Configuring Precision Time Protocol (PTP)

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Restrictions and Limitations for PTP

- The output of the **show clock** command on the device and PTP servo clock displayed in the output of the **show platform software fed switch active ptp domain** command are not synchronized. These are two different clocks used on the switch.
- Inter-VLAN is not supported in PTP Transparent Clock Mode.
- PTP is not supported on Cisco StackWise Virtual enabled devices.
- The switch supports IEEE 802.1AS and IEEE 1588 Default profile and they are both mutually exclusive. Only one profile can be enabled on the switch at a time.
- The Cisco PTP implementation supports only the two-step clock and not the one-step clock. If the switch receives a one-step message from the Grand Master Clock, the message will be dropped.
- We do not recommend having non-PTP enabled devices in the PTP network since it decreases clock synchronization accuracy.
- Signaling messages are not supported in Cisco IOS XE Gibraltar 16.12.1. These messages are dropped in the switch without being processed.
- Management messages with broadcast target id will be forwarded with a reduced hop count when the boundary clock mode is enabled. Management messages will be forwarded without decreasing the boundary hop count when transparent clock mode is enabled.
- Moving directly from one PTP mode to the other is not recommended. Clear the existing mode using **no PTP mode** and then configure a new mode.
- IPv6 and VRF do not support PTP.
- Transparent clock mode is not supported on native Layer 3 ports and EtherChannel interfaces. (boundary clock mode is supported on native Layer 3 ports)

- You cannot configure PTP on any port of a supervisor module.
- Stateful Switchover (SSO) does not support PTP. The PTP protocol restarts after a switchover.
- MACsec with Precision Time Protocol (PTP) is not supported.

Information About PTP

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.

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

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.

Why PTP?

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 the 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 can occur when packets entering a switch are stored in local memory while the switch searches the MAC address table to verify packet CRC fields. This process causes variations in packet forwarding time latency, and these variations can result in asymmetrical packet delay times.

Adding PTP to a network can compensate 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 (BCs) and transparent clocks (TCs).

Message-based Synchronisation

To ensure clock synchronization, PTP requires an accurate measurement of the communication path delay between the time source (master) and the receiver (slave). PTP sends messages between the master and slave device to determine the delay measurement. Types of messages are described in detail in PTPv2 Message Types, on page 3. Then, PTP measures the exact message transmit and receive times and uses these times to calculate the communication path delay. PTP then adjusts 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 the network, and the local clocks are adjusted for this delay using a series of messages sent between masters and slaves. 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, due to 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 master and slave nodes on the network. An end-to-end transparent clock forwards all messages on the network in the same way that a switch does.

Note Cisco PTP supports multicast PTP messages only.

The following figure shows a typical 1588 PTP network that includes grandmaster clocks, switches in boundary clock mode, and Intelligent Electronic Device (IEDs) such as a digital relays or protection devices. In this diagram, Master 1 is the grandmaster clock. If Master 1 becomes unavailable, the boundary clock slaves switch to Master 2 for synchronization.

Figure 1: PTP Network

PTPv2 Message Types

PTP messages are categorized into the following two types:

- Event Messages — Event messages are tagged with a timestamp when data packets are reaching or leaving a port and are used to calculate the link delay based on the timestamps. Event messages are listed below:
  - Sync
  - Delay_Req
  - Pdelay_Req
  - Pdelay_Resp
-

Announce messages are used to establish the synchronization hierarchy.

General Messages — General messages are not tagged with timestamps and are used to establish a master-slave hierarchy. General messages are listed below:

- Announce
- Follow_Up
- Delay_Resp
- Pdelay_Resp_Follow_Up

Sync, Delay_Req, Follow_Up, and Delay_Resp messages are used to synchronize ordinary and boundary clocks.

Pdelay_Req, Pdelay_Resp, and Pdelay_Resp_Follow_Up messages are used to measure the link delay in transparent clocks.

The Best Master Clock Algorithm elects the grandmaster clock and assign the ports as master or slave. Following this, all the master ports start sourcing the clock to the downstream slaves using the Sync and Follow_Up messages. The downstream slaves receive the clock and update their clock after computing the delay of the link, time offset, frequency offset and drift error parameters.

The downstream slaves computes the link delay using one of the below mechanism.

- #unique_194
- Peer-to-Peer Delay Mechanism, on page 5

PTP Event Message Sequences

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

End-to-End Delay Mechanism

The ordinary and boundary clocks that are 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

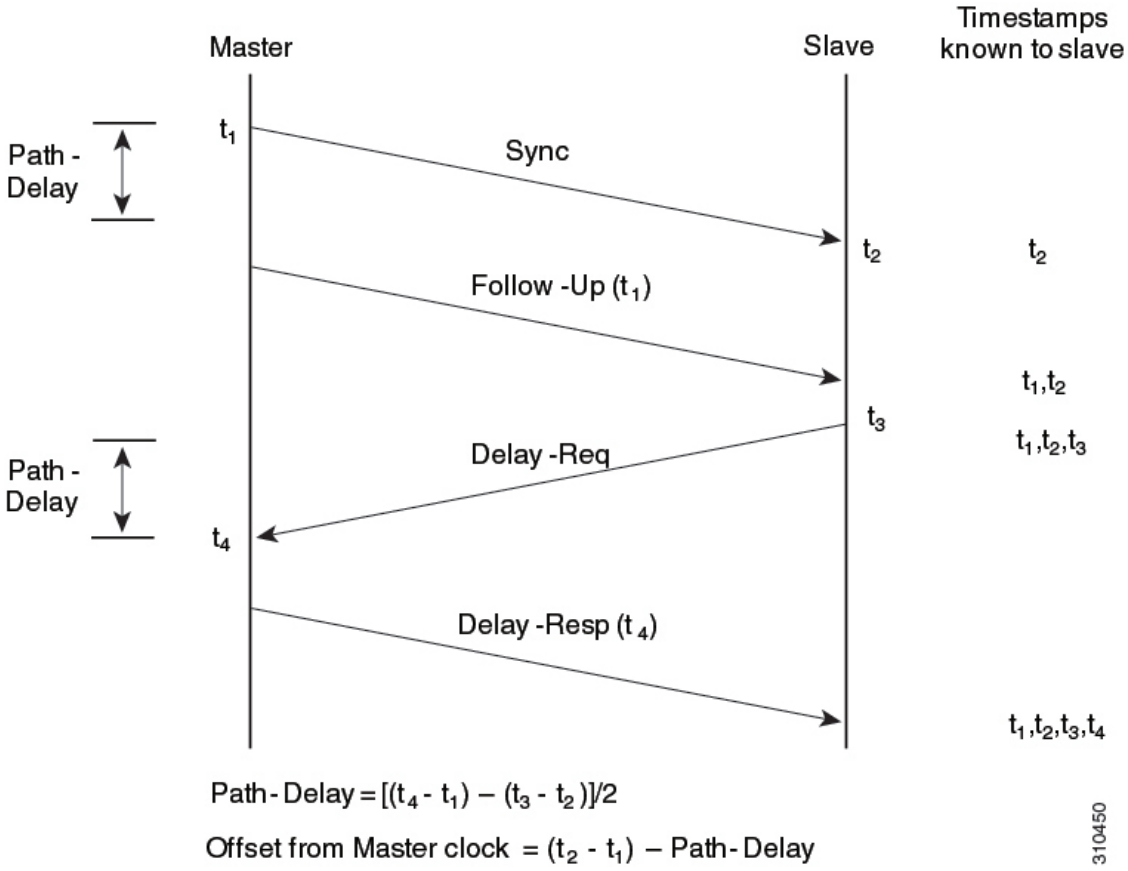
These messages are sent in the following sequence:

1. The master sends a Sync message to the slave and notes the time (t1) at which it was sent.
2. The slave receives the Sync message and notes the time of reception (t2).
3. The master conveys to the slave the timestamp t1 by embedding the timestamp t1 in a Follow_Up message.
4. The slave sends a Delay_Req message to the master and notes the time (t3) at which it was sent.
5. The master receives the Delay_Req message and notes the time of reception (t4).
6. The master conveys to the slave the timestamp t4 by embedding it in a Delay_Resp message.

After this sequence, the slave possesses all four timestamps. These timestamps can be used to compute the offset of the slave clock relative to the master, 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 master to slave is the same as the time required from slave to master. Assumption is not always valid on an Ethernet network due to asymmetrical packet delay times.

Figure 2: End-to-End Delay Mechanism



Peer-to-Peer Delay Mechanism

When the 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 due to any 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 Delay Mechanism

Synchronizing the Local Clock

In an ideal PTP network, the master and slave clock operate at the same frequency. However, drift can occur on the network. Drift is the frequency difference between the master and slave clock. 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 master 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 master clock in its subdomain of all the clocks it can see, including itself. The BMCA runs locally on each port in the network continuously for every Announce interval and quickly adjusts for changes in network configuration. BMCA based on IEEE 1588-2008 uses Announce messages for advertising clock properties.

The BMCA uses the following criteria to determine the best master 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

BMCA based on IEEE 1588-2008 uses own data set with the received data set to determine the best clock based on the attributes with the following properties, in the indicated order:

- Priority1 - User-assigned priority to each clock. The range is from 0 to 255. The default value is 128.
- Class - Class to which the a clock belongs to, each class has its own priority
- Accuracy - Precision between clock and UTC, in nanoseconds
- Variance - Variability of the clock
- Priority2 - Final-defined priority. The range is from 0 to 255. The default value is 128.
- Unique Identifier - 64-bit Extended Unique Identifier (EUI)

In addition to identifying the best master 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 master clocks or no master clocks, as a result of the master clock identification process

PTP Clocks

A PTP network is made up of PTP-enabled devices. The PTP-enabled devices typically consist of the following clock types.

Grandmaster Clock

Within a PTP domain, the grandmaster clock is the primary source of time for clock synchronization using PTP. The grandmaster clock 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 grandmaster clock can free run.

Note We do not recommend you to use the switch as GM clock in the network considering its reduced clock accuracy.

Ordinary Clock

An ordinary clock is a PTP clock with a single PTP port. It functions as a node in a PTP network and can be selected by the BMCA as a master or slave within a subdomain. 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 interface 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 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 as a slave. The master port synchronizes the clocks connected downstream, while the slave port synchronizes with the upstream master clock.

Transparent Clock

The role of transparent clocks in a PTP network is to update the time-interval field that is part of the 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 slave uses this information when determining the offset between the slave's and the master'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, and the correction field of the message received by the slave contains the sum of all link delays. In theory, this is the total end-to-end delay (from master to slave) of the SYNC packet.

The following figure illustrates PTP clocks in a master-slave hierarchy within a PTP network.

Figure 4: PTP Clock Hierarchy

PTP Profiles

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:

- Best master clock algorithm 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
- Closest clock to the grandmaster
- 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

The default PTP profile mode on the switch is Default Profile mode. The PTP mode of transport is Layer 2 and Layer 3.

By default, PTP default profile is disabled globally on these platforms.

How to Configure PTP

Configuring PTP Default Profile

To configure Layer 2 PTP globally, follow these steps:

Procedure

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

Step 3	**ptp mode** {**boundary** {**delay-req** | **pdelay-req** } | **e2etransparent** | **p2ptransparent**}
	Example:
	`Device(config)# ptp mode boundary delay-req`
	`Device(config)# ptp mode boundary pdelay-req`
	`Device(config)# ptp mode e2etransparent`
	`Device(config)# ptp mode p2ptransparent`
		Specifies the synchronization clock mode:
		• **boundary** — mode to enable the switch to participate in selecting the best master clock. If no better clocks are detected, the switch becomes the grandmaster clock on the network and the parent clock to all connected devices. If the best master is determined to be a clock connected to the switch, the switch synchronizes to that clock as a child to the clock, then acts as a parent clock to devices connected to other ports. After initial synchronization, the switch and the connected devices exchange timing messages to correct time skew caused by clock offsets and network delays. Use this mode when overload or heavy load conditions produce significant delay jitter
		• **e2etransparent** — mode for the switch to synchronize all switch ports with the grand master clock connected to the switch,. This is the default clock mode. The switch corrects for the delay incurred by every packet passing through it (referred to residence time). This mode causes less jitter and error accumulation than boundary mode.
		• **p2ptransparent** — mode where the switch does not synchronize its clock with the master clock. A switch in this mode does not participate in master clock selection and uses the default PTP clock mode on all ports.

	Command or Action	Purpose
		Note Once PTP default profile is enabled globally on the device, PTP is enabled on all the interfaces. To disable PTP selectively on individual interfaces, use **no ptp enable** command under interface configuration.
Step 4	[**no**]**ptp domain** *value* **Example:** `Device(config)# ptp domain 8`	Configures the domain value on PTP. • A single domain value can be set. The range is from 4 to 127. The default value is 0. No ptp domain command will set the value to default.

Configuring Precision Time Protocol on Layer 2 interface

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface TenGigabitEthernet1/0/1`	Specifies the physical interface to be configured, and enters interface configuration mode. The interface that you specify can be part of an EtherChannel.
Step 4	[**no**]**ptp enable**	
Step 5	**ptp vlan** *vlan-id* **Example:** `Device(config-if)# ptp vlan 5`	Sets the PTP VLAN on a trunk port. 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 6	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

Configuring PTP on SVI or Layer 3 Interface

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ptp transport ipv4 udp** **Example:** `Device(config)# ptp transport ipv4 udp`	Configures IPv4 as the PTP transport mode. **Note** Only IPv4 is supported as the PTP transport method for Layer 3 PTP.

Configuring the Source IP on PTP

Procedure

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

Step 3	[**no**]**ptp source** {**source-address** | **loopback** |**vlan**}
	Example:
	`Device(config)# ptp source source address`
	`Device(config)# ptp source loopback`
	`Device(config)# ptp source vlan`
		Specifies the synchronization clock mode:
		• **source address** — once configured, ptp messages in all the interfaces will carry this source ip
		• **loopback** — ptp messages in all the interfaces will carry the ip configured on the loopback interface
		• **vlan** — tp messages will carry the ip configured on the svi interface corresponding to the port.
		Note You can use no ptp source command as default.

	Command or Action	Purpose
Step 4	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

Configuring PTP Timers

To change the PTP timer values from default to required values, follow these steps:

Before you begin

Timer inputs are measured in units of log mean message interval value. To determine the *value* in seconds for the **interval** keyword, use a logarithmic scale. The following table shows examples of the *value* keyword converted to seconds with a logarithmic scale:

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

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet2/0/1`	Specifies the physical port to be configured, and enters interface configuration mode.
Step 4	**ptp announce** {**interval** *value* | **timeout** *count*} **Example:** `Device(config-if)# ptp announce interval 1`	(Optional) Configures the interval between PTP announce messages on an interface or the number of PTP intervals before a timeout occurs on an interface. • **interval** *value* — Sets the logarithmic mean interval to send announce messages. The range is 0 to 4. The default is 0 (1 second).

	Command or Action	Purpose
		• **timeout** *count* — Sets the logarithmic mean interval in seconds to announce timeout messages. The range is 2 to 10. The default is 3 (8 seconds).
Step 5	**ptp sync** {**interval** *value* | **limit** *offset-value*} **Example:** `Device(config-if)# ptp sync interval 1`	(Optional) Configures the interval between PTP synchronization messages on an interface. • **interval** *value* — Sets the logarithmic mean interval to send synchronization messages. The range is –3 to 1. The default is 0 (1 second). • **limit** *offset-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.
Step 6	**ptp delay-req interval** *value* **Example:** `Device(config-if)# ptp delay-req interval 1`	(Optional) Configures the logarithmic mean interval allowed between PTP delay-request messages when the port is in the master state. The range is 0 to 5. The default is 0 (1 second).
Step 7	**ptp pdelay-req interval** *value* **Example:** `Device(config-if)# ptp pdelay-req interval 1`	(Optional) Configures the logarithmic mean interval allowed between pdelay request messages when the port is in the master state. The range is 0 to 5. The default is 0 (1 second).
Step 8	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

Configuring the Values of Precision Time Protocol Clocks

Follow these steps to configure the values of PTP clock priority1 and priority2:

Procedure

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

	Command or Action	Purpose
	`Device# configure terminal`	
Step 3	**ptp priority1** *value* **Example:** `Device(config)# ptp priority1 120`	Sets the value of PTP clock priority1. The range is from 0 to 255. The default value is 128. **Note** If the value of priority1 is configured as 255, the clock cannot be considered as Grandmaster.
Step 4	**ptp priority2** *value* **Example:** `Device(config)# ptp priority2 120`	Sets the value of PTP clock priority2. The range is from 0 to 255. The default value is 128.
Step 5	**exit** **Example:** `Device(config)# exit`	Returns to global configuration mode.

Configuration Examples for PTP

Example: Layer 2 and Layer 3 PTP Configurations

Example

show ptp port interface *interface-name*

To verify PTP port state, use **show ptp port interface** *interface-name* command.

To verify the PTP port states on all interfaces use **show ptp brief** command.

The following is a sample output for boundary mode configuration with delay request mechanism:

```
Device# show ptp port GigabitEthernet1/0/45
PTP PORT DATASET: GigabitEthernet1/0/45
  Port identity: clock identity: 0xCC:46:D6:FF:FE:C5:24:0
  Port identity: port number: 45
  PTP version: 2
  Port state: SLAVE
  Delay request interval(log mean): 0
  Announce receipt time out: 3
  Announce interval(log mean): 1
  Sync interval(log mean): 0
  Delay Mechanism: End to End
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000
```

The following is a sample output for boundary mode configuration with pdelay request mechanism:

```
Device# show ptp port GigabitEthernet1/0/45
 PTP PORT DATASET: GigabitEthernet1/0/45
```

```
  Port identity: clock identity: 0xCC:46:D6:FF:FE:C5:24:0
  Port identity: port number: 45
  PTP version: 2
  Port state: MASTER
  Delay request interval(log mean): 0
  Announce receipt time out: 3
  Announce interval(log mean): 1
  Sync interval(log mean): 0
  Delay Mechanism: Peer to Peer
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000
```

show ptp brief

To verify the PTP port states on all interfaces use **show ptp brief** command.

The following is a sample output for **show ptp brief** command:

```
Device# show ptp brief
Interface                         Domain    PTP State
TenGigabitEthernet1/0/1           0         MASTER
TenGigabitEthernet1/0/2           0         SLAVE
TenGigabitEthernet1/0/3           0         FAULTY
```

show ptp clock

To verify the PTP clock identity details and to verify the configured values of Priority1 and Priority2, use **show ptp clock** command.

The following is a sample output for **show ptp clock** command:

```
Device# show ptp clock
 PTP CLOCK INFO
  PTP Device Type: Boundary clock
  PTP Device Profile: Default Profile
  Clock Identity: 0xCC:46:D6:FF:FE:C5:24:0  <<clock identity of this
switch>>
  Clock Domain: 0
  Number of PTP ports: 52
  Priority1: 128
  Priority2: 128
  Clock Quality:
            Class: 248
            Accuracy: Unknown
            Offset (log variance): 16640
  Offset From Master(ns): 0
  Mean Path Delay(ns): 0
  Steps Removed: 1
```

show ptp parent

To identify which Grandmaster Clock identity the device is synced to in boundary mode, use **show ptp parent** command.

Note **show ptp parent** will not display any output if the device is configured in transparent clock mode.

The following is a sample output for **show ptp parent** command:

```
Device# show ptp parent
 PTP PARENT PROPERTIES
  Parent Clock:
  Parent Clock Identity: 0x0:11:1:FF:FE:0:0:1
  Parent Port Number: 1
  Observed Parent Offset (log variance): 16640
  Observed Parent Clock Phase Change Rate: N/A

  Grandmaster Clock:
  Grandmaster Clock Identity: 0x0:11:1:FF:FE:0:0:1     <<Grandmaster clock
 identity to which the device is synced to>>
  Grandmaster Clock Quality:
             Class: 6
             Accuracy: Within 25ns
             Offset (log variance): 0
             Priority1: 128
             Priority2: 128
```

show platform software fed switch active ptp domain 0

To verify the local servo PTP clock synchronization to Grandmaster clock on a device configured in boundary mode with delay-request mechanism, use **show platform software fed switch active ptp domain 0** command.

```
Device# show platform software fed switch active ptp domain 0

Displaying data for domain number 0
============================

Profile Type : DEFAULT
Profile State: enabled
Clock Mode : BOUNDARY CLOCK
Delay mechanism: End-to-End
PTP clock : 2017-6-28 5:58:59
Transport Method: L2 Ethernet
```

By default, local servo PTP clock will be displaying EPOCH time(1970-1-1) when the device is not synced to any PTP Grandmaster Clock.

Example

show ptp port interface *interface-name*

To verify PTP port state, use **show ptp port interface** *interface-name* command.

To verify the PTP port states on all interfaces use **show ptp brief** command.

The following is a sample output for boundary mode configuration with delay request mechanism:

```
Device# show ptp port FortyGigabitEthernet1/0/10
 PTP PORT DATASET: FortyGigabitEthernet1/0/10
  Port identity: clock identity: 0x0:A3:D1:FF:FE:5A:12:0
  Port identity: port number: 10
  PTP version: 2
  Port state: SLAVE
  Delay request interval(log mean): 0
  Announce receipt time out: 3
  Announce interval(log mean): 1
  Sync interval(log mean): 0
  Delay Mechanism: End to End
       << PTP mode delay >>
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000
```

show ptp parent

To identify which Grandmaster Clock identity the device is synced to in boundary mode, use **show ptp parent** command.

Note **show ptp parent** will not display any output if the device is configured in transparent clock mode.

The following is a sample output for **show ptp parent** command:

```
Device# show ptp parent
 PTP PARENT PROPERTIES
  Parent Clock:
  Parent Clock Identity: 0x38:E:4D:FF:FE:81:FE:29
<< Immediate next Master >>
  Parent Port Number: 196
  Observed Parent Offset (log variance): 17258
  Observed Parent Clock Phase Change Rate: N/A

  Grandmaster Clock:
  Grandmaster Clock Identity: 0x0:0:0:5:0:0:0:1
<< GM: External Clock Source acting Grand Master >>
  Grandmaster Clock Quality:
    Class: 6
    Accuracy: Within 1us
    Offset (log variance): 0
    Priority1: 128
    Priority2: 128
```

show platform software fed switch active ptp domain 0

To verify the local servo PTP clock synchronization to Grandmaster clock on a device configured in boundary mode with delay-request mechanism, use **show platform software fed switch active ptp domain 0** command.

```
Device# show platform software fed switch active ptp domain 0
Displaying data for domain number 0
=====================================
```

```
Profile Type : DEFAULT
Profile State: enabled
Clock Mode : BOUNDARY CLOCK
Delay Mechanism: : END-TO-END
PTP clock : 2017-12-15 15:27:27
mean_path_delay 214 nanoseconds
Transport Method : udp-ipv4                        << PTP Transport Method
  >>
```

Table 1: Debug Commands

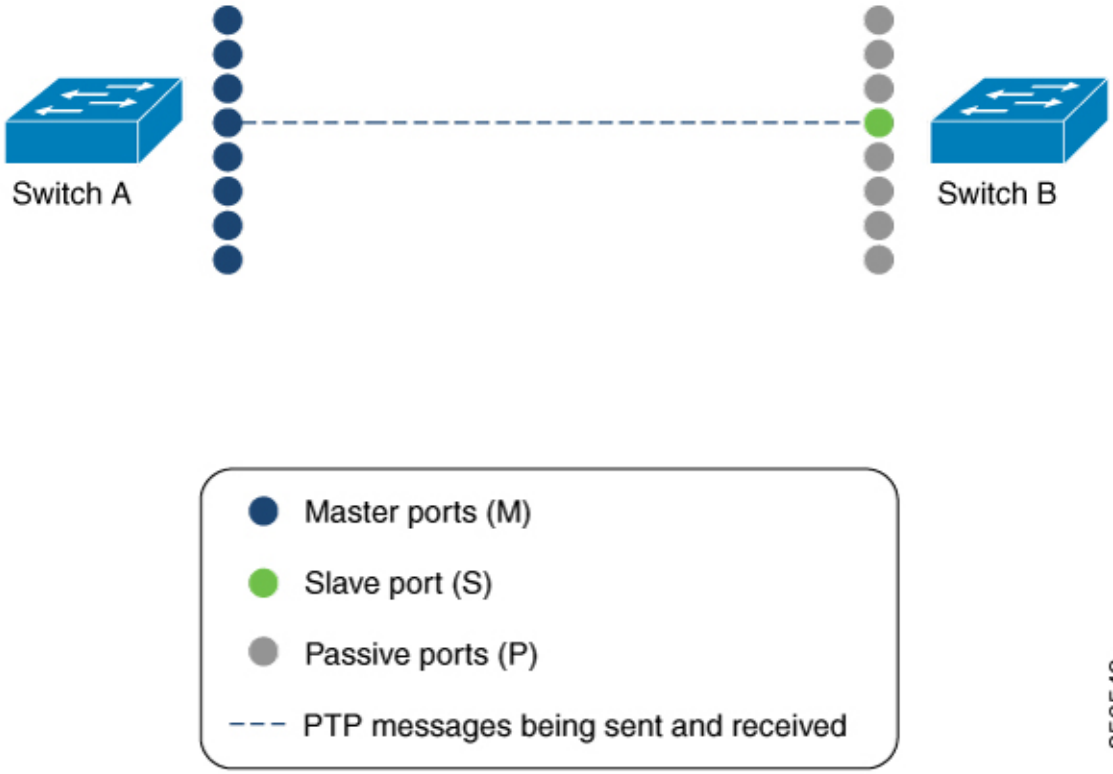
Command	Purpose
debug ptp messages	Enables debugging of PTP messages.
debug ptp error	Enables debugging of PTP errors.
debug ptp bmc	Enables debugging of the PTP Best Master Clock Algorithm.
debug ptp event	Enables debugging of PTP state event.

Example: Configuring PTP on an EtherChannel Interface

An EtherChannel interface allows multiple physical Ethernet links to combine into one logical channel. Configuring EtherChannel interface allows load sharing of traffic among the links in the channel as well as redundancy if one or more links in the EtherChannel fail. This behaviour of an EtherChannel interface does not change when PTP is configured. The example below illustrates how PTP works when it is configured on an EtherChannel interface.

For example, in the figure below there are two switches (Switch A and Switch B) connected through an eight member EtherChannel. If you consider Switch A as the master clock, all the ports that are a part of the EtherChannel are master ports. Similarly, Switch B is the slave clock and one of the ports from the EtherChannel bundle becomes the slave port while all other ports become passive ports. It is always the port with the lowest port number in the Etherchannel bundle that is designated as the slave port. If that slave port is disabled or shut down for any reason, the next port with the lowest port number is designated as the slave port.

The master and slave relationship is established when the feature is configured on an EtherChannel interface as well. The master ports from Switch A sends and receives PTP messages. In Switch B only the slave port exchanges PTP messages. There is no exchange of PTP messages in the passive ports.



Master Clock

The following command can be used to verify the PTP state on an interface:

```
Device# show ptp brief | exclude FAULTY
Interface                Domain     PTP State
TenGigE1/0/39              0         MASTER
TenGigE1/0/44              0         MASTER
TenGigE1/0/48              0         MASTER
```

The following command can be used to verify if the interface configured on each port is an EtherChannel interface:

```
Device# show  etherchannel 1  summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

        A - formed by Auto LAG
Number of channel-groups in use: 3
Number of aggregators:           3

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
```

```
1      Po1(SU)         LACP        Hu1/0/39(P)     Hu1/0/44(P)
                                   Hu1/0/48(P)
```

The following command can be used to verify the port state of each interface:

```
Device# show ptp port tengigabitethernet 1/0/39
PTP PORT DATASET: TenGigE1/0/39
  Port identity: clock identity: 0x0:A7:42:FF:FE:8A:84:C0
  Port identity: port number: 39
  PTP version: 2
  Port state: MASTER
  Delay request interval(log mean): 0
  Announce receipt time out: 3
  Announce interval(log mean): 0
  Sync interval(log mean): 0
  Delay Mechanism: End to End
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000

Device# show ptp port tengigabitethernet 1/0/44
PTP PORT DATASET: TenGigE1/0/44
  Port identity: clock identity: 0x0:A7:42:FF:FE:8A:84:C0
  Port identity: port number: 44
  PTP version: 2
  Port state: MASTER
  Delay request interval(log mean): 0
  Announce receipt time out: 3
  Announce interval(log mean): 0
  Sync interval(log mean): 0
  Delay Mechanism: End to End
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000

Device# show ptp port tengigabitethernet 1/0/48
PTP PORT DATASET: TenGigE1/0/48
  Port identity: clock identity: 0x0:A7:42:FF:FE:8A:84:C0
  Port identity: port number: 48
  PTP version: 2
  Port state: MASTER
 Delay request interval(log mean): 0
  Announce receipt time out: 3
  Announce interval(log mean): 0
  Sync interval(log mean): 0
  Delay Mechanism: End to End
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000
```

Slave Clock

The following command can be used to verify the PTP state on the interfaces:

```
Device# show ptp brief | exclude FAULTY
Interface                      Domain    PTP State
tenGigE1/0/12                    0         SLAVE
TenGigE1/0/20                    0         PASSIVE
TenGigE1/0/23                    0         PASSIVE
```

The following command can be used to verify if the interface configured on each port is an EtherChannel interface:

```
Device# show etherchannel 1 summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
```

```
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port
        A - formed by Auto LAG


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1      Po1(SU)         LACP        Hu1/0/12(P)     Hu1/0/20(P)
                                   Hu1/0/23(P)
```

The following command can be used to verify the port state of each interface:

```
Device# show ptp port tengigabitethernet 1/0/12
PTP PORT DATASET: TenGigE1/0/12
  Port identity: clock identity: 0x0:A7:42:FF:FE:9B:DA:E0
  Port identity: port number: 12
  PTP version: 2
  PTP port number: 12
  PTP slot number: 0
  Port state: SLAVE
  Delay request interval(log mean): 0
  Announce receipt time out: 3
  Announce interval(log mean): 0
  Sync interval(log mean): 0
  Delay Mechanism: End to End
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000

Device# show ptp port tengigabitethernet 1/0/20
PTP PORT DATASET: TenGigE1/0/20
  Port identity: clock identity: 0x0:A7:42:FF:FE:9B:DA:E0
  Port identity: port number: 20
  PTP version: 2
  PTP port number: 20
  PTP slot number: 0
  Port state: PASSIVE
  Delay request interval(log mean): 0
  Announce receipt time out: 3
  Announce interval(log mean): 0
  Sync interval(log mean): 0
  Delay Mechanism: End to End
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000

Device# show ptp port tengigabitethernet 1/0/23
PTP PORT DATASET: TenGigE1/0/23
  Port identity: clock identity: 0x0:A7:42:FF:FE:9B:DA:E0
  Port identity: port number: 23
  PTP version: 2
  PTP port number: 23
  PTP slot number: 0
  Port state: PASSIVE
  Delay request interval(log mean): 0
  Announce receipt time out: 3
  Announce interval(log mean): 0
  Sync interval(log mean): 0
  Delay Mechanism: End to End
```

```
Peer delay request interval(log mean): 0
Sync fault limit: 500000000
```

Feature History for PTP

This table provides release and related information for features explained in this module.

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 Fuji 16.8.1a	IEEE 1588v2, Precision Time Protocol (PTP) support	PTP was developed to synchronize the clocks in packet-based networks that include distributed device clocks of varying precisionand stability. Support for PTP on Layer 2 ports was introduced. Support for this feature was introduced only on the C9500-12Q, C9500-16X, C9500-24Q, C9500-40X models of the Cisco Catalyst 9500 Series Switches.
Cisco IOS XE Gibraltar 16.12.1	IEEE 1588v2, Precision Time Protocol (PTP) support	PTP Version 2 (PTPv2) was introduced. Support for this feature was introduced only on the C9500-32C, C9500-32QC, C9500-48Y4C, and C9500-24Y4C models of the Cisco Catalyst 9500 Series Switches.
Cisco IOS XE Gibraltar 16.12.1	PTP on native Layer 3 ports	Support for PTP on native Layer 3 ports was introduced. Support for this feature was introduced on all the models of the Cisco Catalyst 9500 Series Switches.
Cisco IOS XE Amsterdam 17.2.1	IEEE 1588v2 PTP on EtherChannel Interfaces	Support for PTP on an EtherChannel was introduced. Support for this feature was introduced on all the models of the Cisco Catalyst 9500 Series Switches.

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.