

Adaptive mode (**ptp transfer filter adaptive**) is not available in Power Profile mode.

PTP interaction with other features

- The following PTP clock modes do not support EtherChannels:
    - e2etransparent
    - p2ptransparent
    - boundary delay-req
    - boundary pdelay-req
- The following PTP clock modes only operate on a single VLAN:
    - e2etransparent
    - p2ptransparent

Table 5: Resiliency Protocol Support

IE Switch	MRP	REP Fast	REP	RSTP/MSTP	G.8032
IE3100	No[2] **Note** Only the **1588v2 default transparent clock mode** is supported over MRP on Cisco Catalyst IE3100 switches.	Yes	Yes	Yes	No

[2] PTP not supported over the protocol

NTP to PTP conversion

- The NTP to PTP feature supports the Default E2E Profile and Power Profile.

Default Settings

- PTP is enabled on the switch by default.
- By default, the switch uses configuration values defined in the Default Profile (Default Profile mode is enabled).
- The switch default PTP clock mode is E2E Transparent clock mode.
- The default BC synchronization algorithm is linear filter.
- PTP alarms are disabled by default.

Configuring PTP on the Switch

Use one of the following procedures in this section to configure the switch for PTP.

Note To configure the switch for grandmaster-boundary clock mode (gmc-bc), see Configuring NTP to PTP Time Conversion, on page 29.

Note On the ESS3300, the 10 GE ports do not support PTP. Only ports gi1/3-gi1-10 and gi2/1-gi2/16 support PTP.

Configuring PTP Power Profile Mode on the Switch

This section describes how to configure the switch to use the PTP Power Profile and operate in Power Profile mode.

Before you begin

These are some guidelines for configuring the Power Profile on the switch:

- When you enter **no** with PTP port configuration commands, the specified port property is set to the default value.
- To determine the value in seconds for the ptp global command *interval* variable, use a logarithmic scale. Below are examples of the *interval* variable value converted to seconds with a logarithmic scale:

Value Entered	Logarithmic Calculation	Value in Seconds
-1	2^{-1}	1/2
0	2^{0}	1

SUMMARY STEPS

1. Enter global configuration mode:
2. Set the Power Profile:
3. Specify the synchronization clock mode:
4. (Optional, BC and TC mode) Specify TLV settings:
5. (Optional, BC and TC mode) Specify the PTP clock domain:
6. (Optional, BC and TC mode) Specify the packet priority:
7. (Optional, BC mode only) Specify the BMCA priority:
8. (Optional, BC mode only) Specify time-property preservation:
9. (Optional, BC mode only) Specify the BC synchronization algorithm:
10. (Optional) Enter interface configuration mode:
11. (Optional) Specify port settings:
12. Return to privileged EXEC mode:
13. Verify your entries:
14. (Optional) Save your entries in the configuration file:

DETAILED STEPS

Procedure

Step 1 Enter global configuration mode:

configure terminal

Step 2 Set the Power Profile:

ptp profile power

Step 3 Specify the synchronization clock mode:

ptp mode {boundary pdelay-req | p2ptransparent | forward | gmc-bc}

- **mode boundary pdelay-req**—Configures the switch for boundary clock mode using the delay-request mechanism. In this mode, the switch participates in the selection of the most accurate time source clock. Use this mode when overload or heavy load conditions produce significant delay jitter.
- **mode p2ptransparent**—Configures the switch for peer-to-peer transparent clock mode and synchronizes all switch ports with the time source clock. The link delay time between the participating PTP ports and the message transit time is added to the resident time. Use this mode to reduce jitter and error accumulation. This is the default in Power Profile mode.
- **mode forward**—Configures the switch to pass incoming PTP packets as normal multicast traffic.
- **mode gmc-bc** —Configures the switch for grandmaster-boundary clock mode. See Configuring NTP to PTP Time Conversion to configure the switch for this mode.

Step 4 (Optional, BC and TC mode) Specify TLV settings:

ptp allow-without-tlv

Note
Using this command when switch mode is p2ptransparent allows the switch to operate in PTP networks where IEC61850-9-3 is required.

Step 5 (Optional, BC and TC mode) Specify the PTP clock domain:

ptp domain *domain-number*

domain-number—A number from 0 to 255.

The participating grandmaster clock, switches, and time recipient devices should be in the same domain.

Step 6 (Optional, BC and TC mode) Specify the packet priority:

ptp packet *priority*

The PTP packets have a default priority of 4.

Step 7 (Optional, BC mode only) Specify the BMCA priority:

ptp priority1 *priority* **priority2** *priority*

- **priority1** *priority*—Overrides the default criteria (such as clock quality and clock class) for the most accurate time source clock selection.
- **priority2** *priority*—Breaks the tie between two switches that match the default criteria. For example, enter 2 to give a switch priority over identical switches.
- *priority* —A priority number from 0 to 255. The default is 128.

Note
A lower value has higher priority.

Step 8 (Optional, BC mode only) Specify time-property preservation:

ptp time-property persist {*value* | **infinite**}

- *value*—Time duration, in seconds, from 0-100000. The default is 300.
- **infinite**—Time properties are preserved indefinitely.

Preserving the time properties prevents time recipient clocks from detecting a variance in the time values when the redundant GMC comes out of standby.

Step 9 (Optional, BC mode only) Specify the BC synchronization algorithm:

ptp transfer {**feedforward** | **filter linear**}

- **feedforward**—Very fast and accurate. No PDV filtering.
- **filter linear**—Provides a simple linear filter (default).

Step 10 (Optional) Enter interface configuration mode:

interface *interface-id*

Step 11 (Optional) Specify port settings:

Boundary pdelay-req mode:

ptp {**announce** {**interval** *value* | **timeout** *value*} | **pdelay-req interval** *value* | **enable** | **sync** {**interval** *value* | **limit** *value*} | **vlan** *value*}

p2ptransparent mode:

ptp {**pdelay-req interval** *value* | **enable** | **sync limit** *value* | **vlan** *value*}

- **announce interval** *value*—Sets the logarithmic mean interval in seconds to send announce messages. The range is 0 to 4. The default is 1 (2 seconds).
- **announce timeout** *value*—Sets the logarithmic mean interval in seconds to announce timeout messages. The range is 2 to 10. The default is 3 (8 seconds).
- **pdelay-req interval** *value*—Sets the logarithmic mean interval in seconds for time recipient devices to send pdelay request messages when the port is in the time source clock state. The range is -3 to 5. The default is 0 (1 second).
- **enable**—Enables PTP on the port base module.
- **sync interval** *value*—Sets the logarithmic mean interval in seconds to send synchronization messages. The range is –2 to 1. The default is 1 second.
- **sync limit** *value*—Sets the maximum clock offset value before PTP attempts to resynchronize. The range is from 50 to 500000000 nanoseconds. The default is 10000 nanoseconds.
- **vlan** *value*—Sets the PTP VLAN on a trunk port. The range is from 1 to 4094. The default is the native VLAN of the trunk port. In boundary mode, only PTP packets in PTP VLAN will be processed, PTP packets from other VLANs will be dropped. Before configuring the PTP VLAN on an interface, the PTP VLAN must be created and allowed on the trunk port.

Step 12 Return to privileged EXEC mode:

end

Step 13 Verify your entries:

show running-config

Step 14 (Optional) Save your entries in the configuration file:

copy running-config startup-config

Example

The following example configures the switch for P2P transparent mode (the default in Power Profile mode), specifies **allow-without-tlv** PTP message processing, and uses default values for all PTP interval settings:

```
switch(config)# ptp allow-without-tlv
```

The following example configures the switch for boundary clock mode using the peer delay request (pdelay-req) mechanism and uses default values for all PTP interval settings:

```
switch(config)# ptp mode boundary pdelay-req
```

Configuring Default Profile Mode on the Switch

This section describes how to configure the switch to operate in Default Profile mode.

Before you begin

The switch sends untagged PTP packets on the native VLAN when the switch port connected to the grandmaster clock is configured as follows:

- Switch is in Default Profile mode.
- Switch is in trunk mode.
- VLAN X is configured as the native VLAN.

When the grandmaster clock requires tagged packets, make one of the following configuration changes:

- Force the switch to send tagged frames by entering the global **vlan dot1q tag native** command.
- Configure the grandmaster clock to send and receive untagged packets. If you make this configuration change on the grandmaster clock, you can configure the switch port as an access port.

These are some guidelines for configuring the Default Profile on the switch:

- When you enter **no** with PTP port configuration commands, the specified port property is set to the default value.
- To determine the value in seconds for the ptp global command *interval* variable, use a logarithmic scale. Below are examples of the *interval* variable value converted to seconds with a logarithmic scale:

Value Entered	Logarithmic Calculation	Value in Seconds
-1	2^{-1}	1/2
0	2^{0}	1

SUMMARY STEPS

1. Enter global configuration mode:
2. Specify the synchronization clock mode:
3. (Optional, BC and TC mode) Specify the PTP clock domain:
4. (Optional, BC mode only) Specify the BMCA priority:
5. (Optional, BC mode only) Specify time-property preservation:
6. (Optional, BC mode only) Specify the BC synchronization algorithm:
7. (Optional) Enter interface configuration mode:
8. (Optional) Specify port settings:
9. Return to privileged EXEC mode:
10. Verify your entries:
11. (Optional) Save your entries in the configuration file:

DETAILED STEPS

Procedure

Step 1 Enter global configuration mode:

configure terminal

Step 2 Specify the synchronization clock mode:

ptp {**mode boundary delay-req** | **e2etransparent** | **forward** | **gmc-bc**}

- **mode boundary delay-req**—Configures the switch for boundary clock mode using the delay-request mechanism. In this mode, the switch participates in the selection of the most accurate time source clock. Use this mode when overload or heavy load conditions produce significant delay jitter.
- **mode e2etransparent**—Configures the switch for end-to-end transparent clock mode. A switch clock in this mode synchronizes all switch ports with the time source clock. This switch does not participate in time source clock selection and uses the default PTP clock mode on all ports. This is the default clock mode. The message transit time is added to the resident time. Use this mode to reduce jitter and error accumulation.
- **mode forward**—Configures the switch to pass incoming PTP packets as normal multicast traffic.
- **mode gmc-bc**—Configures the switch for grandmaster-boundary clock mode. See Configuring NTP to PTP Time Conversion, on page 29 to configure the switch for this mode.

Step 3 (Optional, BC and TC mode) Specify the PTP clock domain:

ptp domain *domain-number*

domain-number —A number from 0 to 255.

The participating grandmaster clock, switches, and time recipient devices should be in the same domain.

Step 4 (Optional, BC mode only) Specify the BMCA priority:

ptp priority1 *priority* **priority2** *priority*

- **priority1** *priority*—Overrides the default criteria (such as clock quality and clock class) for the most accurate time source clock selection.
- **priority2** *priority*—Breaks the tie between two switches that match the default criteria. For example, enter 2 to give a switch priority over identical switches.*priority* —A priority number from 0 to 255. The default is 128.

Step 5 (Optional, BC mode only) Specify time-property preservation:

ptp time-property persist {*value* | infinite}

- *value*—Time duration, in seconds, from 0-100000. The default is 300.
- infinite—Time properties are preserved indefinitely.

Preserving the time properties prevents time recipient clocks from detecting a variance in the time values when the redundant GMC comes out of standby.

Step 6 (Optional, BC mode only) Specify the BC synchronization algorithm:

ptp transfer {**feedforward** | **filter** {**adaptive** | **linear**}}

- **feedforward**—Very fast and accurate. No PDV filtering.
- **filter adaptive**—Automatically filters as much PDV as possible.
- **filter linear**—Provides a simple linear filter (default).

Step 7 (Optional) Enter interface configuration mode:

interface *interface-id*

Step 8 (Optional) Specify port settings:

Boundary delay-req mode:

ptp {**announce** {**interval** *value* | **timeout** *value*} | **delay-req interval** *value* | **enable** | **sync** {**interval** *value* | **limit** *value*} | **vlan** *value*}

e2etransparent mode:

ptp {**enable | sync** {**interval** *value* | **limit** *value*}}

- **announce interval** *value*—Sets the logarithmic mean interval in seconds to send announce messages. The range is 0 to 4. The default is 1 (2 seconds).
- **announce timeout** *value*— Sets the logarithmic mean interval in seconds to announce timeout messages. The range is 2 to 10. The default is 3 (8 seconds).
- **delay-req interval** *value*—Sets the logarithmic mean interval in seconds for time recipient devices to send delay request messages when the port is in the time source clock state. The range is -2 to 6. The default is -5 (1 packet every 1/32 seconds, or 32 packets per second).
- **enable**—Enables PTP on the port base module.

- **sync interval** *value*—Sets the logarithmic mean interval in seconds to send synchronization messages. The range is –2 to 1. The default is 1 second.
- **sync limit** *value*—Sets the maximum clock offset value before PTP attempts to resynchronize. The range is from 50 to 500000000 nanoseconds. The default is 500000000 nanoseconds.
- **vlan** *value*—Sets the PTP VLAN on a trunk port. The range is from 1 to 4094. The default is the native VLAN of the trunk port. In boundary mode, only PTP packets in PTP VLAN will be processed, PTP packets from other VLANs will be dropped. Before configuring the PTP VLAN on an interface, the PTP VLAN must be created and allowed on the trunk port.

Step 9 Return to privileged EXEC mode:

end

Step 10 Verify your entries:

show running-config

Step 11 (Optional) Save your entries in the configuration file:

copy running-config startup-config

Example

The following example configures the switch to operate in Default Profile mode and end-to-end transparent mode, and uses default values for all PTP interval settings:

```
switch(config)# no ptp profile
switch(config)# ptp mode e2etransparent
```

The following example configures the switch for Default Profile mode and boundary clock mode with the delay_request mechanism, and uses default values for all PTP interval settings:

```
switch(config)# no ptp profile
switch(config)# ptp mode boundary delay-req
```

Verifying Configuration

Command	Purpose
show ptp {**clock**|**foreign-master-records**|**parent**|**port**{**FastEthernet**|**GigabitEthernet**} | **time-property**} | **histogram** | **history** | **internal-info**	Specifies the PTP information to display. • **clock**—Displays PTP clock information. • **foreign-master-records**—Displays PTP foreign-master-records. • **parent**—Displays PTP parent properties. • **port FastEthernet**—Displays PTP properties for the FastEthernet IEEE 802.3 interfaces. • **port GigabitEthernet**—Displays PTP properties for the GigabitEthernet IEEE 802.3z interfaces. • **time-property**—Displays PTP clock-time properties. • **histogram**—Displays PTP offset, delay, or time-error data. • **history**—Displays PTP historical data. • **internal-info**—Displays PTP offset.

Power Profile Example

```
switch# show ptp parent
 PTP PARENT PROPERTIES
  Parent Clock:
  Parent Clock Identity: 0xA4:C:C3:FF:FE:BF:B4:0
  Parent Port Number: 23
  Observed Parent Offset (log variance): N/A
  Observed Parent Clock Phase Change Rate: N/A
  Grandmaster Clock:
  Grandmaster Clock Identity: 0xA4:C:C3:FF:FE:BF:2B:0
  Grandmaster Clock Quality:
        Class: 248
        Accuracy: Unknown
        Offset (log variance): N/A
        Priority1: 128
```

```
        Priority2: 128
switch# show ptp clock
 PTP CLOCK INFO
  PTP Device Type: Boundary clock
  PTP Device Profile: Power Profile
  Clock Identity: 0xA4:C:C3:FF:FE:BF:E0:80
  Clock Domain: 0
  Number of PTP ports: 26
  PTP Packet priority: 4
  Priority1: 128
  Priority2: 128
  Clock Quality:
        Class: 248
        Accuracy: Unknown
        Offset (log variance): N/A
  Offset From Master(ns): 25
  Mean Path Delay(ns): 705
  Steps Removed: 4
  Local clock time: 14:23:56 PST Apr 5 2013
switch# show ptp foreign-master-record
PTP FOREIGN MASTER RECORDS
 Interface GigabitEthernet1/1
   Foreign master port identity: clock id: 0xF4:4E:5:FF:FE:E5:82:0
   Foreign master port identity: port num: 1
   Number of Announce messages: 4
   Message received port: 1
   Time stamps: 1999872004, 1999870997
 Interface GigabitEthernet1/2
   Empty
 Interface GigabitEthernet1/3
   Empty
 Interface GigabitEthernet1/4
   Empty
 Interface GigabitEthernet1/5
   Empty
 Interface GigabitEthernet1/6
   Empty
 Interface GigabitEthernet1/7
   Empty
 Interface GigabitEthernet1/8
   Empty
 Interface GigabitEthernet1/9
   Empty
switch#
switch# show ptp ?
  clock                  show ptp clock information
  foreign-master-record  show PTP foreign master records
  parent                 show PTP parent properties
  port                   show PTP port properties
  time-property          show PTP clock time property
switch# show ptp time-property
 PTP CLOCK TIME PROPERTY
  Current UTC offset valid: 0
  Current UTC offset: 35
  Leap 59: 0
  Leap 61: 0
  Time Traceable: 16
  Frequency Traceable: 32
  PTP Timescale: 1
  Time Source: Internal Osciliator
  Time Property Persistence: 300 seconds
switch# show ptp port GigabitEthernet 1/1
PTP PORT DATASET: GigabitEthernet1/1
  Port identity: clock identity: 0xF4:4E:5:FF:FE:E5:91:80
```

```
  Port identity: port number: 1
  PTP version: 2
  Port state: UNCALIBRATED
  Delay request interval(log mean): 5
  Announce receipt time out: 3
  Peer mean path delay(ns): 0
  Announce interval(log mean): 0
  Sync interval(log mean): 0
  Delay Mechanism: Peer to Peer
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000
switch#
```

Configuration Example

The following example configures the switch for P2P transparent mode, specifies **allow-without-tlv** PTP message processing, and uses default values for all PTP interval settings:

Note The commands work only in power profile.

```
switch(config)# ptp mode p2ptransparent
switch(config)# ptp allow-without-tlv
```

The following example configures the switch for boundary clock mode using the peer delay request (**pdelay-req**) mechanism and uses default values for all PTP interval settings:

```
switch(config)# ptp mode boundary pdelay-req
```

The following example configures the switch to operate in Default Profile mode and end-to-end transparent mode and uses default values for all PTP interval settings:

```
switch(config)# no ptp profile
switch(config)# ptp mode e2etransparent
```

The following example configures the switch for Default Profile mode and boundary clock mode with the delay-request mechanism, and uses default values for all PTP interval settings:

```
switch(config)# no ptp profile
switch(config)# ptp mode boundary delay-req
```

Configuring NTP to PTP Time Conversion

Note Beginning with the Cisco IOS XE Dublin 17.12.x release, Cisco Catalyst IE3100 Rugged Series Switches are supported for NTP to PTP time conversion.

Before you begin

- Review the Guidelines and limitations, on page 16.

- To use the NTP to PTP conversion feature, the switch must have an IP address for NTP to function.
- To use the NTP to PTP conversion feature, you must configure at least one NTP server. Configuring three or more NTP servers allows NTP to ignore bad clocks.

Note For information about configuring NTP, see Network Time Protocol

- When you enter **no** with PTP port configuration commands, the specified port property is set to the default value.
- To determine the value in seconds for the ptp global command *interval* variable, use a logarithmic scale. Below are examples of the *interval* variable value converted to seconds with a logarithmic scale:

Value Entered	Logarithmic Calculation	Value in Seconds
-1	2^{-1}	1/2
0	2^{0}	1

SUMMARY STEPS

1. Enter global configuration mode:
2. Configure the switch for Default Profile mode or Power Profile mode.
3. Specify GMC-BC as the synchronization clock:
4. (Optional) Specify the BMCA priority:
5. (Optional) Specify the BC synchronization algorithm:
6. Enter interface configuration mode:
7. (Optional) Specify port settings:
8. Return to privileged EXEC mode:
9. Verify your entries:
10. (Optional) Save your entries in the configuration file:

DETAILED STEPS

Procedure

Step 1 Enter global configuration mode:

configure terminal

Step 2 Configure the switch for Default Profile mode or Power Profile mode.

ptp profile power

Step 3 Specify GMC-BC as the synchronization clock:

ptp mode gmc-bc delay-req

The GMC-BC automatically selects NTP as the time source if it is available.

Step 4 (Optional) Specify the BMCA priority:

ptp priority1 *priority* **priority2** *priority*

- **priority1** *priority*—Overrides the default criteria (such as clock quality and clock class) for the most accurate time source clock selection.
- **priority2** *priority*—Breaks the tie between two switches that match the default criteria. For example, enter 2 to give a switch priority over identical switches.
- *priority* —A priority number from 0 to 255. The default is 128.

Note
A lower value has higher priority.

Step 5 (Optional) Specify the BC synchronization algorithm:

ptp transfer {**feedforward** | **filter** {**adaptive** | **linear**}}

- **feedforward**—Very fast and accurate. No PDV filtering.
- **filter adaptive**—Automatically filters as much PDV as possible.
- **filter linear**—Provides a simple linear filter (default).

Step 6 Enter interface configuration mode:

interface interface-id

Step 7 (Optional) Specify port settings:

ptp {**announce** {**interval** *value* | **timeout** *value*} | **delay-req interval** *value* | **enable** | **sync** {**interval** *value* | **limit** *value*} | **vlan** *value*}

- **announce interval** *value*—Sets the logarithmic mean interval in seconds to send announce messages. The range is 0 to 4. The default is 1 (2 seconds).
- **announce timeout** *value*— Sets the time to announce timeout messages. The range is 2 to 10 seconds. The default is 3 (8 seconds).
- **delay-req interval** *value*—Sets the logarithmic mean interval in seconds for time recipient devices to send delay request messages when the port is in the time source clock state. The range is -2 to 6. The default is -5 (1 packet every 1/32 seconds, or 32 packets per second).
- **enable**—Enables PTP on the port base module.
- **sync interval** *value*—Sets the logarithmic mean interval in seconds to send synchronization messages. The range is –2 to 1. The default is 1 second.
- **sync limit** *value*—Sets the maximum clock offset value before PTP attempts to resynchronize. The range is from 50 to 500000000 nanoseconds. The default is 500000000 nanoseconds.
- **vlan** *value*—Sets the PTP VLAN on a trunk port. The range is from 1 to 4094. The default is the native VLAN of the trunk port. In boundary mode, only PTP packets in PTP VLAN will be processed, PTP packets from other VLANs will be dropped. Before configuring the PTP VLAN on an interface, the PTP VLAN must be created and allowed on the trunk port.

Step 8 Return to privileged EXEC mode:

end

Step 9 Verify your entries:

show running-config

Step 10 (Optional) Save your entries in the configuration file:

copy running-config startup-config

Example

The following example configures the switch to use the Default Profile, act as Grandmaster Clock with NTP as the time source, and use the feedforward BC synchronization algorithm:

```
switch(config)# ptp mode gmc-bc delay-req
switch(config)# ptp transfer feedforward
```

Verifying Configuration

Perform these steps to verify that switch is running as GMC-BC, and that NTP and PTP are synchronized:

SUMMARY STEPS

1. Monitor the status of NTP until NTP locks:
2. Display the status of each individual NTP server:
3. After NTP is up and running, verify that the NTP clock and the PTP clock are in sync.

DETAILED STEPS

Procedure

Step 1 Monitor the status of NTP until NTP locks:

show ntp status

Note especially the following fields:

- Clock is synchronized/unsynchronized.
- System poll interval—how often the NTP client sends messages in seconds.
- Last update—how many seconds since the last clock adjustment.

Example:

```
switch# show ntp status
```

```
Clock is synchronized, stratum 2, reference is 72.163.32.43
nominal freq is 286.1023 Hz, actual freq is 286.0738 Hz, precision is 2**21
ntp uptime is 58682700 (1/100 of seconds), resolution is 3496
reference time is D95162A8.68E52FF9 (22:52:24.409 UTC Wed Jul 15 2015)
clock offset is 0.0459 msec, root delay is 16.19 msec
root dispersion is 15.07 msec, peer dispersion is 0.10 msec
loopfilter state is 'CTRL' (Normal Controlled Loop), drift is 0.000099341 s/s
system poll interval is 1024, last update was 925 sec ago.
```

Step 2 Display the status of each individual NTP server:

show ntp association

- The sys.peer is the currently selected reference.
- Candidates are fallback references.
- Falsetickers are bad clocks that are ignored.

Note
There is a delay of several seconds from NTP picking an association to NTP declaring lock.

Example:

```
switch# show ntp association
address         ref clock       st   when   poll reach  delay  offset   disp
+~171.68.38.65    .GPS.            1    706   1024   377 60.318  -0.255  0.166
+~171.68.38.66    .GPS.            1    450   1024   377 60.333  -0.096  0.121
-~10.81.254.202   .GPS.            1    555   1024   377 48.707   2.804  0.111
x~173.38.201.115  .GPS.            1    322   1024   377 293.19  74.409  0.107
*~72.163.32.43    .GPS.            1     37   1024   375 17.110  -0.410  0.081
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```

Step 3 After NTP is up and running, verify that the NTP clock and the PTP clock are in sync.

- **show clock detail** shows the NTP time.
- **show ptp clock** shows the PTP time and the BMCA dataset details.
- **show ptp clock** Steps Removed field indicates whether the GMC-BC really is the GMC or if some other clock is running the PTP network. When the GMC wins the BMCA, the Steps Removed field should be 0.

Example:

```
show clock detail
23:16:53.865 UTC Wed Jul 15 2015
Time source is NTP
show ptp clock
 PTP CLOCK INFO

PTP Device Type: Grand Master clock - Boundary clock
  PTP Device Profile: Default Profile
  Clock Identity: 0xF4:4E:5:FF:FE:E5:95:0
  Clock Domain: 0
  Number of PTP ports: 20

Time Transfer: Linear Filter <<< Displayed when the clock is configured as a BC or a GMC-BC
  Priority1: 128
  Priority2: 128
  Clock Quality:
        Class: 13
        Accuracy: Within 1s
```

```
      Offset (log variance): N/A
  Offset From Master(ns): 0
  Mean Path Delay(ns): 0

Steps Removed: 0
  Local clock time: 23:16:53 UTC Jul 15 2015
```

Configuration Example

```
switch# conf t
switch(config)# no ptp profile power
switch(config)# ptp mode gmc-bc delay-req
switch(config)# ptp transfer feedforward
switch(config)# end
```

PTP Serviceability

PTP Serviceability refers to the ability to troubleshoot and monitor PTP performance on a network with a Cisco IE Switch. This section describes how to display the following PTP Serviceability statistics and information:

- PTP message counters
- PTP error counters
- Timestamp offset and mean path delay maximum and minimum values
- Histogram of the offset and mean path delay values
- PTP alarms

Displaying PTP Message Counters

To display counter information for PTP messages sent and received on all interfaces, use the **show ptp port counters messages** command. To display counters for a specific interface, enter **show ptp port counters messages <interface>**. For example:

```
NAT1#show ptp port counters messages

GigabitEthernet1/1

       Transmit                                Receive
         1680  Sync                              47  Sync
           15  Delay_Req                          0  Delay_Req
            0  Pdelay_Req                         0  Pdelay_Req
            0  Pdelay_Resp                        0  Pdelay_Resp
         1680  Follow_Up                         47  Follow_Up
            0  Delay_Resp                        15  Delay_Resp
            0  Pdelay_Resp_Follow_Up              0  Pdelay_Resp_Follow_Up
          841  Announce                          47  Announce
            0  Signaling                          0  Signaling
            0  Management                         0  Management
```

```
NAT2#show ptp port gi1/2 counters messages

GigabitEthernet1/2

       Transmit                                  Receive
            0  Sync                             7848  Sync
          242  Delay_Req                           0  Delay_Req
            0  Pdelay_Req                          0  Pdelay_Req
            0  Pdelay_Resp                         0  Pdelay_Resp
            0  Follow_Up                        7848  Follow_Up
            0  Delay_Resp                        242  Delay_Resp
            0  Pdelay_Resp_Follow_Up               0  Pdelay_Resp_Follow_Up
            0  Announce                         3929  Announce
            0  Signaling                           0  Signaling
            0  Management                          0  Management

NAT2#
```

The command output is described in the table below.

Enter **clear ptp port counters messages** to clear the message counters for all interfaces.

To clear the counters for specific port, enter **clear ptp port interface_name counters messages**.

Port	The port type and number (for example, Gi1/3).
Transmit, Receive	The direction of the data displayed in the table.
Sync	Event message tagged with a timestamp when data packets reach or leave a port and used to synchronize ordinary and boundary clocks.
Delay_Req	Delay request—Event message tagged with a timestamp when data packets reach or leave a port and used to synchronize ordinary and boundary clocks.
Pdelay_Req	Peer delay request—Event message tagged with a timestamp when data packets reach or leave a port and used to measure the link delay in transparent clocks.
Pdelay_Resp	Peer delay response—Event message tagged with a timestamp when data packets reach or leave a port and used to measure the link delay in transparent clocks.
Follow_Up	General message (not tagged with a timestamp) used to use to synchronize ordinary and boundary clocks.
Delay_Resp	Delay response—General message used to synchronize ordinary and boundary clocks. The time source conveys the timestamp t4 to the time recipient by embedding it in a Delay_Resp message.
Pdelay_Resp_Follow_Up	Peer delay response follow up—General message (not tagged with a timestamp) used to measure the link delay in transparent clocks.

Announce	General message (not tagged with a timestamp) used to establish a time source-time recipient hierarchy.
Signaling	Message used to transport a sequence of one or more TLV entities. Signaling messages are transmitted from one clock to one or more other clocks.
Management	Messages used to access attributes and to generate certain events defined in the PTP standard.

Displaying PTP Error Message Counters

PTP errors are categorized as field mismatch errors, unexpected messages, duplicate messages, and generic errors. To display counter information for PTP errors that occurred on all interfaces, use the **show ptp port counters errors** command. To display counters for a specific interface, enter **show ptp port counters errors <interface>**. For example:

```
NAT2#show ptp port counters errors

GigabitEthernet1/1

            0  Sanity check failed                0  Blocked port
            0  Timestamp get failed               0  ParentId invalid
            0  Vlan mismatch                      0  GmcId invalid
            0  Domain mismatch                    0  SequenceId invalid
            0  Sync fault                         0  Unmatched Follow_Up
            0  Duplicate Sync                     0  Unmatched Delay_Resp
            0  Duplicate Announce                 0  Unmatched Pdelay_Resp
            0  Send error                         0  Unmatched Pdelay_Resp_Follow_Up
            0  Misc error                         0  Rogue master Sync
            0  Rogue master Follow_Up             0  Rogue master Announce

NAT2#show ptp port gi1/2 counters errors

GigabitEthernet1/2

            0  Sanity check failed                0  Blocked port
            0  Timestamp get failed               0  ParentId invalid
            0  Vlan mismatch                      0  GmcId invalid
            0  Domain mismatch                    0  SequenceId invalid
            0  Sync fault                         0  Unmatched Follow_Up
            0  Duplicate Sync                     0  Unmatched Delay_Resp
            0  Duplicate Announce                 0  Unmatched Pdelay_Resp
            0  Send error                         0  Unmatched Pdelay_Resp_Follow_Up
            0  Misc error                         0  Rogue master Sync
            0  Rogue master Follow_Up             0  Rogue master Announce

NAT2#
```

The command output is described in the table below.

Enter **clear ptp port counters errors** to clear the error counters for all interfaces.

To clear the error counters for specific port, enter **clear ptp port interface_name counters errors**.

Port	The port type and number.
Sanity check failed	The PTP message header field(s) of ingress PTP packets are invalid.

Timestamp get failed	The timestamp for PTP messages is generated by the hardware. The timestamp error counter is incremented when the software is unable to fetch the timestamp for a given PTP message. The PTP messages that have a timestamp are Sync, Delay_Req, Pdelay_Req, and Pdelay_Resp.
Vlan mismatch	The VLAN ID of ingress PTP messages is different from the VLAN ID configured in the **ptp vlan** command.
Domain mismatch	(Applicable only in Boundary Clock mode) The domain number field of ingress PTP messages is different from the configured PTP clock domain (the PTP domain number configured in the **ptp domain** command).
Sync fault	The PTP clock offset value has exceeded the "sync limit" value configured on the PTP time recipient port (the value configured for **ptp sync limit** on the interface, which is in the PTP SLAVE state).
Duplicate sync	The number of duplicate PTP Sync messages received by the switch. (Duplicates are identified by checking the PTP sequence number on received messages.)
Duplicate announce	The number of duplicate PTP Announce messages received by the switch. (Duplicates are identified by checking the PTP sequence number on received messages.)
Send error	The number of PTP messages that could not be sent due to failures. PTP software might fail to send PTP messages due to reasons such as memory allocation failure, failure to obtain the correct outgoing interface information, etc.
Misc error	The number of miscellaneous errors that have occurred in the PTP protocol. Any error other than the ones listed above is classified as a miscellaneous error.
Rogue master Follow_Up	The number of dropped incoming follow up messages for rogue packets.
Blocked port	The PTP messages (except Peer-Delay messages) are received on REP/STP blocked ports.

ParentId invalid	(Applicable only in Boundary Clock mode) The source port identity of ingress PTP messages is different from parent port identity of the local PTP clock.
GMCId invalid	(Applicable only in Boundary Clock mode) The grandmaster clock identity of ingress announce messages has an invalid value (the grandmaster clock identity of ingress announce messages is the same as the clock identity of the local PTP clock).
SequenceId invalid	(Applicable only in Boundary Clock mode) The sequence ID field of ingress PTP messages has an invalid value (the sequence ID of the follow-up message is different from the sequence ID of the preceding sync message).
Unmatched Follow_Up	The switch received a Follow up message when there was no outstanding SYNC message for which it expected a Follow up.
Unmatched Delay_Resp	Unmatched Delay Response—The switch received a Delay Response without sending a Delay Request.
Unmatched Pdelay_Resp	Unmatched Peer Delay Response—The switch received a Peer Delay Response message without sending a Peer Delay Request.
Unmatched Pdelay_Resp_Follow_Up	Unmatched Peer Delay Response Follow up—The switch received a Peer Delay Response Follow up message without sending a Peer Delay Request.
Rogue master Sync	The number of dropped incoming Sync messages for rogue packets.
Rogue master Announce	The number of dropped incoming Announce messages for rogue packets.

Displaying PTP Offset and Delay

The PTP offset value is the measured offset of the clock from the time source clock, in nanoseconds. The mean path delay is the average time, in nanoseconds, taken by PTP frames to travel between time source and time recipient. You can display the historical maximum and minimum values for the offset from time source and mean path delay when the switch is operating in GMC-BC (Grandmaster Boundary Clock) or BC (Boundary Clock) modes. You can also display a histogram of offset, delay, and time errors, where the historical values of the field specified are divided into bins to show the data distribution.

High offset and delay values can indicate a problem, for example, when a device goes down in the network and the link to the time source is available but not viable. Ideally, offset and delay values should be as small as possible. Some PTP modes or profiles might cause higher offset values. Offsets can be negative.

Offset and delay values are shown for the last day and the past 5 seconds, 15 seconds, 1 minute, 5 minutes, 15 minutes, 1 hour, 5 hours, 15 hours, 1 day (same as last day), 5 days, 15 days, and more than fifteen days.

If the switch is the time source or grandmaster clock these values are zero.



Note The commands to show historical maximum and minimum values for the offset from time source and mean path delay are supported for both PTP Default Profile and Power Profile.

The commands to show time error data apply to p2ptransparent or e2etransparent clock modes.

Delay

To display the historical maximum and minimum values for the mean path delay, enter **show ptp history delay**, as shown in this example:

```
NAT1#sh ptp history delay

                            5 seconds  15 seconds    1 minute   5 minutes

Max mean path delay(ns):            0           0           0           0
Min mean path delay(ns):            0           0           0           0

                           15 minutes      1 hour     5 hours    15 hours

Max mean path delay(ns):            0           0           0           0
Min mean path delay(ns):            0           0           0           0

                                 1 day      5 days     15 days    >15 days

Max mean path delay(ns):        12154       12154       12154       12154
Min mean path delay(ns):            0           0           0           0

NAT1#
```

Time Error

To display the historical maximum and minimum values for time error data when the clock mode is p2ptransparent or e2etransparent, enter **show ptp history time-error**, as shown in this example:

```
NAT2#sh ptp history time-error

                       5 seconds  15 seconds    1 minute   5 minutes

Max time error(ns):            0           0           0           0
Min time error(ns):       -35260      -36487      -36487           0

                      15 minutes      1 hour     5 hours    15 hours

Max time error(ns):            0           0           0           0
Min time error(ns):            0           0           0           0

                            1 day      5 days     15 days    >15 days

Max time error(ns):            0           0           0           0
Min time error(ns):            0           0           0           0

NAT2#
```

Histogram

To display a histogram of PTP offset, delay, or time-error data, enter the **show ptp histogram [delay|time-error]** command. Data is shown for the last 60 seconds, the last hour, and the last 24 hours. Values are divided into ranges of 0 to 20 nanoseconds, 20 to 50 nanoseconds, 50 to 100 nanoseconds, 100 to 250 nanoseconds, 250 to 500 nanoseconds, 500 to 1000 nanoseconds, 1000 to 10,000 nanoseconds, and greater than 10,000 nanoseconds. Offset and time-error values are further classified as negative or positive.

- Offset—Available when the clock mode is boundary; displays histogram for offset from time source.
- Delay—Available when the clock mode is boundary or gmc-boundary; displays histogram of mean path delay data.
- Time-error—Available when the clock mode is p2ptransparent or e2etransparent; displays histogram of data for time-error (frequency error * residence time).

The following example shows the histogram for PTP offset and delay.

The following example shows the histogram for time error data.

```
NAT2#sh ptp histogram time-error

Time Error (in nanoseconds)

Last 60 seconds:
        286        270        264        240        211        201        172
        137        129        105         83         38         -5        -48
        -69        -97       -148       -208       -229       -266       -336
       -357       -427       -451       -500       -567       -664       -705
       -772       -840       -910      -1022      -1071      -1165      -1262
      -1435      -1489      -1592      -1757      -1836      -1969      -2199
      -2263      -2498      -2578      -2735      -3013      -3106      -3311
      -3509      -3718      -3936      -4183      -4596      -4729      -5020
      -5338      -5650      -6121      -6282

Time Error range        Positive     Negative
----------------        --------     --------
  0-20ns                   0            1
 20-50ns                   1            1
 50-100ns                  1            2
100-250ns                  7            3
250-500ns                  3            6
500-1us                    0            6
  1-10us                   0           29
   >10us                   0            0

Last 60 minutes:
       -208      -3106     -16704          0          0          0          0
          0          0          0          0          0          0          0
          0          0          0          0          0          0          0
          0          0          0          0          0          0          0
          0          0          0          0          0          0          0
          0          0          0          0          0          0          0
          0          0          0          0          0          0          0
          0          0          0          0          0          0          0
          0          0          0          0

Time Error range        Positive     Negative
----------------        --------     --------
  0-20ns                  57            0
 20-50ns                   0            0
 50-100ns                  0            0
100-250ns                  0            1
```

```
250-500ns                   0           0
500-1us                     0           0
  1-10us                    0           1
   >10us                    0           1

Last 24 hours:
          0          0          0          0          0          0          0
          0          0          0          0          0          0          0
          0          0          0          0          0          0          0
          0          0          0

Time Error range        Positive     Negative
----------------        --------     --------
  0-20ns                   24           0
 20-50ns                    0           0
 50-100ns                   0           0
100-250ns                   0           0
250-500ns                   0           0
500-1us                     0           0
  1-10us                    0           0
   >10us                    0           0

NAT2#
```

Clearing Statistics

Enter **clear ptp history** to clear the offset, delay, and time error historical statistics.

Enter **clear ptp histogram** to clear the offset, delay, and time error histogram statistics.

Debugging PTP

Commands that you can use to debug PTP are listed in the following table.

debug ptp messages [*message-type*]	Enables debugging of PTP messages. You can specify *message-type* to filter out the logs based on the PTP message type: • announce • delayreq • delayresp • followup • peerdelayfollowup • peerdelayreq • peerdelayresp • sync
debug ptp error	Enables debugging of PTP errors.
debug ptp bmc	Enables debugging of the PTP Best Master Clock Algorithm.

debug ptp event	Enables debugging of PTP state event.

PTP alarms

PTP alarms are system notifications that help you manage and monitor PTP on the switch by alerting you to specific events or state changes related to PTP operation. PTP alarms:

- can be configured to trigger external alarm relay outputs and send system messages to a syslog server.
- are raised only once for the first 5-minute interval after bootup and subsequently once every 30 minutes.
- are disabled by default and are damped during continuous state changes such as port or parent flapping.

PTP alarm timing and types

PTP alarm monitoring starts 5 minutes after bootup. The alarm is raised only once for the first 5-minute interval and subsequently once for an interval of 30 minutes. Alarms are damped when there is continuous state change, such as PTP port state flapping or PTP parent flapping.

This table describes the types of PTP alarms:

Table 6: PTP alarms

Alarm	Alarm Type	Clock Mode Supported	Description
PTP SLAVE port state change	Minor	Boundary and transparent clock modes	This alarm is raised when the PTP port state changes from “SLAVE” to any of the following PTP port states: Initializing, Faulty, Disabled, Listening, Pre_Master, Master, Passive, or Uncalibrated. A system message is generated when the PTP port state transitions between Slave and Passive Slave. This alarm remains raised until you clear the alarm.

Alarm	Alarm Type	Clock Mode Supported	Description
PTP PASSIVE_SLAVE port state change	Minor	Boundary and transparent clock modes	This alarm is raised when the PTP port state changes from "PASSIVE-SLAVE" to any of the following PTP port states: Initializing, Faulty, Disabled, Listening, Pre_Master, Master, Passive, or Uncalibrated. A system message is generated when the PTP port state transitions between Slave and Passive Slave.
PTP Parent change	Minor	Boundary clock mode	This alarm is raised when there is a change in PTP parent. This alarm remains raised until you clear the alarm.
PTP Time Property Clock Synchronized	Minor	Transparent clock mode	This alarm is raised when the PTP Clock Time Property "Clock Syntonized" field changes from TRUE to FALSE. This alarm is cleared when the "Clock Syntonized" field changes from FALSE to TRUE.

Configure the PTP alarms

To enable and configure the global PTP alarms:

Procedure

Step 1 Use the **enable** command to enable the privileged EXEC mode.

Example:

```
Switch> enable
```

Enter your password if prompted.

Step 2 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Switch# configure terminal
```

Step 3 Use the **alarm facility ptp enable** command to enable PTP alarms.

Example:

```
Switch(config)# alarm facility ptp enable
```

Step 4 Use the **alarm facility ptp notifies** command to enable notifications to be sent to an SNMP server.

Example:

```
Switch(config)# alarm facility ptp notifies
```

Step 5 Use the **alarm facility ptp relay major** command to configure the association of PTP alarms to a relay.

Example:

```
Switch(config)# alarm facility ptp relay major
```

Step 6 Use the **alarm facility ptp relay major** command to send PTP alarm traps to a syslog server.

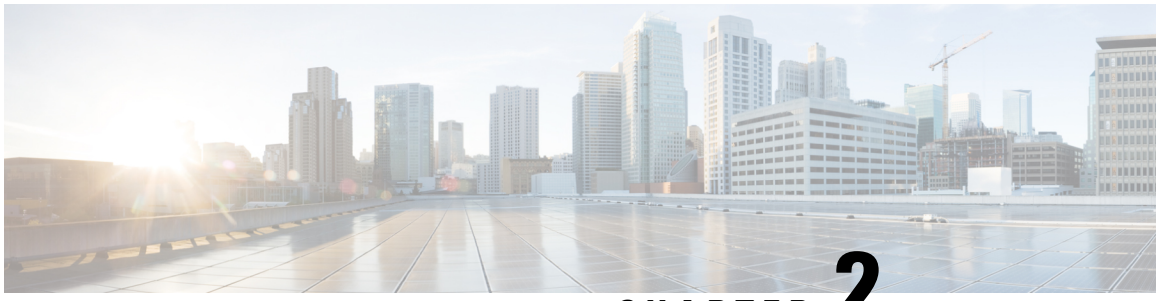
Example:

```
Switch(config)# alarm facility ptp syslog
```

```
Switch# configure terminal
                Switch(config)# alarm facility ptp enable
                Switch(config)# alarm facility ptp syslog
                Switch(config)# end
                Switch# show alarm settings
                …..
                …..
                …..
                PTP
                Alarm     Enabled
                Relay     MIN
                Notifies  Enabled
                Syslog    Enabled
                Switch# show facility-alarm status
                Source                  Severity Description                        Relay
    Time
                Switch                   MINOR    32 PTP Clock Parent change          NONE
     Mar 09 2022 01:23:45
                GigabitEthernet1/0/21    MINOR    5 PTP SLAVE port state changed      NONE
     Mar 09 2022 01:23:45
                GigabitEthernet1/0/21    MINOR    6 PTP PASSIVE_SLAVE port state chan NONE
     Mar 09 2022 01:23:45
```

Feature History

Feature Name	Release	Feature Information
NTP to PTP Time Conversion	17.12.1	Initial support on Cisco Catalyst IE3100 Rugged Series Switches.



CHAPTER 2

Manage file systems and the Swap Drive

- Primary file system and swap drive, on page 45
- ROM Monitor variables and configuration, on page 46
- SD card operation, on page 47
- Insert or remove SD card, on page 50
- Enable the SD card, on page 51
- Disable the SD card, on page 52
- Configure automatic synchronization from internal flash to SD card, on page 53
- Setup switch using SD card, on page 54
- Format the SD card to load Cisco IOx, on page 54
- Emergency recovery for Cisco IOS XE image, on page 55

Primary file system and swap drive

The flash file system on IE switches is the primary file system for booting an IE switch. The swap drive allows you to use SD card as a backup for the startup configuration and the installation file (Cisco IOS XE .bin).

Primary file system

The flash file system on IE switches is the primary file system for booting an IE switch, regardless of whether an SD card is present. If the IE switch cannot find a configuration in flash, it will attempt to find one in sdflash, copy the configuration and the installation file to flash, and then boot from flash.

Swap drive

The Swap Drive feature allows you to use an SD card as a backup for the startup configuration and the installation file. You can remove the SD card from one IE switch and install into a new IE switch. When the new IE switch (without a startup configuration in flash) is powered on, it checks flash for a configuration file. If the file is not found, the feature checks for a configuration file in the sdflash. If found, it:

- copies the startup configuration and the installation files from sdflash to flash
- automatically reboots, and
- uses the copied files from the previous IE switch.

Supported SD card options and usage considerations

- The switch does not support third-party SD cards or SD High Capacity (SDHC) cards. Attempting to use a non-supported card results in the following message being displayed:

```
WARNING: Non-IT SD flash detected.
Use of this card during normal operation can impact and
severely degrade performance of the system.
Please use supported SD flash cards only.
```

- When the SD card's write-protect switch is locked, the switch can read and boot from the card. However, updates and files cannot be written to the card.

Note After running the **write erase** command and reloading the device, the following message may appear during bootup.

```
% failed to initialize nvram
```

This is a harmless message and does not indicate a functional issue.

ROM Monitor variables and configuration

The following table explains the ROM Monitor variables and configurations.

Table 7: ROM Monitor variables and configuration

Boot and Install Settings	Description
Storage Location	ROM Monitor variables (romvars) and configurations are always stored and retrieved from flash.
Auto Install Condition	If the flash is empty, the software triggers auto install, copying the first available image to flash from removable media.
Boot Precedence	**1.** Boot using the image path set in boot variable. **2.** Install boot using packages.conf file from flash. **3.** Bundle boot using bootable image from flash. **4.** Bundle boot using the bootable image (.conf or .bin) located in the sdflash. **5.** Bundle boot using the bootable image (.conf or .bin) located in the usbflash.

SD card operation

An SD card (Secure Digital card) is a non-volatile memory card used for storing data. An SD card provides external storage for configuration files, system logs, and software images.

You can insert or remove an SD card while the switch is running. If you insert a supported SD card while the switch is running, it validates the Cisco-embedded string in the Product Name (PNM) field and displays the product number and the flash capacity of the SD card. If you remove an SD card while the switch is running, a warning message is displayed to alert you that the SD card has been removed.

Enable syslog to get a message when the SD card is inserted or removed.

How commands work with SD cards

When an SD card is installed in the switch, the **write**, **boot**, and **sync** commands behave as described in the below sections.

Behavior of write command

The **write** command saves the running configuration. See the table below for command behavior details.

Table 8: Behavior of write command

Command	Boot Source	SD Card Status	Behavior
write	SD card	Present	Saves running configuration to internal flash
write	SD card	Removed	Saves running configuration to internal flash
write	Internal flash	Present	Saves running configuration to internal flash

Behavior of boot command

The **boot** command lets you change the system boot parameters. See the table below for the command behavior details.

Table 9: SD card boot behavior

Command	Boot Source	SD Card Status	Behavior
boot	SD card	Present	• If the boot path points to the SD card, the system boot path is saved to the SD card • If the boot path points to flash, the system boot path is saved to the flash memory
boot	SD card	Removed	• If the boot path points to the SD card, an error is displayed stating that SD card is not available • If the boot path points to flash, the system boot path is saved to the flash memory

Command	Boot Source	SD Card Status	Behavior
boot	Internal flash	Inserted	• If the boot path points to flash, the system boot path is saved to the flash memory • If the boot path points to the SD card, the system boot path is saved to the SD card

Table 10: Internal flash boot behavior with SD card

Command	Boot Source	SD Card Status	Behavior
boot	Internal flash	Present	• If the boot path points to internal flash, the system boot path is set to the flash memory • If the boot path points to the SD card, the system boot path is set to the SD card

Boot loader commands

You can run these boot loader commands on an SD card.

Table 11: Boot loader commands

Command	Description
boot	Load and boot an executable Cisco IOS XE image
cat	Concatenate (type) a file or files
copy	Copy a file
dir	List files in directories
fsck	Check file system consistency
format	Format a file system
mkdir	Create directories
more	Concatenate (display) file
rename	Rename a file
rmdir	Delete empty directories
sd_init	Initialize SD flash file systems

Behavior of sync command

The **sync** command copies the Cisco IOS XE image directory, configuration files, and boot parameters from internal flash memory to the SD card.

Note The **sync** command works only in one direction—from flash to sdflash—as the sync from sdflash to flash is an automated process.

When a type-6 password is configured, the **sync** command status shows the configuration as out of sync with the message that `type-6 passwords are not synced`.

Table 12: Components and files copied by sync command

Component	Included Files
Cisco IOS XE Image Directory	• Cisco IOS XE image file (`.bin`) • Device Manager files • Profinet/CIP configuration files
Configuration Files	• NVRAM config files • VLAN configuration file (`vlan.dat`) • DLR, PNP, and CIP config files
Boot Parameters	Cisco IOS XE boot parameters

Table 13: Options of sync command

Command	Purpose	Examples
sync sdflash	Synchronizes the Cisco IOS XE image directory, configuration files, and boot parameters from internal flash memory to the SD card and restores the IE switch in install mode by default.	`Switch# sync sdflash`
sync sdflash: ios-image *ios-image-name*	Synchronizes the Cisco IOS XE image directory from internal flash memory to the SD card.	`Switch# sync sdflash: ios-image ie3x00-universalk9.17.10.01.SPA.bin`
sync sdflash: restore-bundle	Synchronizes the Cisco IOS XE image directory from internal flash memory to the SD card to restore the IE switch in bundle mode.	`Switch# sync sdflash: restore-bundle`
sync sdflash: skip [**all** | **config** | **ios-image**]	Synchronizes either the Cisco IOS XE configuration or the Cisco IOS XE image directory flash memory to the SD card.	`Switch# sync sdflash: skip ios-image`

SD card alarms

The SD card alarms notify users of potential issues related to the SD card.

The SD card alarms are disabled by default. To activate the alarms, use the options of the **alarm facility sd-card** global configuration command. Additionally, you can configure the alarms and associated traps to be sent to syslog and the SNMP server.

Table 14: SD card alarm facility command options

Command	Purpose	Examples
enable	Enables the SD card alarm feature	`Switch(config)# alarm facility sd-card enable`
notifies	Enable notifications to the server	`Switch(config)# alarm facility sd-card notifies`
relay	Enables relay setting	`Switch(config)# alarm facility sd-card relay major`
syslog	Enables system logging	`Switch(config)# alarm facility sd-card syslog`

Note To disable alarms or clear alarm warnings, use the following commands:

no alarm facility sd-card enable— disables the alarm facility enabled for the SD card.

clear facility-alarm—clears the alarm warning state for the alarms configured on the switch.

Insert or remove SD card

This section explains how to insert and remove an SD card. It also describes the hot-swappable behavior supported by the IE switch.

Hot-swappable behavior

Follow these important guidelines for handling the SD card on the IE switch:

- The SD card is hot-swappable. You can insert or remove it while the switch is running.
- Do not remove the SD card during the boot process or when a write operation to SD card is in progress.

Insert the SD card into the Switch

This task instructs you on inserting an SD card into the switch.

Procedure

Step 1 Orient the SD card correctly.

Step 2 Press the SD card into the slot until it clicks.

Inserting an SD card triggers the system to log a syslog message similar to:

```
Mar 30 01:38:51.965: %FLASH-6-DEVICE_INSERTED: Flash device inserted
```

Remove the SD card from the Switch

This task instructs you on removing an SD card from the Switch.

Procedure

Step 1 Press the SD card slightly inward to release it.

Step 2 After the card ejects, pull it straight out of the slot.

Removing an SD card triggers the system to log a syslog message similar to:

```
Mar 30 01:39:12.467: %FLASH-1-DEVICE_REMOVED: Flash device removed
```

Enable the SD card

The SD card provides external storage for system data.

Procedure

Step 1 To enable an SD card on the switch, use one of the following options:

- ROMMON mode: Set the SD card-related ROMMON variable to 'no'.

```
Switch# set var DISABLE_SD_FLASH=no
```

- Switch CLI mode: Enable the SD card from the switch using the **sdflash** command in the global configuration mode.

```
Switch(config)# sdflash
```

Step 2 (Optional) To confirm whether the SD card is enabled, use the **show file systems** command.

```
Switch# show file systems

File Systems:

Size(b) Free(b) Type Flags Prefixes
- - opaque rw system:
- - opaque rw tmpsys:
518885376 474765312 disk rw crashinfo:
* 1697755136 1133522944 disk rw flash: bootflash:
3967811584 3962859520 disk rw sdflash:
1711341568 1645002752 disk ro webui:
- - opaque ro xmodem:
- - opaque ro ymodem:
- - opaque rw null:
- - opaque ro tar:
- - network rw tftp:
```

```
33554432 33492400 nvram rw nvram:
```

Step 3 (Optional) To confirm that the SD card has been enabled, use the **dir sdflash:** command.

```
Switch# dir sdflash:

Directory of sdflash:/

5 drwx 4096 Nov 4 2024 12:25:50 +00:00 System Volume Information
8 drwx 4096 Nov 4 2024 07:11:22 +00:00 ProfinetGSD
7 drwx 8192 Nov 4 2024 07:10:50 +00:00 EDScisco
6 drwx 4096 Jun 17 2014 23:49:52 +00:00 moncfg
```

Disable the SD card

Procedure

Step 1 To disable an SD card on the switch, use one of the following options:

- ROMMON mode: Set the SD card-related ROMMON variable to 'yes'.

```
Switch# set var DISABLE_SD_FLASH=yes
```

- Switch CLI mode: Disable the SD card from the switch using the **no sdflash** command in the global configuration mode.

```
Switch(config)# no sdflash
```

Step 2 (Optional) After you log in to the switch, you will not see the SD card in the list of file systems. To confirm, use the **show file systems** command.

```
Switch# show file systems

File Systems:
Size(b) Free(b) Type Flags Prefixes
- - opaque rw system:
- - opaque rw tmpsys:
518885376 474765312 disk rw crashinfo:
* 1697755136 1133522944 disk rw flash: bootflash:
1711341568 1645002752 disk ro webui:
- - opaque ro xmodem:
- - opaque ro ymodem:
- - opaque rw null:
- - opaque ro tar:
- - network rw tftp:
33554432 33492400 nvram rw nvram:
- - opaque wo syslog:
```

Step 3 (Optional) To confirm that the SD card has been disabled, use the **dir sdflash:** command.

```
Switch# dir sdflash:
```

```
%Error opening flash:/sdflash (No such file or directory)
```

Configure automatic synchronization from internal flash to SD card

This procedure configures automatic synchronization of files from the internal flash memory of the switch to an SD card.

Procedure

Step 1 Use **configure terminal** command to enter global configuration mode.

Example:

```
Switch# configure terminal
```

Step 2 Use the **auto sync enable** command to enable the automatic synchronization service, allowing the switch to automatically synchronize files from the internal flash to the SD card.

Example:

```
Switch(config)# auto sync enable
```

Note
auto sync is disabled by default. Unless you enable it, you cannot use other options for the feature.

Step 3 Use the **auto sync run time** *hh:mm:ss* command to configure the time of day when the automatic synchronization service should run.

```
Switch(config)# auto sync run time 02:00:00
```

Step 4 (Optional) Use the **auto sync config sdflash: restore-bundle** command to set up automatic synchronization for restoring configurations and image files using bundle mode.

```
Switch(config)# auto sync config sdflash: restore-bundle
```

Step 5 (Optional) Use the **auto sync config sdflash: skip ios-image** command to configure the automatic synchronization to exclude Cisco IOS XE image files, syncing only the configuration files.

```
Switch(config)# auto sync config sdflash: skip ios-image
```

Step 6 (Optional) Use the **auto sync config sdflash: skip config** command to skip configuration files and synchronize only the Cisco IOS XE image.

```
Switch(config)# auto sync config sdflash: skip config
```

Step 7 (Optional) Use **auto sync config sdflash: ios-image** *image_name* command to replace the existing image with the image file you wish to synchronize.

```
Switch(config)# auto sync config sdflash: ios-image ie3x00-universalk9.17.10.01.SPA.bin
```

Setup switch using SD card

This task shows how to restore a switch using an SD card.

Note

- You cannot use the packages from the SD card to load or boot the IE3100 devices. Do not run the **boot sdflash:packages.conf** command at the switch prompt.
- If you are operating in install mode and the IE switch is loading package files (*.pkg) using the file `packages.conf`, do not use the **sync sdflash: restore-bundle** command:
- To load the device in bundle mode using the boot file as an image (for example, `ie3k_iosxe.17.17.01.SPA.bin`), use the **sync sdflash:restore-bundle** command to sync the image and restore the switch. After recovery, the switch comes up in bundle mode.

Procedure

Step 1 Run the **write memory** command on the switch before inserting the SD card.

```
Switch# write memory
```

Step 2 Run the **sync sdflash:** command to synchronize from internal flash to SD card. This saves the startup configuration and Cisco IOS XE bundle images on the switch to the SD card.

```
Switch# sync sdflash:
```

Step 3 Insert the SD card with the startup configuration and the Cisco IOS XE bundle images into the new switch.

Step 4 Power on the new switch.
The switch automatically restores and loads both the startup configuration and Cisco IOS XE bundle image from the SD card.

Format the SD card to load Cisco IOx

To support Cisco IOx applications on the switch, the SD card must be formatted for the successful deployment and operation of IOx applications.

Before you begin

To run Cisco IOx applications on the switch, format the SD card in EXT4 format.

To run both Cisco IOS XE and Cisco IOx applications, create both FAT32 and EXT4 file system partitions on the SD card using the **partition sdflash** command.

- The first partition is the FAT32 partition for Cisco IOS XE, which requires a minimum of 1 GB of space.
- The second partition is the EXT4 partition for Cisco IOx, which requires a minimum of 2.5 GB of space.

Procedure

Step 1 Use the **partition sdflash** command to create a partition for Cisco IOx.

```
partition sdflash <create iox partition [size (MB or percentage)]>
```

The command splits the SD card into two partitions. See the table below for partition information.

SD Card Size	Partition 1 (FAT32)	Partition 2 (EXT4)	Notes
4 GB or greater	34% of total SD card size, mounted to `/flash11`	66% of total SD card size, mounted to `/flash12`	The SD card is auto-partitioned by default.
Less than 4 GB	Must be manually specified	Must be manually specified	At least 1 GB for Cisco IOS XE partition and 2.5 GB for IOx is required. If inadequate space is specified, a warning is shown and partitioning fails.

Caution
When the **partition sdflash** command is used, all data present before the partition is lost.

Step 2 Use the **format sdflash** command to dedicate the entire SD card to Cisco IOx or Cisco IOS XE.

```
format sdflash <filesystem format>
```

This command deletes all existing partitions and replaces them with a single partition of the specified filesystem format:

- FAT32 — Cisco IOS XE
- EXT4— Cisco IOx

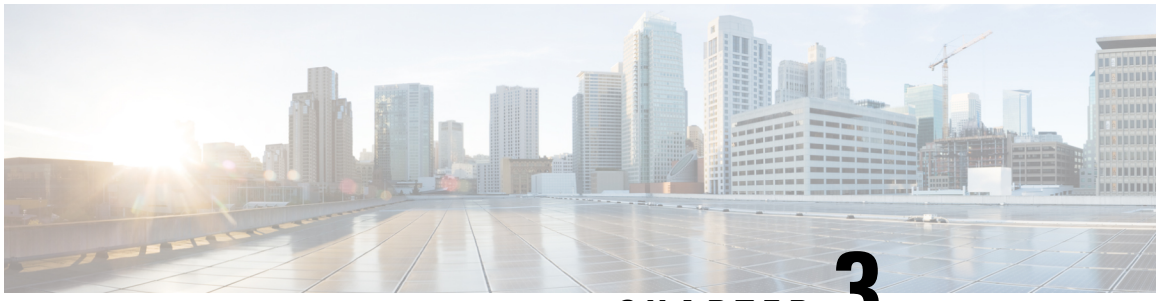
Note
The standard SD card format is FAT32.

Emergency recovery for Cisco IOS XE image

The emergency recovery process for the Cisco IOS XE image restores the switch to a functional state.

When a switch or SD card has a corrupted image and configuration file, or if the switch is stuck in ROMMON mode at the **switch: prompt**, perform the emergency recovery procedure using a valid image in the emgy0 storage directory.

At the **switch: prompt**, boot the image from the emgy0 partition. Ensure you have a connection to the switch console. After fixing the issue, the switch boots with factory default settings. For information on the emergency recovery steps, see Emergency Recovery Installation for Cisco Catalyst IE3x00 Rugged and IE3400 Heavy Duty Switches.



CHAPTER 3

Onboard Failure Logging

- Onboard Failure Logging, on page 57
- Feature History for Onboard Failure Logging, on page 59

Onboard Failure Logging

Onboard failure logging (OBFL) monitors and records the health of vital pieces of network equipment, storing the information in a separate partition of the internal flash. The logging is automatic; there is nothing to configure.

OBFL is supported on Cisco Catalyst IE3100 Rugged Series Switches beginning with the Cisco IOS XE 17.13.1 release.

Parameters and Commands

The following table lists the parameters OBFL monitor and the **show** CLI commands that you use to view the logged information.

Parameter	Description	CLI Command
`status`	Shows the OBFL parameters and logging submodules enabled.	**show logging onboard rp active status**
`temperature`	Monitors the two temperature points on both line cards.	**show logging onboard rp active temperature**
`voltage`	Monitors primary DC power connector status. Displays 0 if the DC power supply is not connected and 1 if the DC power supply is connected.	**show logging onboard rp active voltage**
`hw-errors`	Logs FPGA-related correctable and uncorrectable errors.	**show logging onboard rp active hw-err**
`uptime`	Shows the time from which the system came up and the reason for the last reload.	**show logging onboard rp active uptime**

Command Examples

The following list shows the CLI commands and their output:

show logging onboard rp active status

```
Switch# show logging onboard rp active status

Status: Enabled
```

show logging onboard rp active temperature

```
Switch# show logging onboard rp active temperature

Name               Id     Data (C)  Poll      Last Update
-------------------------------------------------------------------------
Temp: LM75BXXX     20           39  1         02/15/17 19:14:12
Temp: LM75BXXX     20           39  1         02/15/17 19:14:12
Temp: LM75BXXX     20           41  1         02/17/17 21:56:14
Temp: LM75BXXX     20           41  1         02/17/17 21:56:14
Temp: LM75BXXX     20           39  1         02/18/17 10:51:12
Temp: LM75BXXX     20           39  1         02/18/17 10:51:12
Temp: LM75BXXX     20           39  1         02/19/17 02:57:22
Temp: LM75BXXX     20           39  1         02/19/17 02:57:22
Temp: LM75BXXX     20           41  1         02/21/17 15:58:13
Temp: LM75BXXX     20           41  1         02/21/17 15:58:13
Temp: LM75BXXX     20           39  1         02/21/17 18:34:22
```

show logging onboard rp active voltage

```
Switch# show logging onboard rp active voltage

Name               Id    Data (mV)  Poll      Last Update
-------------------------------------------------------------------------
DCA                1             1  1         03/11/17 23:40:43
DCB                2             0  1         03/11/17 23:40:43
DCA                1             1  1         03/11/17 23:46:30
DCB                2             0  1         03/11/17 23:46:30
DCA                1             1  1         03/11/17 23:52:17
DCB                2             0  1         03/11/17 23:52:17
DCA                1             1  1         03/11/17 23:58:04
DCB                2             0  1         03/11/17 23:58:04
DCA                1             1  1         03/12/17 00:03:51
```

show logging onboard rp active hw-err

```
Switch# show logging onboard rp active hw_errors
```



Note The output is displayed only if there is an error. If there are no errors in the unit, nothing will be shown. In the above output, nothing is omitted.

show logging onboard rp active uptime

```
Switch# show logging onboard rp active uptime

----------------------------------------------
UPTIME SUMMARY INFORMATION
----------------------------------------------
First customer power on: 01/15/00 07:08:43
Number of resets: 2
Number of slot changes: 0
Last reset reason: Reload command
Current slot: 1
```

```
Current power on: 03/11/17 22:15:57

-----------------------------------------------
UPTIME CONTINUOUS INFORMATION
-----------------------------------------------
 Slot              Reset reason  Power On               Up: Years   Days  Hours   Mins

-------------------------------------------------------------------------------------

    1             image install  03/11/17 22:11:52             0      0      0      0

    1            Reload command  03/11/17 22:15:57             0      0      0      0
```

To clear OBFL logs, use the command **clear logging onboard slot r0 ?**, as shown in the following example:

```
Switch#clear logging onboard slot r0 ?

dram Clear DRAM ECC error log
serdes Clear onboard serdes log
temperature Clear onboard temperature log
voltage Clear onboard voltage log
```

Feature History for Onboard Failure Logging

This table provides release and related information for features explained in this chapter. These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE 17.13.1	Onboard Failure Logging	OBFL is supported for Cisco Catalyst IE3100 Rugged Series Switches beginning in this release.