



## Configuring Precision Time Protocol (PTP)

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### Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

### Restrictions and Limitations for PTP

- PTP is supported on the following Catalyst 3850 and Catalyst 3650 SKUs.
  - WS-C3650-24PDM
  - WS-C3650-48FQM
  - WS-C3650-8X24UQ
  - WS-C3650-12X48UQ
  - WS-C3850-12X48U
  - WS-C3850-12XS
  - WS-C3850-16XS
  - WS-C3850-24XS

- WS-C3850-24XU
  - WS-C3850-32XS
  - WS-C3850-48XS
- 
- The output of **show clock** on the device and PTP servo clock displayed in **show platform software fed switch active ptp domain 0** are not synced to each other. These are two different clocks used on the switch.
  - Inter-VLAN is not supported in PTP Transparent Clock Mode.
  - PTP is not supported in stacked systems.
  - 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.
  - We do not recommend having non-PTP enabled devices in the PTP network since it decreases clock synchronization accuracy.
  - Management and Signaling messages are not supported in Cisco IOS XE Fuji 16.8.1a. These messages are dropped in the switch without being processed.
  - Moving 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, VRF, Etherchannel interface and native L3 ports are not supported.

## 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.

Starting with Cisco IOS XE Fuji 16.8.1, layer 2 PTP and layer 3 PTP support is enabled.

### 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 4](#). 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.



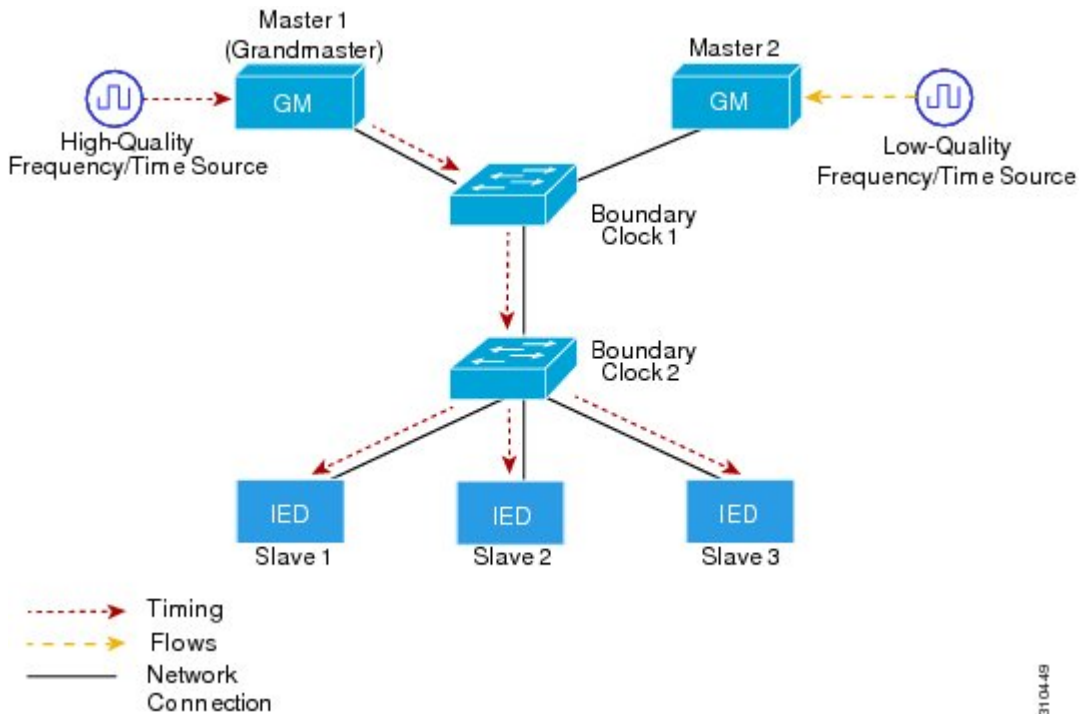
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**Note** Cisco PTP supports multicast PTP messages only.

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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
- 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

Announce messages are used to establish the synchronization hierarchy.

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.

- [End-to-End Delay Mechanism, on page 5](#)
- [Peer-to-Peer Delay Mechanism, on page 6](#)

## 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 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

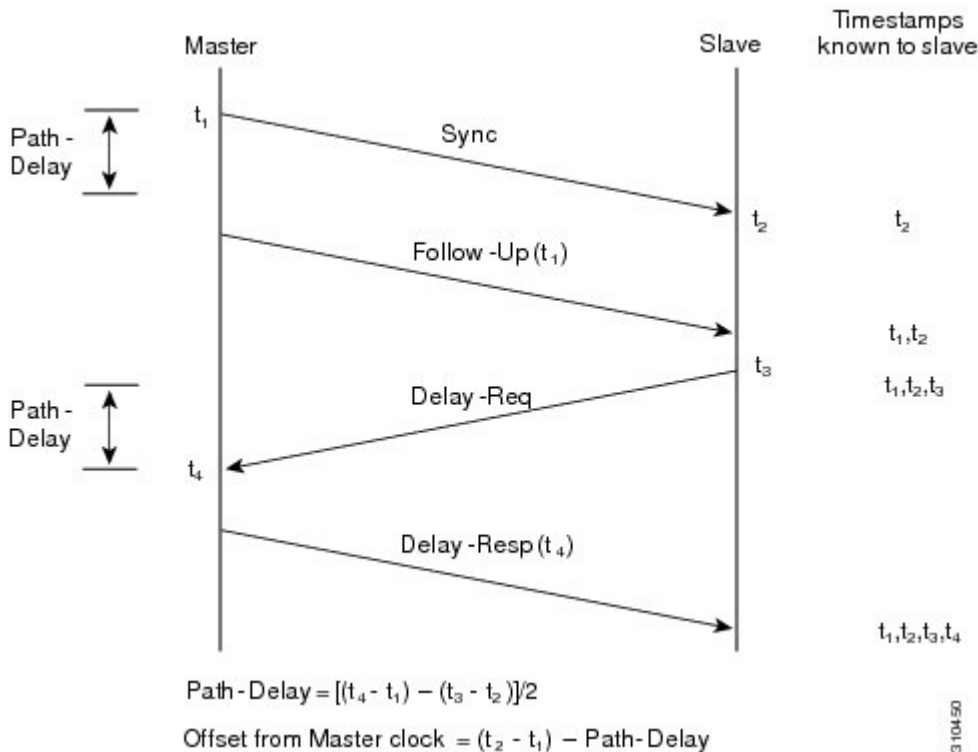
These messages are sent in the following sequence:

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. This assumption is not always valid on an Ethernet network due to asymmetrical packet delay times.

Figure 2: Detailed Steps—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  $\text{mean\_path\_delay}/2$ , 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

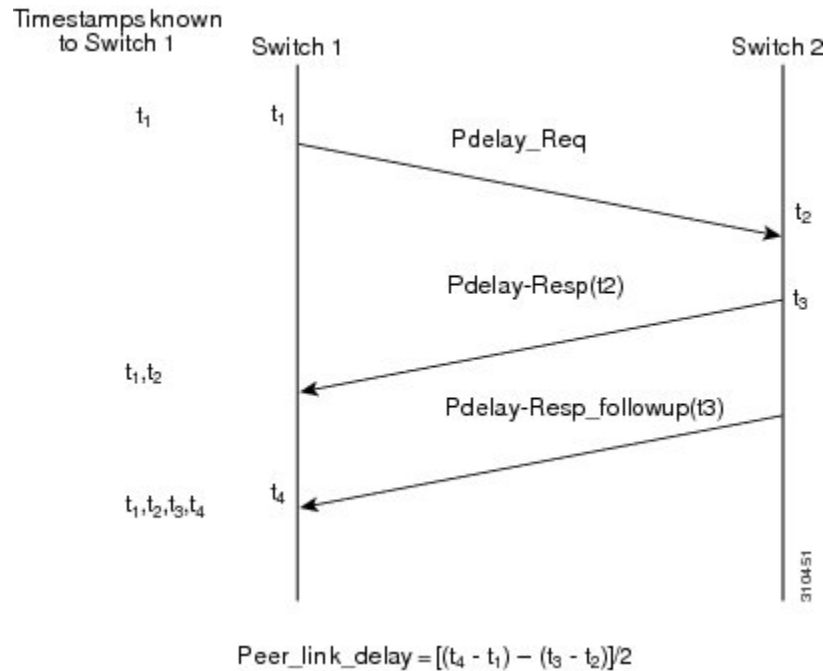
These messages are sent in the following sequence:

1. Port 1 generates timestamp  $t_1$  for a Pdelay\_Req message.
2. Port 2 receives and generates timestamp  $t_2$  for this message.
3. Port 2 returns and generates timestamp  $t_3$  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  $t_2$  and  $t_3$  in the Pdelay\_Resp and Pdelay\_Resp\_Follow\_Up messages respectively.
5. Port 1 generates timestamp  $t_4$  after receiving the Pdelay\_Resp message. Port 1 then uses the four timestamps ( $t_1$ ,  $t_2$ ,  $t_3$ , and  $t_4$ ) 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.

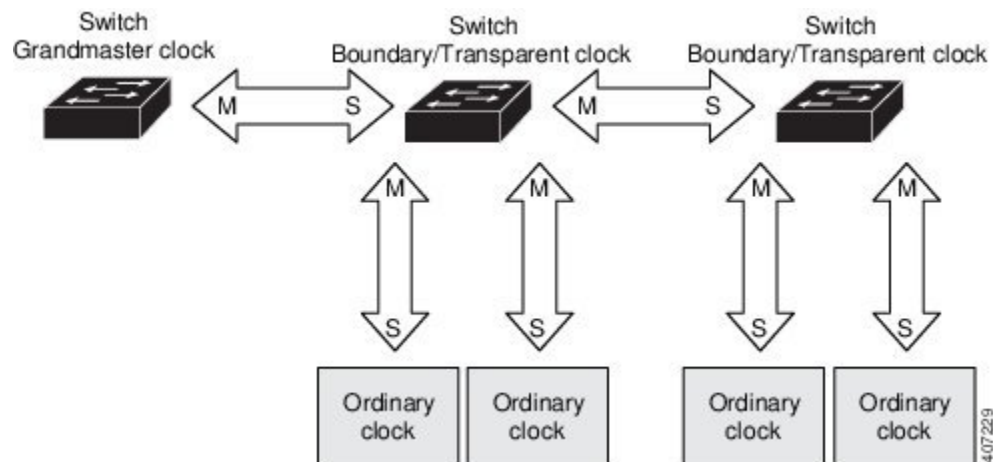
The slave uses this information when determining the offset between the slave's and the master's time. E2E transparent clocks do not provide correction for the propagation delay of the link itself.

**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.

# Configuring PTP

## Configuring Layer 2 PTP Default Profile

To configure Layer 2 PTP globally, follow these steps:

### SUMMARY STEPS

1. **configure terminal**
2. **ptp mode {boundary {delay-req | pdelay-req } | e2transparent | p2pttransparent}**
3. **interface *interface-id***
4. **switchport mode { access | trunk }**
5. **switchport access vlan *vlan-id***
6. **switchport trunk allowed vlan { { add | except | remove } *vlan\_list* | all | none }**
7. **ptp vlan *vlan-id***
8. **end**

### DETAILED STEPS

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ptp mode {boundary {delay-req   pdelay-req }   e2transparent   p2pttransparent}</b>  <b>Example:</b>  Device(config)# <b>ptp mode boundary delay-req</b> Device(config)# <b>ptp mode boundary pdelay-req</b>	Specifies the synchronization clock mode: <ul style="list-style-type: none"> <li>• <b>boundary</b> — 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</li> </ul>

	Command or Action	Purpose
	<pre>Device(config)# ptp mode e2ettransparent Device(config)# ptp mode p2ptrtransparent</pre>	<p>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</p> <ul style="list-style-type: none"> <li>• <b>e2ettransparent</b> — 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.</li> <li>• <b>p2ptrtransparent</b> — 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.</li> </ul> <p>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 <b>no ptp enable</b> command under interface configuration.</p> <p>Within PTP default profile, PTP messages are processed in VLAN 1 by default. Use <b>ptp vlan vlan-name</b> command under interface configurations to allow PTP message processing on specific VLAN. You must add this to the VLAN database of the device.</p>
<b>Step 3</b>	<p><b>interface</b> <i>interface-id</i></p> <p><b>Example:</b></p> <pre>Device(config)# interface TenGigabitEthernet1/0/1</pre>	Specifies the physical interface to be configured, and enters interface configuration mode.
<b>Step 4</b>	<p><b>switchport mode { access   trunk }</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# switchport mode trunk</pre>	<p>Sets the interface type : Access or trunk.</p> <ul style="list-style-type: none"> <li>• <b>access</b> — Sets the interface as a nontrunking nontagged single-VLAN interface. An access port can carry traffic in one VLAN only. By default, an access port carries traffic for VLAN1; to set the access port to carry traffic for a different VLAN, use the <b>switchport access vlan</b> command in Step 5.</li> <li>• <b>trunk</b> — Sets the interface as an Ethernet trunk port. A trunk port can carry traffic in one or more VLANs on the same physical link (VLANs are based on the trunk-allowed VLANs list). By default, a trunk interface can carry traffic for all VLANs. To specify</li> </ul>

	Command or Action	Purpose
		that only certain VLANs are allowed on the specified trunk, use the <b>switchport trunk allowed vlan</b> command in Step 6.  <b>Note</b> If switchport mode is trunk, you should configure PTP VLAN using the <b>ptp vlan vlan-id</b> command.
<b>Step 5</b>	<b>switchport access vlan</b> <i>vlan-id</i>  <b>Example:</b> Device(config-if) # <b>switchport access vlan 5</b>	Specifies the VLAN for which this access port will carry traffic. If you do not enter this command, the access port carries traffic on VLAN1 only; use this command to change the VLAN for which the access port carries traffic.
<b>Step 6</b>	<b>switchport trunk allowed vlan</b> { { <b>add</b>   <b>except</b>   <b>remove</b> } <i>vlan_list</i>   <b>all</b>   <b>none</b> }  <b>Example:</b> Device(config-if) # <b>switchport trunk allowed vlan 2,10</b>	Sets allowed VLANs for the trunk interface. The default is to allow all VLANs on the trunk interface: 1 to 3967 and 4048 to 4094. VLANs 3968 to 4047 are the default VLANs reserved for internal use by default; this group of VLANs is configurable. By default, all VLANs are allowed on all trunk interfaces.
<b>Step 7</b>	<b>ptp vlan</b> <i>vlan-id</i>  <b>Example:</b> Device(config-if) # <b>ptp vlan 5</b>	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.
<b>Step 8</b>	<b>end</b>  <b>Example:</b>  Device(config-if) # <b>end</b>	Returns to privileged EXEC mode.

## Configuring Layer 3 PTP Default Profile

To configure Layer 3 PTP globally, follow these steps:

### SUMMARY STEPS

1. **configure terminal**
2. **ptp transport ipv4 udp**
3. **ptp mode {boundary {delay-req | pdelay-req} | e2transparent | p2pttransparent}**
4. **interface** *vlan vlan-id*
5. **ip address** *ip-address subnet-mask*
6. **interface** *interface-id*
7. **switchport mode** { **access** | **trunk** }
8. **switchport access vlan** *vlan-id*

9. `switchport trunk allowed vlan { { add | except | remove } vlan_list | all | none }`
10. `ptp vlan vlan-id`
11. `end`

## DETAILED STEPS

	Command or Action	Purpose
Step 1	<b>configure terminal</b>  <b>Example:</b>  <pre>Device# configure terminal</pre>	Enters global configuration mode.
Step 2	<b>ptp transport ipv4 udp</b>  <b>Example:</b>  <pre>Device(config)# ptp transport ipv4 udp</pre>	Configures IPv4 as the PTP transport mode.  <b>Note</b> Only IPv4 is supported as the PTP transport method for Layer 3 PTP.
Step 3	<b>ptp mode {boundary {delay-req   pdelay-req }   e2ettransparent   p2pttransparent}</b>  <b>Example:</b>  <pre>Device(config)# ptp mode boundary delay-req Device(config)# ptp mode boundary pdelay-req Device(config)# ptp mode e2ettransparent Device(config)# ptp mode p2pttransparent</pre>	Specifies the synchronization clock mode: <ul style="list-style-type: none"> <li>• <b>boundary</b> — 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</li> <li>• <b>e2ettransparent</b> — 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.</li> <li>• <b>p2pttransparent</b> — 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.</li> </ul> <p>Once PTP default profile is enabled globally on the device, PTP is enabled on all the interfaces. To disable PTP</p>

	Command or Action	Purpose
		selectively on individual interfaces, use <b>no ptp enable</b> command under interface configuration.  Within PTP default profile, PTP messages are processed in VLAN 1 by default. Use <b>ptp vlan</b> <i>vlan-name</i> command under interface configurations to allow PTP message processing on specific VLAN. You must add this to the VLAN database of the device.
<b>Step 4</b>	<b>interface</b> <i>vlan</i> <i>vlan-id</i>  <b>Example:</b> Device(config)# <b>interface</b> <i>vlan</i> 2	Specifies the VLAN or SVI interface to be configured, and enters interface configuration mode.  <b>Note</b> Layer 3 PTP is supported only on VLAN and SVI interfaces.
<b>Step 5</b>	<b>ip address</b> <i>ip-address</i> <i>subnet-mask</i>  <b>Example:</b> Device(config)# <b>p address</b> 100.1.1.1 255.255.255.0	Configures the IP address and IP subnet.
<b>Step 6</b>	<b>interface</b> <i>interface-id</i>  <b>Example:</b> Device(config)# <b>interface</b> TenGigabitEthernet1/0/1	Specifies the physical interface to be configured, and enters interface configuration mode.
<b>Step 7</b>	<b>switchport mode</b> { <i>access</i>   <i>trunk</i> }  <b>Example:</b> Device(config-if)# <b>switchport mode</b> <i>trunk</i>	Sets the interface type : Access or trunk.  <ul style="list-style-type: none"> <li>• <b>access</b> — Sets the interface as a nontrunking nontagged single-VLAN interface. An access port can carry traffic in one VLAN only. By default, an access port carries traffic for VLAN1; to set the access port to carry traffic for a different VLAN, use the <b>switchport access vlan</b> command in Step 8.</li> <li>• <b>trunk</b> — Sets the interface as an Ethernet trunk port. A trunk port can carry traffic in one or more VLANs on the same physical link (VLANs are based on the trunk-allowed VLANs list). By default, a trunk interface can carry traffic for all VLANs. To specify that only certain VLANs are allowed on the specified trunk, use the <b>switchport trunk allowed vlan</b> command in Step 9.</li> </ul> <b>Note</b> If switchport mode is trunk, you should configure PTP VLAN using the <b>ptp vlan</b> <i>vlan-id</i> command.
<b>Step 8</b>	<b>switchport access vlan</b> <i>vlan-id</i>  <b>Example:</b> Device(config-if)# <b>switchport access</b> <i>vlan</i> 5	Specifies the VLAN for which this access port will carry traffic. If you do not enter this command, the access port carries traffic on VLAN1 only; use this command to change the VLAN for which the access port carries traffic.

	Command or Action	Purpose
<b>Step 9</b>	<b>switchport trunk allowed vlan</b> { { <b>add</b>   <b>except</b>   <b>remove</b> } <i>vlan_list</i>   <b>all</b>   <b>none</b> }  <b>Example:</b> Device(config-if) # <b>switchport trunk allowed vlan 2,10</b>	Sets allowed VLANs for the trunk interface. The default is to allow all VLANs on the trunk interface: 1 to 3967 and 4048 to 4094. VLANs 3968 to 4047 are the default VLANs reserved for internal use by default; this group of VLANs is configurable. By default, all VLANs are allowed on all trunk interfaces.
<b>Step 10</b>	<b>ptp vlan</b> <i>vlan-id</i>  <b>Example:</b> Device(config-if) # <b>ptp vlan 5</b>	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.
<b>Step 11</b>	<b>end</b>  <b>Example:</b> Device(config-if) # <b>end</b>	Returns to privileged EXEC mode.

## Disabling PTP on an interface

PTP is enabled on all the ports, by default. To disable PTP on an interface, follow these steps:

### SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. [ **no** ] **ptp enable**
4. **end**

### DETAILED STEPS

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface</b> <i>interface-id</i>  <b>Example:</b> Device(config) # <b>interface gigabitethernet2/0/1</b>	Specifies the physical port to be configured, and enters interface configuration mode.
<b>Step 3</b>	[ <b>no</b> ] <b>ptp enable</b>  <b>Example:</b>	To disable PTP, use the no form of this command.

	Command or Action	Purpose
	<code>Device(config-if) #no ptp enable</code>	
<b>Step 4</b>	<b>end</b>  <b>Example:</b>  <code>Device(config-if) # end</code>	Returns to privileged EXEC mode.

## Configuring PTP Timers

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

### SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **ptp announce** {*interval seconds* | **timeout count**}
4. **ptp sync** {*interval seconds* | **limit offset-value**}
5. **ptp delay-req interval** *seconds*
6. **ptp pdelay-req interval** *seconds*
7. **end**

### DETAILED STEPS

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  <code>Device# configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>interface</b> <i>interface-id</i>  <b>Example:</b>  <code>Device(config) # interface gigabitethernet2/0/1</code>	Specifies the physical port to be configured, and enters interface configuration mode.
<b>Step 3</b>	<b>ptp announce</b> { <i>interval seconds</i>   <b>timeout count</b> }	(Optional) Configures the interval between PTP announce messages on an interface or the number of PTP intervals before a timeout occurs on an interface. <ul style="list-style-type: none"> <li>• <b>interval seconds</b> — Sets the logarithmic mean interval in seconds to send announce messages. The range is 0 to 4. The default is 1 (2 seconds).</li> <li>• <b>timeout count</b> — Sets the logarithmic mean interval in seconds to announce timeout messages. The range is 2 to 10. The default is 3 (8 seconds).</li> </ul>
	<b>Example:</b>  <code>Device(config-if) #ptp announce interval 1</code>	



	Command or Action	Purpose
<b>Step 4</b>	<b>ptp sync</b> { <i>interval seconds</i>   <i>limit offset-value</i> } <b>Example:</b> Device(config-if) # <b>ptp sync interval 1</b>	(Optional) Configures the interval between PTP synchronization messages on an interface.  <ul style="list-style-type: none"> <li>• <b>interval seconds</b> — Sets the logarithmic mean interval in seconds to send synchronization messages. The range is -2 to 1. The default is 1 second.</li> <li>• <b>limit offset-value</b> — Sets the maximum clock offset value before PTP attempts to resynchronize. The range is from 50 to 500000000 nanoseconds. The default is 500000000 nanoseconds.</li> </ul>
<b>Step 5</b>	<b>ptp delay-req interval seconds</b> <b>Example:</b> Device(config-if) # <b>ptp delay-req interval 1</b>	(Optional) Configures the logarithmic mean interval allowed between PTP delay-request messages when the port is in the master state. The range is -3 to 5. The default is 0 (1 second).
<b>Step 6</b>	<b>ptp pdelay-req interval seconds</b> <b>Example:</b> Device(config-if) # <b>ptp pdelay-req interval 1</b>	(Optional) Configures the logarithmic mean interval allowed between pdelay request messages when the port is in the master state. The range is -3 to 5. The default is 0 (1 second).
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config-if) # <b>end</b>	Returns to privileged EXEC mode.

## Configuring the Values of PTP Clocks

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

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ptp priority1 value</b> <b>Example:</b> Device(config)# <b>ptp priority1 120</b>	Sets the value of PTP clock priority1. The range is from 0 to 255. The default value is 128.  <b>Note</b> If the value of priority1 is configured as 255, the clock cannot be considered as Grandmaster.

	Command or Action	Purpose
<b>Step 4</b>	<b>ptp priority2</b> <i>value</i> <b>Example:</b> Device(config) # <b>ptp priority2 120</b>	Sets the value of PTP clock priority2. The range is from 0 to 255. The default value is 128.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config) # <b>exit</b>	Returns to global configuration mode.

## Examples: Layer 2 and Layer 3 PTP Configurations

### Show Commands for viewing Layer 2 PTP Configuration

**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.

### **Show Commands for viewing Layer 3 PTP Configuration**

#### **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
<b>debug ptp messages</b>	Enables debugging of PTP messages.
<b>debug ptp error</b>	Enables debugging of PTP errors.

Command	Purpose
<b>debug ptp bmc</b>	Enables debugging of the PTP Best Master Clock Algorithm.
<b>debug ptp event</b>	Enables debugging of PTP state event.

## 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 precision and stability.  Support for PTP on Layer 2 ports was introduced.

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>.