IP Application Services Configuration Guide, Cisco IOS Release 15S

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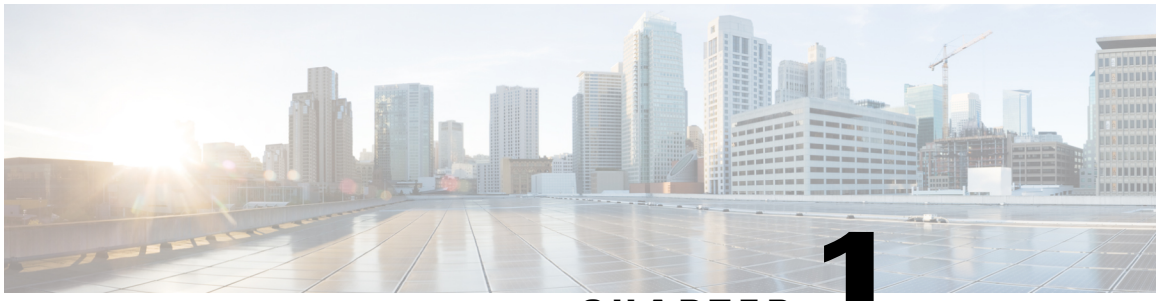


CHAPTER 1

Configuring Enhanced Object Tracking

Before the introduction of the Enhanced Object Tracking feature, the Hot Standby Router Protocol (HSRP) had a simple tracking mechanism that allowed you to track the interface line-protocol state only. If the line-protocol state of the interface went down, the HSRP priority of the router was reduced, allowing another HSRP router with a higher priority to become active.

The Enhanced Object Tracking feature separates the tracking mechanism from HSRP and creates a separate standalone tracking process that can be used by other processes and HSRP. This feature allows tracking of other objects in addition to the interface line-protocol state.

A client process such as HSRP, Virtual Router Redundancy Protocol (VRRP), or Gateway Load Balancing Protocol (GLBP), can register its interest in tracking objects and then be notified when the tracked object changes state.

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 www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for Enhanced Object Tracking

Enhanced Object Tracking is not stateful switchover (SSO)-aware and cannot be used with Hot Standby Routing Protocol (HSRP), Virtual Router Redundancy Protocol (VRRP), or Gateway Load Balancing Protocol (GLBP) in SSO mode.

Information About Enhanced Object Tracking

Feature Design of Enhanced Object Tracking

The Enhanced Object Tracking feature provides complete separation between the objects to be tracked and the action to be taken by a client when a tracked object changes. Thus, several clients such as HSRP, VRRP, or GLPB can register their interest with the tracking process, track the same object, and each take different action when the object changes.

Each tracked object is identified by a unique number that is specified on the tracking CLI. Client processes use this number to track a specific object.

The tracking process periodically polls the tracked objects and notes any change of value. The changes in the tracked object are communicated to interested client processes, either immediately or after a specified delay. The object values are reported as either up or down.

You can configure a combination of tracked objects in a list and a flexible method for combining objects using Boolean logic. This functionality includes the following capabilities:

- Threshold—The tracked list can be configured to use a weight or percentage threshold to measure the state of the list. Each object in a tracked list can be assigned a threshold weight. The state of the tracked list is determined by whether the threshold has been met.
- Boolean "and" function—When a tracked list has been assigned a Boolean "and" function, each object defined within a subset must be in an up state so that the tracked object can become up.
- Boolean "or" function—When the tracked list has been assigned a Boolean "or" function, at least one object defined within a subset must be in an up state so that the tracked object can become up.

With CSCtg75700, a maximum of 1000 objects can be tracked. Although 1000 tracked objects can be configured, each tracked object uses CPU resources. The amount of available CPU resources on a router depends on variables such as traffic load and how other protocols are configured and run. The ability to use 1000 tracked objects depends on the available CPU. Testing should be conducted on site to ensure that the service works under the specific site traffic conditions.

Interface State Tracking

An IP-routing object is considered up when the following criteria exist:

- IP routing is enabled and active on the interface.
- The interface line-protocol state is up.

- The interface IP address is known. The IP address is configured or received through Dynamic Host Configuration Protocol (DHCP) or IP Control Protocol (IPCP) negotiation.

Interface IP routing will go down when one of the following criteria exists:

- IP routing is disabled globally.
- The interface line-protocol state is down.
- The interface IP address is unknown. The IP address is not configured or received through DHCP or IPCP negotiation.

Tracking the IP-routing state of an interface using the **track interface ip routing** command can be more useful in some situations than just tracking the line-protocol state using the **track interface line-protocol** command, especially on interfaces for which IP addresses are negotiated. For example, on a serial interface that uses the PPP, the line protocol could be up (link control protocol [LCP] negotiated successfully), but IP could be down (IPCP negotiation failed).

The **track interface ip routing** command supports the tracking of an interface with an IP address acquired through any of the following methods:

- Conventional IP address configuration
- PPP/IPCP
- DHCP
- Unnumbered interface

You can configure Enhanced Object Tracking to consider the carrier-delay timer when tracking the IP-routing state of an interface by using the **carrier-delay** command in tracking configuration mode.

Scaled Route Metrics

The **track ip route** command enables tracking of a route in the routing table. If a route exists in the table, the metric value is converted into a number. To provide a common interface to tracking clients, normalize route metric values to the range from 0 to 255, where 0 is connected and 255 is inaccessible. Scaled metrics can be tracked by setting thresholds. Up and down state notification occurs when the thresholds are crossed. The resulting value is compared against threshold values to determine the tracking state as follows:

- State is up if the scaled metric for that route is less than or equal to the up threshold.
- State is down if the scaled metric for that route is greater than or equal to the down threshold.

Tracking uses a per-protocol configurable resolution value to convert the real metric to the scaled metric. The table below shows the default values used for the conversion. You can use the **track resolution** command to change the metric resolution default values.

Table 1: Metric Conversion

Route Type[1]	Metric Resolution
Static	10
Enhanced Interior Gateway Routing Protocol (EIGRP)	2560

Route Type[1]	Metric Resolution
Open Shortest Path First (OSPF)	1
Intermediate System-to-Intermediate System (IS-IS)	10

1 RIP is scaled directly to the range from 0 to 255 because its maximum metric is less than 255.

For example, a change in 10 in an IS-IS metric results in a change of 1 in the scaled metric. The default resolutions are designed so that approximately one 2-Mbps link in the path will give a scaled metric of 255.

Scaling the very large metric ranges of EIGRP and IS-IS to a 0 to 255 range is a compromise. The default resolutions will cause the scaled metric to exceed the maximum limit with a 2-Mb/s link. However, this scaling allows a distinction between a route consisting of three Fast-Ethernet links and a route consisting of four Fast-Ethernet links.

IP SLA Operation Tracking

Object tracking of IP Service Level Agreements (SLAs) operations allows tracking clients to track the output from IP SLAs objects and use the provided information to trigger an action.

Cisco IOS IP SLAs is a network performance measurement and diagnostics tool that uses active monitoring. Active monitoring is the generation of traffic in a reliable and predictable manner to measure network performance. software uses IP SLAs to collect real-time metrics such as response time, network resource availability, application performance, jitter (interpacket delay variance), connect time, throughput, and packet loss.

These metrics can be used for troubleshooting, for proactive analysis before problems occur, and for designing network topologies.

Every IP SLAs operation maintains an operation return-code value. This return code is interpreted by the tracking process. The return code can return OK, OverThreshold, and several other return codes. Different operations can have different return-code values, so only values common to all operation types are used.

Two aspects of an IP SLAs operation can be tracked: state and reachability. The difference between these aspects is the acceptance of the OverThreshold return code. The table below shows the state and reachability aspects of IP SLAs operations that can be tracked.

Table 2: Comparison of State and Reachability Operations

Tracking	Return Code	Track State
State	OK (all other return codes)	Up Down
Reachability	OK or OverThreshold (all other return codes)	Up Down

Enhanced Object Tracking and Embedded Event Manager

Enhanced Object Tracking (EOT) is now integrated with Embedded Event Manager (EEM) to allow EEM to report on status change of a tracked object and to allow EOT to track EEM objects. A new type of tracking object--a stub object--is created. The stub object can be modified by an external process through a defined Application Programming Interface (API). See the Embedded Event Manager Overview document in the *Network Management Configuration Guide* for more information on how EOT works with EEM.

Benefits of Enhanced Object Tracking

- Increases the availability and speed of recovery of a network.
- Decreases the number of network outages and their duration.
- Enables client processes such as VRRP and GLBP to track objects individually or as a list of objects. Prior to the introduction of this functionality, the tracking process was embedded within HSRP.

How to Configure Enhanced Object Tracking

Tracking the Line-Protocol State of an Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track timer interface** {*seconds* | **msec** *milliseconds*}
4. **track** *object-number* **interface** *type number* **line-protocol**
5. **carrier-delay**
6. **delay** {**up** *seconds* [**down** [*seconds*] | [**up** *seconds*] **down** *seconds*]}
7. **end**
8. **show track** *object-number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**track timer interface** {*seconds* | **msec** *milliseconds*} **Example:** `Device(config)# track timer interface 5`	(Optional) Specifies the interval in which the tracking process polls the tracked object. • The default interval that the tracking process polls interface objects is 1 second. **Note** All polling frequencies can be configured down to 500 milliseconds, overriding the minimum 1-second interval configured using the **msec** keyword and *milliseconds* argument.
Step 4	**track** *object-number* **interface** *type number* **line-protocol** **Example:** `Device(config)# track 3 interface ethernet 0/1 line-protocol`	Tracks the line-protocol state of an interface and enters tracking configuration mode.
Step 5	**carrier-delay** **Example:** `Device(config-track)# carrier-delay`	(Optional) Enables EOT to consider the carrier-delay timer when tracking the status of an interface.
Step 6	**delay** {**up** *seconds* [**down** [*seconds*] | [**up** *seconds*] **down** *seconds*]} **Example:** `Device(config-track)# delay up 30`	(Optional) Specifies a period of time (in seconds) to delay communicating state changes of a tracked object.
Step 7	**end** **Example:** `Device(config-track)# end`	Exits to privileged EXEC mode.
Step 8	**show track** *object-number* **Example:** `Device# show track 3`	(Optional) Displays tracking information. • Use this command to verify the configuration.

Example

The following example shows the state of the line protocol on an interface when it is tracked:

```
Device# show track 3

Track 3
   Interface Ethernet0/1 line-protocol
   Line protocol is Up
     1 change, last change 00:00:05
   Tracked by:
     HSRP Ethernet0/3 1
```

Tracking the IP-Routing State of an Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track timer interface** {*seconds* | **msec** *milliseconds*}
4. **track** *object-number* **interface** *type number* **ip routing**
5. **carrier-delay**
6. **delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*}
7. **end**
8. **show track** *object-number*

DETAILED STEPS

	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	**track timer interface** {*seconds* | **msec** *milliseconds*} **Example:** `Device(config)# track timer interface 5`	(Optional) Specifies the interval in which the tracking process polls the tracked object. • The default interval that the tracking process polls interface objects is 1 second. **Note** All polling frequencies can be configured down to 500 milliseconds, overriding the minimum 1-second interval configured using the **msec** keyword and *milliseconds* argument.

	Command or Action	Purpose
Step 4	**track** *object-number* **interface** *type number* **ip routing** **Example:** `Device(config)# track 1 interface ethernet 0/1 ip routing`	Tracks the IP-routing state of an interface and enters tracking configuration mode. • IP-route tracking tracks an IP route in the routing table and the ability of an interface to route IP packets.
Step 5	**carrier-delay** **Example:** `Device(config-track)# carrier-delay`	(Optional) Enables EOT to consider the carrier-delay timer when tracking the status of an interface.
Step 6	**delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*} **Example:** `Device(config-track)# delay up 30`	(Optional) Specifies a period of time (in seconds) to delay communicating state changes of a tracked object.
Step 7	**end** **Example:** `Device(config-track)# end`	Returns to privileged EXEC mode.
Step 8	**show track** *object-number* **Example:** `Device# show track 1`	Displays tracking information. • Use this command to verify the configuration.

Example

The following example shows the state of IP routing on an interface when it is tracked:

```
Device# show track 1

Track 1
   Interface Ethernet0/1 ip routing
   IP routing is Up
     1 change, last change 00:01:08
   Tracked by:
     HSRP Ethernet0/3 1
```

Tracking IP-Route Reachability

Perform this task to track the reachability of an IP route. A tracked object is considered up when a routing table entry exists for the route and the route is accessible.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track timer ip route** {*seconds* | **msec** *milliseconds*}
4. **track** *object-number* **ip route** *ip-address*/*prefix-length* **reachability**
5. **delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*}
6. **ip vrf** *vrf-name*
7. **end**
8. **show track** *object-number*

DETAILED STEPS

	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	**track timer ip route** {*seconds*	**msec** *milliseconds*} **Example:** `Device(config)# track timer ip route 20`	(Optional) Specifies the interval in which the tracking process polls the tracked object. • The default interval that the tracking process polls IP-route objects is 15 seconds. **Note** All polling frequencies can be configured down to 500 milliseconds, overriding the minimum 1-second interval configured using the **msec** keyword and *milliseconds* argument.
Step 4	**track** *object-number* **ip route** *ip-address*/*prefix-length* **reachability** **Example:** `Device(config)# track 4 ip route 10.16.0.0/16 reachability`	Tracks the reachability of an IP route and enters tracking configuration mode.

	Command or Action	Purpose
Step 5	**delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*} **Example:** `Device(config-track)# delay up 30`	(Optional) Specifies a period of time (in seconds) to delay communicating state changes of a tracked object.
Step 6	**ip vrf** *vrf-name* **Example:** `Device(config-track)# ip vrf VRF2`	(Optional) Configures a VPN routing and forwarding (VRF) table.
Step 7	**end** **Example:** `Device(config-track)# end`	Returns to privileged EXEC mode.
Step 8	**show track** *object-number* **Example:** `Device# show track 4`	(Optional) Displays tracking information. • Use this command to verify the configuration.

Example

The following example shows the state of the reachability of an IP route when it is tracked:

```
Device# show track 4

Track 4
   IP route 10.16.0.0 255.255.0.0 reachability
   Reachability is Up (RIP)
     1 change, last change 00:02:04
   First-hop interface is Ethernet0/1
   Tracked by:
     HSRP Ethernet0/3 1
```

Tracking the Threshold of IP-Route Metrics

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track timer ip route** {*seconds* | **msec** *milliseconds*}
4. **track resolution ip route** {**eigrp** | **isis** | **ospf** | **static**} *resolution-value*
5. **track** *object-number* **ip route** *ip-address*/*prefix-length* **metric threshold**
6. **delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*}
7. **ip vrf** *vrf-name*
8. **threshold metric** {**up** *number* [**down** *number*] | **down** *number* [**up** *number*]}
9. **end**
10. **show track** *object-number*

DETAILED STEPS

	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	**track timer ip route** {*seconds*	**msec** *milliseconds*} **Example:** `Device(config)# track timer ip route 20`	(Optional) Specifies the interval in which the tracking process polls the tracked object. • The default interval that the tracking process polls IP-route objects is 15 seconds. **Note** All polling frequencies can be configured down to 500 milliseconds, overriding the minimum 1-second interval configured using the **msec** keyword and *milliseconds* argument.
Step 4	**track resolution ip route** {**eigrp**	**isis**	**ospf**	**static**} *resolution-value* **Example:** `Device(config)# track resolution ip route eigrp 300`	(Optional) Specifies resolution parameters for a tracked object. • Use this command to change the default metric resolution values.

	Command or Action	Purpose
Step 5	**track** *object-number* **ip route** *ip-address*/*prefix-length* **metric threshold** **Example:** `Device(config)# track 6 ip route 10.16.0.0/16 metric threshold`	Tracks the scaled metric value of an IP route to determine if it is above or below a threshold and enters tracking configuration mode. • The default down value is 255, which equates to an inaccessible route. • The default up value is 254.
Step 6	**delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*} **Example:** `Device(config-track)# delay up 30`	(Optional) Specifies a period of time (in seconds) to delay communicating state changes of a tracked object.
Step 7	**ip vrf** *vrf-name* **Example:** `Device(config-track)# ip vrf VRF1`	(Optional) Configures a VRF table.
Step 8	**threshold metric** {**up** *number* [**down** *number*] | **down** *number* [**up** *number*]} **Example:** `Device(config-track)# threshold metric up 254 down 255`	(Optional) Sets a metric threshold other than the default value.
Step 9	**end** **Example:** `Device(config-track)# end`	Exits to privileged EXEC mode.
Step 10	**show track** *object-number* **Example:** `Device# show track 6`	(Optional) Displays tracking information. • Use this command to verify the configuration.

Example

The following example shows the metric threshold of an IP route when it is tracked:

```
Device# show track 6

Track 6
   IP route 10.16.0.0 255.255.0.0 metric threshold
   Metric threshold is Up (RIP/6/102)
```

```
  1 change, last change 00:00:08
Metric threshold down 255 up 254
First-hop interface is Ethernet0/1
Tracked by:
  HSRP Ethernet0/3 1
```

Tracking the State of an IP SLAs Operation

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track** *object-number* **ip sla** *operation-number* **state**
4. **delay** {**up** *seconds* [**down** *seconds* | [**up** *seconds*] **down** *seconds*}
5. **end**
6. **show track** *object-number*

DETAILED STEPS

	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	**track** *object-number* **ip sla** *operation-number* **state** **Example:** `Device(config)# track 2 ip sla 4 state`	Tracks the state of an IP SLAs object and enters tracking configuration mode. With CScsf08092, the **track rtr** command was replaced by the **track ip sla** command.
Step 4	**delay** {**up** *seconds* [**down** *seconds* | [**up** *seconds*] **down** *seconds*} **Example:** `Device(config-track)# delay up 60 down 30`	(Optional) Specifies a period of time (in seconds) to delay communicating state changes of a tracked object.
Step 5	**end** **Example:** `Device(config-track)# end`	Exits to privileged EXEC mode.

	Command or Action	Purpose
Step 6	**show track** *object-number* **Example:** `Device# show track 2`	(Optional) Displays tracking information. • Use this command to verify the configuration.

Example

The following example shows the state of the IP SLAs tracking:

```
Device# show track 2

Track 2
   IP SLA 1 state
   State is Down
     1 change, last change 00:00:47
   Latest operation return code: over threshold
   Latest RTT (millisecs) 4
   Tracked by:
     HSRP Ethernet0/1 3
```

Tracking the Reachability of an IP SLAs IP Host

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track** *object-number* **ip sla** *operation-number* **reachability**
4. **delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down***seconds*}
5. **end**
6. **show track** *object-number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**track** *object-number* **ip sla** *operation-number* **reachability** **Example:** `Device(config)# track 2 ip sla 4 reachability`	Tracks the reachability of an IP SLAs IP host and enters tracking configuration mode. **Note** With CScsf08092, the **track rtr** command was replaced by the **track ip sla** command.
Step 4	**delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down***seconds*} **Example:** `Device(config-track)# delay up 30 down 10`	(Optional) Specifies a period of time (in seconds) to delay communicating state changes of a tracked object.
Step 5	**end** **Example:** `Device(config-track)# end`	Exits to privileged EXEC mode.
Step 6	**show track** *object-number* **Example:** `Device# show track 3`	(Optional) Displays tracking information. • Use this command to verify the configuration.

Example

The following example shows whether the route is reachable:

```
Device# show track 3

Track 3
   IP SLA 1 reachability
   Reachability is Up
     1 change, last change 00:00:47
   Latest operation return code: over threshold
   Latest RTT (millisecs) 4
   Tracked by:
     HSRP Ethernet0/1 3
```

Configuring a Tracked List and Boolean Expression

Perform this task to configure a tracked list of objects and a Boolean expression to determine the state of the list. A tracked list contains one or more objects. The Boolean expression enables two types of calculations by using either “and” or “or” operators. For example, when you configure tracking for two interfaces using the “and” operator up means that *both* interfaces are up, and down means that either interface is down.

You may configure a tracked list state to be measured using a weight or percentage threshold. See the Configuring a Tracked List and Threshold Weight section and the Configuring a Tracked List and Threshold Percentage section.

Before You Begin

An object must exist before it can be added to a tracked list.

Note The “not” operator is specified for one or more objects and negates the state of the object.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track** *track-number* **list boolean** {**and** | **or**}
4. **object** *object-number* [**not**]
5. **delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*}
6. **end**

DETAILED STEPS

	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	**track** *track-number* **list boolean** {**and**	**or**} **Example:** `Device(config)# track 100 list boolean and`	Configures a tracked list object and enters tracking configuration mode.

	Command or Action	Purpose
Step 4	**object** *object-number* [**not**] **Example:** `Device(config-track)# object 3 not`	Specifies the object to be tracked. • The*object-number* argument has a valid range from 1 to 500. There is no default. The optional **not** keyword negates the state of the object. **Note** The example means that when object 3 is up, the tracked list detects object 3 as down.
Step 5	**delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*} **Example:** `Device(config-track)# delay up 3`	(Optional) Specifies a tracking delay in seconds between up and down states.
Step 6	**end** **Example:** `Device(config-track)# end`	Returns to privileged EXEC mode.

Configuring a Tracked List and Threshold Weight

Perform this task to configure a list of tracked objects, to specify that weight be used as the threshold, and to configure a weight for each of the objects in the list of tracked objects. A tracked list contains one or more objects. Enhanced object tracking uses a threshold weight to determine the state of each object by comparing the total weight of all objects that are up against a threshold weight for each object.

You can also configure a tracked list state to be measured using a Boolean calculation or threshold percentage. See the Configuring a Tracked List and Boolean Expression section and the Configuring a Tracked List and Threshold Percentage section.

Before You Begin

An object must exist before it can be added to a tracked list.

Note You cannot use the Boolean “not” operator in a weight or percentage threshold list.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track** *track-number* **list threshold weight**
4. **object** *object-number* [**weight** *weight-number*]
5. **threshold weight** {**up** *number* **down** *number* | **up** *number* | **down** *number*}
6. **delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*}
7. **end**

DETAILED STEPS

	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	**track** *track-number* **list threshold weight** **Example:** `Device(config)# track 100 list threshold weight`	Configures a tracked list object and enters tracking configuration mode. The keywords are as follows: • **threshold —**Specifies that the state of the tracked list is based on a threshold. • **weight —**Specifies that the threshold is based on a specified weight.
Step 4	**object** *object-number* [**weight** *weight-number*] **Example:** `Device(config-track)# object 3 weight 30`	Specifies the object to be tracked. The *object-number* argument has a valid range from 1 to 500. There is no default. The optional **weight** keyword specifies a threshold weight for each object.
Step 5	**threshold weight** {**up** *number* **down** *number* | **up** *number* | **down** *number*} **Example:** `Device(config-track)# threshold weight up 30`	Specifies the threshold weight. • **up** *number* **—**Valid range is from 1 to 255. • **down** *number***—**Range depends upon what you select for the **up** keyword. For example, if you configure 25 for up, you will see a range from 0 to 24 for down.

	Command or Action	Purpose
Step 6	**delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*} **Example:** `Device(config-track)# delay up 3`	(Optional) Specifies a tracking delay in seconds between up and down states.
Step 7	**end** **Example:** `Device(config-track)# end`	Returns to privileged EXEC mode.

Configuring a Tracked List and Threshold Percentage

Perform this task to configure a tracked list of objects, to specify that a percentage will be used as the threshold, and to specify a percentage for each object in the list. A tracked list contains one or more objects. Enhanced object tracking uses the threshold percentage to determine the state of the list by comparing the assigned percentage of each object to the list.

You may also configure a tracked list state to be measured using a Boolean calculation or threshold weight. See the Configuring a Tracked List and Boolean Expression section and theConfiguring a Tracked List and Threshold Weight section.

Note You cannot use the Boolean “not” operator in a weight or percentage threshold list.

Before You Begin

An object must exist before it can be added to a tracked list.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track** *track-number* **list threshold percentage**
4. **object** *object-number*
5. **threshold percentage** {**up** *number* [**down** *number*] | **down** *number* [**up** *number*]}
6. **delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*}
7. **end**

DETAILED STEPS

	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	**track** *track-number* **list threshold percentage** **Example:** `Device(config)# track 100 list threshold percentage`	Configures a tracked list object and enters tracking configuration mode. The keywords are as follows: • **threshold —**Specifies that the state of the tracked list is based on a threshold. • **percentage —**Specifies that the threshold is based on a percentage.
Step 4	**object** *object-number* **Example:** `Device(config-track)# object 3`	Specifies the object to be tracked. • The *object-number* argument has a valid range from 1 to 500. There is no default.
Step 5	**threshold percentage** {**up** *number* [**down** *number*] | **down** *number* [**up** *number*]} **Example:** `Device(config-track)# threshold percentage up 30`	Specifies the threshold percentage. • **up** *number***—**Valid range is from 1 to 100. • **down** *number* **—**Range depends upon what you have selected for the **up** keyword. For example, if you specify 25 as up, a range from 26 to 100 is displayed for the **down** keyword.
Step 6	**delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*} **Example:** `Device(config-track)# delay up 3`	(Optional) Specifies a tracking delay in seconds between up and down states.
Step 7	**end** **Example:** `Device(config-track)# end`	Returns to privileged EXEC mode.

Configuring Track List Defaults

Perform this task to configure a default delay value for a tracked list, a default object, and default threshold parameters for a tracked list.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track** *track-number*
4. **default** {**delay** | **object** *object-number* | **threshold percentage**}
5. **end**

DETAILED STEPS

	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	**track** *track-number* **Example:** `Device(config)# track 3`	Enters tracking configuration mode.
Step 4	**default** {**delay** | **object** *object-number* | **threshold percentage**} **Example:** `Device(config-track)# default delay`	Specifies a default delay value for a tracked list, a default object, and default threshold parameters for a tracked list. • **delay —**Reverts to the default delay. • **object** *object-number***—**Specifies a default object for the track list. The valid range is from 1 to 1000. • **threshold percentage—**Specifies a default threshold percentage.

	Command or Action	Purpose
Step 5	**end** **Example:** `Device(config-track)# end`	Returns to privileged EXEC mode.

Configuring Tracking for Mobile IP Applications

Perform this task to configure a tracked list of Mobile IP application objects.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **track** *track-number* **application home-agent**
4. **exit**
5. **track** *track-number* **application pdsn**
6. **exit**
7. **track** *track-number* **application ggsn**
8. **end**

DETAILED STEPS

	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	**track** *track-number* **application home-agent** **Example:** `Device(config)# track 100 application home-agent`	(Optional) Tracks the presence of Home Agent traffic on a router and enters tracking configuration mode.

	Command or Action	Purpose
Step 4	**exit** **Example:** `Device(config-track)# exit`	Returns to global configuration mode.
Step 5	**track** *track-number* **application pdsn** **Example:** `Device(config)# track 100 application pdsn`	(Optional) Tracks the presence of Packet Data Serving Node (PDSN) traffic on a router tracking configuration mode.
Step 6	**exit** **Example:** `Device(config-track)# exit`	Returns to global configuration mode.
Step 7	**track** *track-number* **application ggsn** **Example:** `Device(config)# track 100 application ggsn`	(Optional) Tracks the presence of Gateway GPRS Support Node (GGSN) traffic on a router tracking configuration mode.
Step 8	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode.

Configuration Examples for Enhanced Object Tracking

Example: Interface Line Protocol

In the following example, the tracking process is configured to track the line-protocol state of GigabitEthernet interface 1/0/0. HSRP on GigabitEthernet interface 0/0/0 then registers with the tracking process to be informed of any changes to the line-protocol state of GigabitEthernet interface 1/0/0. If the line protocol on GigabitEthernet interface 1/0/0 goes down, the priority of the HSRP group is reduced by 10.

Router A Configuration

```
Device(config)# track 100 interface GigabitEthernet1/0/0 line-protocol
!
Device(config)# interface GigabitEthernet0/0/0
Device(config-if)# ip address 10.1.0.21 255.255.0.0
Device(config-if)# standby 1 preempt
```

```
Device(config-if)# standby 1 ip 10.1.0.1
Device(config-if)# standby 1 priority 110
Device(config-if)# standby 1 track 100 decrement 10
```

Router B Configuration

```
Device(config)# track 100 interface GigabitEthernet1/0/0 line-protocol
!
Device(config)# interface GigabitEthernet0/0/0
Device(config-if)# ip address 10.1.0.22 255.255.0.0
Device(config-if)# standby 1 preempt
Device(config-if)# standby 1 ip 10.1.0.1
Device(config-if)# standby 1 priority 105
Device(config-if)# standby 1 track 100 decrement 10
```

Example: Interface IP Routing

In the following example, the tracking process is configured to track the IP-routing capability of GigabitEthernet interface 1/0/0. HSRP on GigabitEthernet interface 0/0/0 then registers with the tracking process to be informed of any changes to the IP-routing state of GigabitEthernet interface 1/0/0. If the IP-routing state on GigabitEthernet interface 1/0/0 goes down, the priority of the HSRP group is reduced by 10.

If both serial interfaces are operational, Router A will be the HSRP active router because it has the higher priority. However, if IP on GigabitEthernet interface 1/0/0 in Router A fails, the HSRP group priority will be reduced and Router B will take over as the active router, thus maintaining a default virtual gateway service to hosts on the 10.1.0.0 subnet.

See the figure below for a sample topology.

Figure 1: Topology for IP-Routing Support

Router A Configuration

```
Device(config)# track 100 interface GigabitEthernet1/0/0 ip routing
!
Device(config)# interface GigabitEthernet0/0/0
Device(config-if)# ip address 10.1.0.21 255.255.0.0
Device(config-if)# standby 1 preempt
Device(config-if)# standby 1 ip 10.1.0.1
Device(config-if)# standby 1 priority 110
Device(config-if)# standby 1 track 100 decrement 10
```

Router B Configuration

```
Device(config)# track 100 interface GigabitEthernet1/0/0 ip routing
!
Device(config)# interface GigabitEthernet0/0/0
Device(config-if)# ip address 10.1.0.22 255.255.0.0
```

```
Device(config-if)# standby 1 preempt
Device(config-if)# standby 1 ip 10.1.0.1
Device(config-if)# standby 1 priority 105
Device(config-if)# standby 1 track 100 decrement 10
```

Example: IP-Route Reachability

In the following example, the tracking process is configured to track the reachability of IP route 10.2.2.0/24:

Router A Configuration

```
Device(config)# track 100 ip route 10.2.2.0/24 reachability
!
Device(config)# interface GigabitEthernet0/0/0
Device(config-if)# ip address 10.1.1.21 255.255.255.0
Device(config-if)# standby 1 preempt
Device(config-if)# standby 1 ip 10.1.1.1
Device(config-if)# standby 1 priority 110
Device(config-if)# standby 1 track 100 decrement 10
```

Router B Configuration

```
Device(config)# track 100 ip route 10.2.2.0/24 reachability
!
Device(config)# interface GigabitEthernet0/0/0
Device(config-if)# ip address 10.1.1.22 255.255.255.0
Device(config-if)# standby 1 preempt
Device(config-if)# standby 1 ip 10.1.1.1
Device(config-if)# standby 1 priority 105
Device(config-if)# standby 1 track 100 decrement 10
```

Example: IP-Route Threshold Metric

In the following example, the tracking process is configured to track the threshold metric of IP route 10.2.2.0/24:

Router A Configuration

```
Device(config)# track 100 ip route 10.2.2.0/24 metric threshold
!
Device(config)# interface GigabitEthernet0/0/0
Device(config-if)# ip address 10.1.1.21 255.255.255.0
Device(config-if)# standby 1 preempt
Device(config-if)# standby 1 ip 10.1.1.1
Device(config-if)# standby 1 priority 110
Device(config-if)# standby 1 track 100 decrement 10
```

Router B Configuration

```
Device(config)# track 100 ip route 10.2.2.0/24 metric threshold
!
Device(config)# interface GigabitEthernet0/0/0
Device(config-if)# ip address 10.1.1.22 255.255.255.0
Device(config-if)# standby 1 preempt
Device(config-if)# standby 1 ip 10.1.1.1
Device(config-if)# standby 1 priority 105
Device(config-if)# standby 1 track 100 decrement 10
```

Example: IP SLAs IP Host Tracking

The following example shows how to configure IP host tracking for IP SLAs operation 1 prior to CSCsf08092:

```
Device(config)# ip sla 1
Device(config-ip-sla)# icmp-echo 10.51.12.4
Device(config-ip-sla-echo)# timeout 1000
Device(config-ip-sla-echo)# threshold 2
Device(config-ip-sla-echo)# frequency 3
Device(config-ip-sla-echo)# request-data-size 1400
Device(config-ip-sla-echo)# exit
Device(config)# ip sla schedule 1 start-time now life forever
Device(config-ip-sla)# track 2 rtr 1 state
Device(config-ip-sla)# exit
Device(config)# track 3 rtr 1 reachability
Device(config-track)# exit
Device(config)# interface ethernet0/1
Device(config-if)# ip address 10.21.0.4 255.255.0.0
Device(config-if)# no shutdown
Device(config-if)# standby 3 ip 10.21.0.10
Device(config-if)# standby 3 priority 120
Device(config-if)# standby 3 preempt
Device(config-if)# standby 3 track 2 decrement 10
Device(config-if)# standby 3 track 3 decrement 10
```

The following example shows how to configure IP host tracking for IP SLAs operation 1 prior to CSCsf08092:

```
Device(config)# ip sla 1
Device(config-ip-sla)# icmp-echo 10.51.12.4
Device(config-ip-sla-echo)# threshold 2
Device(config-ip-sla-echo)# timeout 1000
Device(config-ip-sla-echo)# frequency 3
Device(config-ip-sla-echo)# request-data-size 1400
Device(config-ip-sla-echo)# exit
Device(config)# ip sla schedule 1 start-time now life forever
Device(config)# track 2 ip sla 1 state
Device(config-track)# exit
Device(config)# track 3 ip sla 1 reachability
Device(config-track)# exit
Device(config)# interface ethernet0/1
Device(config-if)# ip address 10.21.0.4 255.255.0.0
Device(config-if)# no shutdown
Device(config-if)# standby 3 ip 10.21.0.10
Device(config-if)# standby 3 priority 120
Device(config-if)# standby 3 preempt
Device(config-if)# standby 3 track 2 decrement 10
Device(config-if)# standby 3 track 3 decrement 10
```

Example: Boolean Expression for a Tracked List

In the following example, a track list object is configured to track two GigabitEthernet interfaces when both interfaces are up and when either interface is down:

```
Device(config)# track 1 interface GigabitEthernet2/0/0 line-protocol
Device(config)# track 2 interface GigabitEthernet2/1/0 line-protocol
Device(config-track)# exit
Device(config)# track 100 list boolean and
Device(config-track)# object 1
Device(config-track)# object 2
```

In the following example, a track list object is configured to track two GigabitEthernet interfaces when either interface is up and when both interfaces are down:

```
Device(config)# track 1 interface GigabitEthernet2/0/0 line-protocol
Device(config)# track 2 interface GigabitEthernet2/1/0 line-protocol
Device(config-track)# exit
Device(config)# track 101 list boolean or
Device(config-track)# object 1
Device(config-track)# object 2
```

The following configuration example shows that tracked list 4 has two objects and one object state is negated (if the list is up, the list detects that object 2 is down):

```
Device(config)# track 4 list boolean and
Device(config-track)# object 1
Device(config-track)# object 2 not
```

Example: Threshold Weight for a Tracked List

In the following example, three GigabitEtherent interfaces in tracked list 100 are configured with a threshold weight of 20 each. The down threshold is configured to 0 and the up threshold is configured to 40:

```
Device(config)# track 1 interface GigabitEthernet2/0/0 line-protocol
Device(config)# track 2 interface GigabitEthernet2/1/0 line-protocol
Device(config)# track 3 interface GigabitEthernet2/2/0 line-protocol
Device(config-track)# exit
Device(config)# track 100 list threshold weight
Device(config-track)# object 1 weight 20
Device(config-track)# object 2 weight 20
Device(config-track)# object 3 weight 20
Device(config-track)# threshold weight  up 40 down 0
```

In the example above the track-list object goes down only when all three serial interfaces go down, and comes up again only when at least two interfaces are up (because 20 + 20 >= 40). The advantage of this configuration is that it prevents the track-list object from coming up if two interfaces are down and the third interface is flapping.

The following configuration example shows that if object 1 and object 2 are down, then track list 4 is up, because object 3 satisfies the up threshold value of up 30. But, if object 3 is down, both objects 1 and 2 need to be up in order to satisfy the threshold weight.

```
Device(config)# track 4 list threshold weight
Device(config-track)# object 1 weight 15
Device(config-track)# object 2 weight 20
Device(config-track)# object 3 weight 30
Device(config-track)# threshold weight up 30 down 10
```

This configuration may be useful to you if you have two small bandwidth connections (represented by object 1 and 2) and one large bandwidth connection (represented by object 3). Also the down 10 value means that once the tracked object is up, it will not go down until the threshold value is lower or equal to 10, which in this example means that all connections are down.

Example: Threshold Percentage for a Tracked List

In the following example, four GigabitEthernet interfaces in track list 100 are configured for an up threshold percentage of 75. The track list is up when 75 percent of the interfaces are up and down when fewer than 75 percent of the interfaces are up.

```
Device(config)# track 1 interface GigabitEthernet2/0/0 line-protocol
Device(config)# track 2 interface GigabitEthernet2/1/0 line-protocol
Device(config)# track 3 interface GigabitEthernet2/2/0 line-protocol
Device(config)# track 4 interface GigabitEthernet2/3/0 line-protocol
Device(config-track)# exit
Device(config)# track 100 list threshold percentage
Device(config-track)# object 1
Device(config-track)# object 2
Device(config-track)# object 3
Device(config-track)# object 4
Device(config-track)# threshold percentage up 75
```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases
Embedded Event Manager	*Embedded Event Manager Overview*
HSRP concepts and configuration tasks	*Configuring HSRP*
GLBP concepts and configuration tasks	*Configuring GLBP*
IP SLAs commands	*Cisco IOS IP SLAs Command Reference*
VRRP concepts and configuration tasks	*Configuring VRRP*
GLBP, HSRP, and VRRP commands	*Cisco IOS IP Application Services Command Reference*

Standards

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

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

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

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for Enhanced Object Tracking

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

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

Table 3: Feature Information for Enhanced Object Tracking

Feature Name	Releases	Feature Information
Enhanced Tracking Support	15.0(1)SY	The Enhanced Tracking Support feature separates the tracking mechanism from HSRP and creates a separate standalone tracking process that can be used by other Cisco IOS processes and HSRP. This feature allows tracking of other objects in addition to the interface line-protocol state. The following commands were introduced or modified: **show track**, **standby track**, **threshold metric**, **track interface**, **track ip route**, **track timer**.
FHRP—Enhanced Object Tracking Integration with Embedded Event Manager	15.0(1)SY	EOT is integrated with Embedded Event Manager (EEM) to allow EEM to report on a status change of a tracked object and to allow EOT to track EEM objects. The following commands were introduced or modified by this feature: **default-state**, **event resource**, **event rf**, **event track**, **show track**, **track stub**.
FHRP—Enhanced Object Tracking of IP SLAs Operations	15.0(1)SY	This feature enables First Hop Redundancy Protocols (FHRPs) and other Enhanced Object Tracking (EOT) clients to track the output from IP SLAs objects and use the provided information to trigger an action. The following command was introduced by this feature: **track rtr**.
FHRP—EOT Deprecation of rtr Keyword	15.0(1)SY	This feature replaces the **track rtr** command with the **track ip sla** command.

Feature Name	Releases	Feature Information
FHRP—Object Tracking List	15.0(1)SY	This feature enhances the tracking capabilities to enable the configuration of a combination of tracked objects in a list, and a flexible method of combining objects using Boolean logic. The following commands were introduced or modified by this feature: **show track**, **threshold percentage**, **threshold weight**, **track list**, **track resolution**.

Glossary

DHCP—Dynamic Host Configuration Protocol. DHCP is a protocol that delivers IP addresses and configuration information to network clients.

GGSN—Gateway GPRS Support Node. A wireless gateway that allows mobile cell phone users to access the public data network (PDN) or specified private IP networks. The GGSN function is implemented on the Cisco routers.

GLBP—Gateway Load Balancing Protocol. Provides automatic router backup for IP hosts that are configured with a single default gateway on an IEEE 802.3 LAN. Multiple first-hop routers on the LAN combine to offer a single virtual first-hop IP router while sharing the IP packet forwarding load. Other routers on the LAN may act as redundant (GLBP) routers that will become active if any of the existing forwarding routers fail.

GPRS—General Packet Radio Service. A 2.5G mobile communications technology that enables mobile wireless service providers to offer their mobile subscribers with packet-based data services over GSM networks.

GSM network—Global System for Mobile Communications network. A digital cellular technology that is used worldwide, predominantly in Europe and Asia. GSM is the world's leading standard in digital wireless communications.

Home Agent—A Home Agent is a router on the home network of the Mobile Node (MN) that maintains an association between the home IP address of the MN and its care-of address, which is the current location of the MN on a foreign or visited network. The HA redirects packets by tunneling them to the MN while it is away from the home network.

HSRP—Hot Standby Router Protocol. Provides high network availability and transparent network topology changes. HSRP creates a Hot Standby router group with a lead router that services all packets sent to the Hot Standby address. The lead router is monitored by other routers in the group, and if it fails, one of these standby routers inherits the lead position and the Hot Standby group address.

IPCP—IP Control Protocol. The protocol used to establish and configure IP over PPP.

LCP—Link Control Protocol. The protocol used to establish, configure, and test data-link connections for use by PPP.

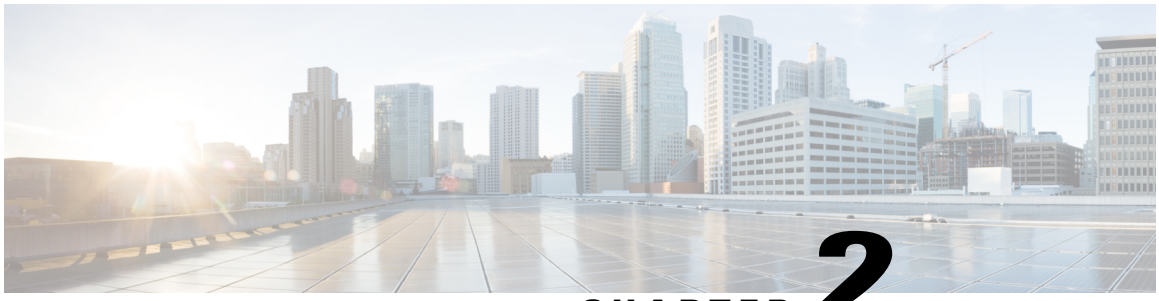
PDSN—Packet Data Serving Node. The Cisco PDSN is a standards-compliant, wireless gateway that enables packet data services in a Code Division Multiplex Access (CDMA) environment. Acting as an access gateway,

the Cisco PDSN provides simple IP and Mobile IP access, foreign-agent support, and packet transport for Virtual Private Networks (VPN).

PPP—Point-to-Point Protocol. Provides router-to-router and host-to-network connections over synchronous and asynchronous circuits. PPP is most commonly used for dial-up Internet access. Its features include address notification, authentication via CHAP or PAP, support for multiple protocols, and link monitoring.

VRF—VPN routing and forwarding instance. A VRF consists of an IP routing table, a derived forwarding table, a set of interfaces that use the forwarding table, and a set of rules and routing protocols that determine what goes into the forwarding table. In general, a VRF includes the routing information that defines a customer VPN site that is attached to a provider edge router.

VRRP—Virtual Router Redundancy Protocol. Eliminates the single point of failure inherent in the static default routed environment. VRRP specifies an election protocol that dynamically assigns responsibility for a virtual router to one of the VRRP routers on a LAN. The VRRP router that controls the IP addresses associated with a virtual router is called the master, and forwards packets sent to these IP addresses. The election process provides dynamic failover in the forwarding responsibility should the master become unavailable. Any of the virtual router IP addresses on a LAN can then be used as the default first-hop router by end hosts.



CHAPTER 2

Configuring IP Services

This module describes how to configure optional IP services. For a complete description of the IP services commands in this chapter, refer to the *Cisco IOS IP Application Services Command Reference*. To locate documentation of other commands that appear in this module, use the master command list, or search online.

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 www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About IP Services

Cisco IP Accounting

Cisco IP accounting support provides basic IP accounting functions. By enabling IP accounting, users can see the number of bytes and packets switched through the software on a source and destination IP address basis. Only transit IP traffic is measured and only on an outbound basis; traffic generated by the software or

terminating in the software is not included in the accounting statistics. To maintain accurate accounting totals, the software maintains two accounting databases: an active and a checkpointed database.

Cisco IP accounting support also provides information identifying IP traffic that fails IP access lists. Identifying IP source addresses that violate IP access lists alerts you to possible attempts to breach security. The data also indicates that you should verify IP access list configurations. To make this functionality available to users, you must enable IP accounting of access list violations using the **ip accounting access-violations** interface configuration command. Users can then display the number of bytes and packets from a single source that attempted to breach security against the access list for the source destination pair. By default, IP accounting displays the number of packets that have passed access lists and were routed.

How to Configure IP Services

Configuring IP Accounting

To configure IP accounting, perform this task for each interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip accounting-threshold** *threshold*
4. **ip accounting-list** *ip-address wildcard*
5. **ip accounting-transits** *count*
6. **interface** *type number*
7. **ip accounting** [**access-violations**] [**output-packets**]
8. **ip accounting mac-address** {**input** | **output**}

DETAILED STEPS

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

	Command or Action	Purpose
Step 3	**ip accounting-threshold** *threshold* **Example:** `Router(config)# ip accounting-threshold 500`	(Optional) Sets the maximum number of accounting entries to be created.
Step 4	**ip accounting-list** *ip-address wildcard* **Example:** `Router(config)# ip accounting-list 192.31.0.0 0.0.255.255`	(Optional) Filters accounting information for hosts.
Step 5	**ip accounting-transits** *count* **Example:** `Router(config)# ip accounting-transits 100`	(Optional) Controls the number of transit records that will be stored in the IP accounting database.
Step 6	**interface** *type number* **Example:** `Router(config)# interface GigabitEthernet 1/0/0`	Specifies the interface and enters interface configuration mode.
Step 7	**ip accounting** [**access-violations**] [**output-packets**] **Example:** `Router(config-if)# ip accounting access-violations`	Configures basic IP accounting. • Use the optional **access-violations** keyword to enable IP accounting with the ability to identify IP traffic that fails IP access lists. • Use the optional **output-packets** keyword to enable IP accounting based on the IP packets output on the interface.
Step 8	**ip accounting mac-address** {**input** | **output**} **Example:** `Router(config-if)# ip accounting mac-address output`	(Optional) Configures IP accounting based on the MAC address of received (input) or transmitted (output) packets.

Monitoring and Maintaining the IP Network

You can display specific statistics such as the contents of IP routing tables, caches, databases and socket processes. The resulting information can be used to determine resource utilization and to solve network problems.

SUMMARY STEPS

1. **clear ip traffic**
2. **clear ip accounting** [**checkpoint**]
3. **clear sockets** *process-id*
4. **show ip accounting** [**checkpoint**] [**output-packets** | **access-violations**]
5. **show interface** *type number* **mac**
6. **show interface** [*type number*] **precedence**
7. **show ip redirects**
8. **show sockets** *process-id* [**detail**] [**events**]
9. **show udp** [**detail**]
10. **show ip traffic**

DETAILED STEPS

Step 1 **clear ip traffic**

To clear all IP traffic statistical counters on all interfaces, use the following command:

Example:

```
Router# clear ip traffic
```

Step 2 **clear ip accounting** [**checkpoint**]

You can remove all contents of a particular cache, table, or database. Clearing a cache, table, or database can become necessary when the contents of the particular structure have become or are suspected to be invalid. To clear the active IP accounting database when IP accounting is enabled, use the following command:

Example:

```
Router# clear ip accounting
```

To clear the checkpointed IP accounting database when IP accounting is enabled, use the following command:

Example:

```
Router# clear ip accounting checkpoint
```

Step 3 **clear sockets** *process-id*

To close all IP sockets and clear the underlying transport connections and data structures for the specified process, use the following command:

Example:

```
Router# clear sockets 35

All sockets (TCP, UDP and SCTP) for this process will be cleared.
Do you want to proceed? [yes/no]: y
Cleared sockets for PID 35
```

Step 4 **show ip accounting** [**checkpoint**] [**output-packets** | **access-violations**]

To display access list violations, use the **show ip accounting** command. To use this command, you must first enable IP accounting on a per-interface basis.

Use the **checkpoint** keyword to display the checkpointed database. Use the **output-packets** keyword to indicate that information pertaining to packets that passed access control and were routed should be displayed. Use the **access-violations** keyword to display the number of the access list failed by the last packet for the source and destination pair. The number of packets reveals how aggressive the attack is upon a specific destination. If you do not specify the **access-violations** keyword, the command defaults to displaying the number of packets that have passed access lists and were routed.

If neither the **output-packets** nor **access-violations** keyword is specified, **output-packets** is the default.

The following is sample output from the **show ip accounting** command:

Example:

```
Router# show ip accounting

   Source           Destination              Packets               Bytes
 172.16.19.40    192.168.67.20               7                    306
 172.16.13.55    192.168.67.20               67                   2749
 172.16.2.50     192.168.33.51               17                   1111
 172.16.2.50     172.31.2.1                  5                    319
 172.16.2.50     172.31.1.2                  463                  30991
 172.16.19.40    172.16.2.1                   4                    262
 172.16.19.40    172.16.1.2                  28                    2552
 172.16.20.2     172.16.6.100                39                    2184
 172.16.13.55    172.16.1.2                  35                    3020
 172.16.19.40    192.168.33.51              1986                   95091
 172.16.2.50     192.168.67.20               233                  14908
 172.16.13.28    192.168.67.53               390                  24817
 172.16.13.55    192.168.33.51             214669                9806659
 172.16.13.111   172.16.6.23               27739                 1126607
 172.16.13.44    192.168.33.51              35412                1523980
 192.168.7.21    172.163.1.2                   11                    824
 172.16.13.28    192.168.33.2                  21                   1762
 172.16.2.166    192.168.7.130                797                 141054
 172.16.3.11     192.168.67.53                  4                    246
 192.168.7.21    192.168.33.51              15696                 695635
 192.168.7.24    192.168.67.20                 21                    916
 172.16.13.111   172.16.10.1                   16                   1137
 accounting threshold exceeded for 7 packets and 433 bytes
```

The following is sample output from the **show ip accounting access-violations** command. The output pertains to packets that failed access lists and were not routed:

Example:

```
Router#  show ip accounting access-violations

   Source           Destination      Packets        Bytes        ACL
172.16.19.40    192.168.67.20             7          306         77
172.16.13.55    192.168.67.20            67         2749        185
172.16.2.50     192.168.33.51            17         1111        140
172.16.2.50     172.16.2.1               5          319        140
172.16.19.40    172.16.2.1               4          262         77
Accounting data age is 41
```

Step 5 **show interface** *type number* **mac**

To display information for interfaces configured for MAC accounting, use the **show interface mac** command. The following is sample output from the **show interface mac** command:

Example:

```
Router# show interface ethernet 0/1 mac

Ethernet0/1
Input  (511 free)
0007.f618.4449(228):  4 packets, 456 bytes, last: 2684ms ago
```

```
Total:  4 packets, 456 bytes
Output  (511 free)
0007.f618.4449(228):  4 packets, 456 bytes, last: 2692ms ago
Total:  4 packets, 456 bytes
```

Step 6 **show interface** [*type number*] **precedence**

To display information for interfaces configured for precedence accounting, use the **show interface precedence** command.

The following is sample output from the **show interface precedence** command. In this example, the total packet and byte counts are calculated for the interface that receives (input) or sends (output) IP packets and sorts the results based on IP precedence.

Example:

```
Router# show interface ethernet 0/1 precedence

Ethernet0/1
Input
Precedence 0:  4 packets, 456 bytes
Output
Precedence 0:  4 packets, 456 bytes
```

Step 7 **show ip redirects**

To display the address of the default router and the address of hosts for which an ICMP redirect message has been received, use the **show ip redirects**command.

Example:

```
Router#  show ip redirects

Default gateway is 172.16.80.29

Host               Gateway           Last Use    Total Uses  Interface
172.16.1.111      172.16.80.240        0:00             9  Ethernet0
172.16.1.4        172.16.80.240        0:00             4  Ethernet0
```

Step 8 **show sockets** *process-id* [**detail**] [**events**]

To display the number of sockets currently open and their distribution with respect to the transport protocol process specified by the *process-id* argument, use the **show sockets** command. The following sample output from the **show sockets** command displays the total number of open sockets for the specified process:

Example:

```
Router# show sockets 35

Total open sockets - TCP:7, UDP:0, SCTP:0
```

The following sample output shows information about the same open processes with the **detail** keyword specified:

Example:

```
Router# show sockets 35 detail

   FD LPort FPort Proto Type    TransID

   0  5000  0     TCP   STREAM  0x6654DEBC
State: SS_ISBOUND
Options: SO_ACCEPTCONN

   1  5001  0     TCP   STREAM  0x6654E494
State: SS_ISBOUND
Options: SO_ACCEPTCONN

   2  5002  0     TCP   STREAM  0x656710B0
```

```
State: SS_ISBOUND
Options: SO_ACCEPTCONN

   3  5003  0     TCP   STREAM  0x65671688
State: SS_ISBOUND
Options: SO_ACCEPTCONN

   4  5004  0     TCP   STREAM  0x65671C60
State: SS_ISBOUND
Options: SO_ACCEPTCONN

   5  5005  0     TCP   STREAM  0x65672238
State: SS_ISBOUND
Options: SO_ACCEPTCONN

   6  5006  0     TCP   STREAM  0x64C7840C
State: SS_ISBOUND
Options: SO_ACCEPTCONN

Total open sockets - TCP:7, UDP:0, SCTP:0
```

The following example displays IP socket event information:

Example:

```
Router# show sockets 35 events

Events watched for this process: READ
FD Watched Present Select Present

0 --- --- R-- R--
```

Step 9 **show udp** [**detail**]

To display IP socket information about UDP processes, use the **show udp** command. The following example shows how to display detailed information about UDP sockets:

Example:

```
Router# show udp detail

 Proto    Remote      Port      Local       Port  In Out Stat TTY OutputIF
 17       10.0.0.0    0         10.0.21.70  67    0  0   2211 0
 Queues: output 0
         input  0 (drops 0, max 50, highwater 0)
 Proto    Remote      Port      Local       Port  In Out Stat TTY OutputIF
 17       10.0.0.0    0         10.0.21.70  2517  0   0  11   0
 Queues: output 0
         input  0 (drops 0, max 50, highwater 0)
 Proto    Remote      Port      Local       Port  In Out Stat TTY OutputIF
 17       10.0.0.0    0         10.0.21.70  5000  0  0   211  0
 Queues: output 0
         input  0 (drops 0, max 50, highwater 0)
 Proto    Remote      Port      Local       Port  In Out Stat TTY OutputIF
 17       10.0.0.0    0         10.0.21.70  5001  0  0   211  0
 Queues: output 0
         input  0 (drops 0, max 50, highwater 0)
 Proto    Remote      Port      Local       Port  In Out Stat TTY OutputIF
 17       10.0.0.0    0         10.0.21.70  5002  0  0   211  0
 Queues: output 0
         input  0 (drops 0, max 50, highwater 0)
 Proto    Remote      Port      Local       Port  In Out Stat TTY OutputIF
 17       10.0.0.0    0         10.0.21.70  5003  0  0   211  0
 Queues: output 0
         input  0 (drops 0, max 50, highwater 0)
 Proto    Remote      Port      Local       Port  In Out Stat TTY OutputIF
 17       10.0.0.0    0         10.0.21.70  5004  0  0   211  0
```

```
 Queues: output 0
         input  0 (drops 0, max 50, highwater 0)
```

Step 10 **show ip traffic**

To display IP protocol statistics, use the **show ip traffic** command. The following example shows that the IP traffic statistics have been cleared by the **clear ip traffic** command:

Example:

```
Router# clear ip traffic

Router# show ip traffic

IP statistics:
 Rcvd:  0 total, 0 local destination
        0 format errors, 0 checksum errors, 0 bad hop count
        0 unknown protocol, 0 not a gateway
        0 security failures, 0 bad options, 0 with options
 Opts:  0 end, 0 nop, 0 basic security, 0 loose source route
        0 timestamp, 0 extended security, 0 record route
        0 stream ID, 0 strict source route, 0 alert, 0 cipso
        0 other
 Frags: 0 reassembled, 0 timeouts, 0 couldn't reassemble
        0 fragmented, 0 couldn't fragment
 Bcast: 0 received, 0 sent
 Mcast: 0 received, 0 sent
 Sent: 0 generated, 0 forwarded
 Drop: 0 encapsulation failed, 0 unresolved, 0 no adjacency
       0 no route, 0 unicast RPF, 0 forced drop

ICMP statistics:
 Rcvd: 0 format errors, 0 checksum errors, 0 redirects, 0 unreachable
       0 echo, 0 echo reply, 0 mask requests, 0 mask replies, 0 quench
       0 parameter, 0 timestamp, 0 info request, 0 other
       0 irdp solicitations, 0 irdp advertisements
 Sent: 0 redirects, 0 unreachable, 0 echo, 0 echo reply
       0 mask requests, 0 mask replies, 0 quench, 0 timestamp
       0 info reply, 0 time exceeded, 0 parameter problem
       0 irdp solicitations, 0 irdp advertisements

UDP statistics:
 Rcvd: 0 total, 0 checksum errors, 0 no port
 Sent: 0 total, 0 forwarded broadcasts

TCP statistics:
 Rcvd: 0 total, 0 checksum errors, 0 no port
 Sent: 0 total

Probe statistics:
 Rcvd: 0 address requests, 0 address replies
       0 proxy name requests, 0 where-is requests, 0 other
 Sent: 0 address requests, 0 address replies (0 proxy)
       0 proxy name replies, 0 where-is replies

EGP statistics:
 Rcvd: 0 total, 0 format errors, 0 checksum errors, 0 no listener
 Sent: 0 total

IGRP statistics:
 Rcvd: 0 total, 0 checksum errors
 Sent: 0 total

OSPF statistics:
 Rcvd: 0 total, 0 checksum errors
       0 hello, 0 database desc, 0 link state req
       0 link state updates, 0 link state acks

 Sent: 0 total
```

```
IP-IGRP2 statistics:
 Rcvd: 0 total
 Sent: 0 total

PIMv2 statistics: Sent/Received
 Total: 0/0, 0 checksum errors, 0 format errors
 Registers: 0/0, Register Stops: 0/0, Hellos: 0/0
 Join/Prunes: 0/0, Asserts: 0/0, grafts: 0/0
 Bootstraps: 0/0, Candidate_RP_Advertisements: 0/0

IGMP statistics: Sent/Received
 Total: 0/0, Format errors: 0/0, Checksum errors: 0/0
 Host Queries: 0/0, Host Reports: 0/0, Host Leaves: 0/0
 DVMRP: 0/0, PIM: 0/0
```

Configuration Examples for IP Services

Example: Configuring IP Accounting

The following example shows how to enable IP accounting based on the source and destination MAC address and based on IP precedence for received and transmitted packets:

```
Router# configure terminal
Router(config)# interface ethernet 0/5
Router(config-if)# ip accounting mac-address input
Router(config-if)# ip accounting mac-address output
Router(config-if)# ip accounting precedence input
Router(config-if)# ip accounting precedence output
```

The following example shows how to enable IP accounting with the ability to identify IP traffic that fails IP access lists and with the number of transit records that will be stored in the IP accounting database limited to 100:

```
Router# configure terminal
Router(config)# ip accounting-transits 100
Router(config)# interface ethernet 0/5
Router(config-if)# ip accounting output-packets
Router(config-if)# ip accounting access-violations
```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases
IP application services commands	Cisco IOS IP Application Services Command Reference

Standards and RFCs

Standard	Title
RFC 1256	ICMP Router Discovery Messages

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

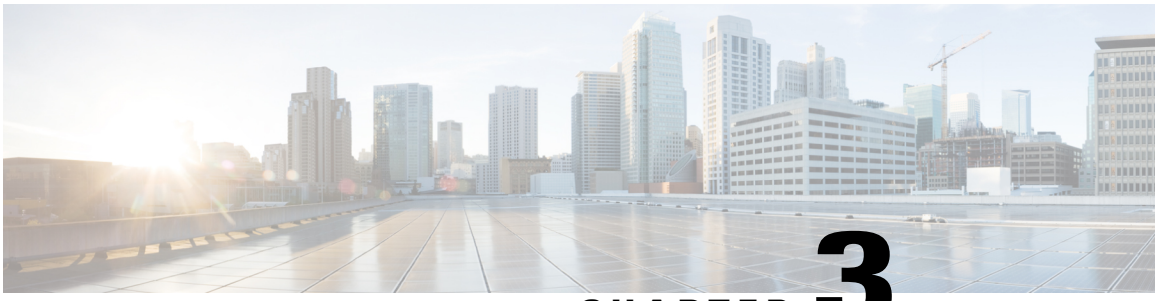
Feature Information for IP Services

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

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

Table 4: Feature Information for IP Services

Feature Name	Releases	Feature Information
IP Precedence Accounting	15.0(1)SY	The IP Precedence Accounting feature provides accounting information for IP traffic based on the precedence of any interface. This feature calculates the total packet and byte counts for an interface that receives or sends IP packets and sorts the results based on the IP precedence. This feature is supported on all interfaces and subinterfaces and supports Cisco Express Forwarding, distributed Cisco Express Forwarding, flow, and optimum switching. The following commands were introduced by this feature: **ip accounting precedence**, **show interface precedence**.



CHAPTER 3

Configuring IPv4 Broadcast Packet Handling

This module explains what IPv4 broadcast packets are, when they are used, and how to customize your router's configuration for situations when the default behavior for handling IPv4 broadcast packets isn't appropriate.

This module also explains some common scenarios that require customizing IPv4 broadcast packet handling by routers. For example, UDP forwarding of Dynamic Host Configuration Protocol (DHCP) traffic to ensure broadcast packets sent by DHCP clients can reach DHCP servers that are not on the same network segment as the client. Configuration tasks and examples are also provided in this module.

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 www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About IPv4 Broadcast Packet Handling

IP Unicast Address

An IP unicast address is not a broadcast addresses. A packet with an unicast destination IP address is intended for a specific IP host. For example, 172.16.1.1/32. Only the intended host of a unicast packets receives and processes the packet. This term is often used in conjunction with references to types of IP broadcast traffic. For example, a network administrator considering upgrading a router in a network must consider the amount of unicast, multicast, and broadcast traffic because each type of traffic can have a different effect on the performance of the router.

IP Broadcast Address

IP broadcast packets are sent to the destination IP broadcast address 255.255.255.255 (or the older but still occasionally used IP broadcast address of 000.000.000.000). The broadcast destination IP addresses 255.255.255.255 and 000.000.000.000 are used when a packet is intended for every IP-enabled device on a network.

Note Packets that use the broadcast IP address as the destination IP address are known as broadcast packets.

If routers forwarded IP broadcast packets by default, the packets would have to be forwarded out every interface that is enabled for IP because the 255.255.255.255 IP destination address is assumed to be reachable via every IP enabled interface in the router. Forwarding IP broadcast packets out every interface that is enabled for IP would result in what is known as a broadcast storm (network overload due to high levels of broadcast traffic). In order to avoid the IP packet broadcast storm that would be created if a router forwarded packets with a broadcast IP destination address out every IP-enabled interface, the default behavior for a router is to *not* forward broadcast packets. This is a key difference between routing IP traffic at Layer 3 versus bridging it at Layer 2. Layer 2 bridges by default forward IP broadcast traffic out every interface that is in a forwarding state, which can lead to scalability problems.

Some TCP/IP protocols use the IP broadcast address to either communicate with all of the hosts on a network segment or to identify the IP address of a specific host on a network segment. For example:

- Routing Information Protocol (RIP) version 1 sends routing table information using the IP broadcast address so that any other host on the network segment running RIP version 1 can receive and process the updates.
- The Address Resolution Protocol (ARP) is used to determine the Layer 2 MAC address of the host that owns a specific Layer 3 IP address. ARP sends an IP broadcast packet (that is also a Layer 2 broadcast frame) on the local network. All of the hosts on the local network receive the ARP broadcast packet because it is sent to as a Layer 2 broadcast frame. All of the hosts on the local network process the ARP packet because it is sent to the IP broadcast address. Only the host that owns the IP address indicated in the data area of the ARP packet responds to the ARP broadcast packet.

IP Directed Broadcast Address

An IP directed broadcast is intended to reach all hosts on a remote network. A router that needs to send data to a remote IP host when only the IP network address is known uses an IP directed broadcast to reach the remote host. For example, a directed broadcast sent by a host with an IP address of 192.168.100.1 with a destination IP address of 172.16.255.255 is intended only for hosts that are in the 172.16.0.0 address space (hosts that have an IP address that begins with 172.16.0.0).

An IP directed broadcast packet is routed through the network as a unicast packet until it arrives at the target subnet, where it is converted into a Layer 2 broadcast frame (MAC address of FFFF.FFFF.FFFF). Because of the nature of the IP addressing architecture, only the last router in the chain, the one that is connected directly to the target subnet, can conclusively identify a directed broadcast. For example, only a router with an interface connected to a network using an IP address in the 172.16.0.0/16 address space such as 172.16.1.1/16 can determine that a packet sent to 172.16.255.255 is a directed broadcast and convert it to a Layer 2 broadcast that is received by all hosts on the local network. The other routers in the network that are not connected to the 172.16.0.0/16 network forward packets addressed to 172.16.255.255 as if they were for a specific IP host.

All of the hosts on the remote network receive IP directed broadcasts after they are converted to Layer 2 broadcast frames. Ideally only the intended destination host will fully process the IP directed broadcast and respond to it. However, IP directed broadcasts can be used for malicious purposes. For example, IP directed broadcasts are used in "smurf" Denial of Service (DoS) attack and derivatives thereof. In a "smurf" attack, the attacker sends Internet Control Message Protocol (ICMP) echo requests (pings) to a directed broadcast address using the source IP address of the device that is the target of the attack. The target is usually a host inside a company's network such as a web server. The ICMP echo requests are sent to an IP directed broadcast address in the company's network that causes all the hosts on the target subnet to send ICMP echo replies to the device under attack. By sending a continuous stream of such requests, the attacker can create a much larger stream of replies, which can completely inundate the host that is under attack. For information on how IP directed broadcasts are used in DoS attacks, search the Internet for "IP directed broadcasts," "denial of service," and "smurf attacks."

Due to the security implications of allowing a router to forward directed broadcasts and the reduction in applications that require directed broadcasts, IP directed broadcasts are disabled by default in Cisco IOS Release 12.0 and later releases. If your network requires support for IP directed broadcasts, you can enable it on the interfaces that you want to translate the IP directed broadcasts to Layer 2 broadcasts using the **ip directed-broadcast** command. For example, if your router is receiving IP directed broadcasts on Fast Ethernet interface 0/0 for the network address assigned to Fast Ethernet interface 0/1, and you want the IP directed broadcasts to be translated to Layer 2 broadcasts out interface Fast Ethernet interface 0/1, configure the **ip directed-broadcast** command on Fast Ethernet interface 0/1. You can specify an access list to control which IP directed broadcasts are translated to Layer 2 broadcasts. When an access list is specified, only those IP packets permitted by the access list are eligible to be translated from directed broadcasts to Layer 2 broadcasts. For example, if you know that the only legitimate source IP address of any IP directed broadcasts in your network is 192.168.10.2, create an extended IP access list allowing traffic from 192.168.10.2 and assign the access list with the **ip directed-broadcast***access-list* command.

IP Directed Broadcasts

IP directed broadcasts are dropped by default. Dropping IP directed broadcasts reduces the risk of DoS attacks.

You can enable forwarding of IP directed broadcasts on an interface where the broadcast becomes a physical broadcast. You enable the translation of directed IP broadcast packets to Layer 2 broadcast frames on the interface that is connected to the IP network that the IP directed broadcast is addressed to. For example, if

you need to translate IP directed broadcasts with the IP destination address of 172.16.10.255 to Layer 2 broadcast frames, you enable the translation on the interface that is connected to IP network 172.16.10.0/24.

You can specify an access list to control which directed broadcasts are forwarded. When an access list is specified, only those IP packets permitted by the access list are eligible to be translated from directed broadcasts to physical broadcasts.

IP directed broadcasts are disabled by default in Cisco IOS Release 12.0 and newer releases.

IP Multicast Addresses

IP multicast addresses are intended to reach an arbitrary subset of the hosts on a local network. IP broadcast addresses create a problem because every host must receive and process the data in each packet to determine if it contains information that the host must process further. IP multicast addresses resolve this problem by using well-known IP addresses that a host must be configured to recognize before it will process packets addressed to it. When a host receives an IP multicast packet, the host compares the IP multicast address with the list of multicast addresses it is configured to recognize. If the host is not configured to recognize the IP multicast address, the host ignores the packet instead of processing it further to analyze the data in the packet. Because the host can ignore the packet it spends less time and fewer resources than it would have had to spend if the packet had been an IP broadcast that had to be processed all the way to the data layer before it was discarded.

The range of IP addresses reserved for Class D multicast addresses is 224.0.0.0 to 239.255.255.255/32 (255.255.255.255).

Most of the TCP/IP routing protocols use IP multicast addresses to send routing updates and other information to hosts on the same local network that are running the same routing protocol. Many other applications such as audio/video streaming over the Internet use IP multicast addresses. For a list of the currently assigned IP multicast addresses see Internet Multicast Addresses.

Information on configuring network devices for IP multicast support is available in the following documentation:

- *Cisco IOS IP Multicast Configuration Guide*
- *Cisco IOS IP Multicast Command Reference*

Early IP Implementations

Several early IP implementations do not use the current broadcast address standard of 255.255.255.255. Instead, they use the old standard, which calls for all zeros (000.000.000.000) instead of all ones to indicate broadcast addresses. Many of these implementations do not recognize an all-1s broadcast address and fail to respond to the broadcast correctly. Others forward all-1s broadcasts by default, which causes a serious network overload known as a *broadcast storm*. Implementations that exhibit these problems include systems based on versions of Berkeley Standard Distribution (BSD) UNIX prior to Version 4.3.

DHCP and IPv4 Broadcast Packets

DHCP requires that the client (host requiring information from the DHCP server) send broadcast packets to find a DHCP server to request configuration information from. If the DHCP server is not on the same network segment as the client that is sending the DHCP broadcasts, the router must be configured to forward the DHCP requests to the appropriate network.

For more information on DHCP, see RFC 2131 *Dynamic Host Configuration Protocol,* at http://www.ietf.org/rfc/rfc2131.txt.

UDP Broadcast Packet Forwarding

UDP broadcast packets are used by TCP/IP protocols such as DHCP and applications that need to send the same data to multiple hosts concurrently. Because routers by default do not forward broadcast packets you need to customize your router's configuration if your network has UDP broadcast traffic on it. One option for forwarding UDP broadcast packets is to use the UDP forwarding feature. UDP forwarding rewrites the broadcast IP address of a UDP packet to either a unicast (specific host) IP address or a directed IP broadcast. After the address is rewritten the UDP packet is forwarded by all of the routers in the path to the destination network without requiring additional configuration changes on the other routers.

You can enable forwarding of UDP broadcast packets, such as DHCP requests, to a host, or to multiple hosts on the same target network. When a UDP broadcast packet is forwarded, the destination IP address is rewritten to match the address that you configure. For example, the **ip helper-address 172.16.10.2** command rewrites the IP destination address from 255.255.255.255 to 172.16.10.2.

To enable UDP broadcast packet forwarding to specific host, use a specific host IP address as the helper address when you configure the **ip helper-address** *address* command. To enable UDP broadcast packet forwarding to a range of hosts to allow for load sharing and redundancy, use an IP directed broadcast address as the helper address when you configure the **ip helper-address** *address* command.

UDP Broadcast Packet Flooding

You can allow IP broadcasts to be flooded throughout your network in a controlled fashion using the database created by theLayer 2 bridging Spanning Tree Protocol (STP). Enabling this feature also prevents flooding loops. In order to support this capability, the Cisco IOS software on your router must include support for transparent bridging, and transparent bridging must be configured on each interface that is to participate in the flooding. If bridging is not configured on an interface, the interface is still able to receive broadcasts. However, the interface will never forward broadcasts it receives, and the router will never use that interface to send broadcasts received on a different interface.

Packets that are forwarded to a single network address using the IP helper address mechanism can be flooded. Only one copy of the packet is sent on each network segment.

In order to be considered for flooding, packets must meet the following criteria. (These are the same conditions used to consider packet forwarding using IP helper addresses.)

- The packet must be a MAC-level broadcast (FFFF.FFFF.FFFF).
- The packet must be an IP-level broadcast (255.255.255.255).
- The packet must be a Trivial File Transfer Protocol (TFTP), Domain Name System (DNS), Time, NetBIOS, Neighbor Discovery (ND), or BOOTP packet, or a UDP protocol specified by the **ip forward-protocol udp** global configuration command.
- The time-to-live (TTL) value of the packet must be at least two.

If you want to send the flooded UDP packets to a specific host, you can change the Layer 3 IP broadcast address of the flooded UDP packets with the **ip broadcast-address** command in interface configuration mode. The address of the flooded UDP packets can be set to any desired IP address. The source address of the flooded UDP packet is never changed. The TTL value of the flooded UDP packet is decremented.

After a decision has been made to send the datagram out on an interface (and the destination IP address possibly changed), the datagram is handed to the normal IP output routines and is, therefore, subject to access lists if they are present on the output interface.

If no actual bridging is desired, you can configure a type-code bridging filter that will deny all packet types from being bridged. Refer to the "Configuring Transparent Bridging" module of the *Cisco IOS Bridging and IBM Networking Configuration Guide* for more information about using access lists to filter bridged traffic. The Spanning-Tree database is still available to the IP forwarding code to use for the flooding.

IP Broadcast Flooding Acceleration

You can accelerate flooding of UDP datagrams using the spanning-tree algorithm. Used in conjunction with the **ip forward-protocol spanning-tree** command in global configuration mode, this feature boosts the performance of spanning-tree-based UDP flooding by a factor of about four to five times. The feature, called *turbo flooding*, is supported over Ethernet interfaces configured for Advanced Research Projects Agency (ARPA) encapsulated, FDDI, and high-level data link control (HDLC)-encapsulated serial interfaces. However, it is not supported on Token Ring interfaces. As long as the Token Rings and the non-HDLC serial interfaces are not part of the bridge group being used for UDP flooding, turbo flooding will behave normally.

Default UDP Port Numbers

If a helper address is specified and UDP forwarding is enabled, broadcast packets destined to the following port numbers are forwarded by default:

- Time service (port 37)
- IEN-116 Name Service (port 42)
- TACACS service (port 49)
- Domain Naming System (port 53)
- BOOTP client and server packets (ports 67 and 68)
- TFTP (port 69)
- NetBIOS Name Server (port 137)
- NetBIOS Datagram Server (port 138)

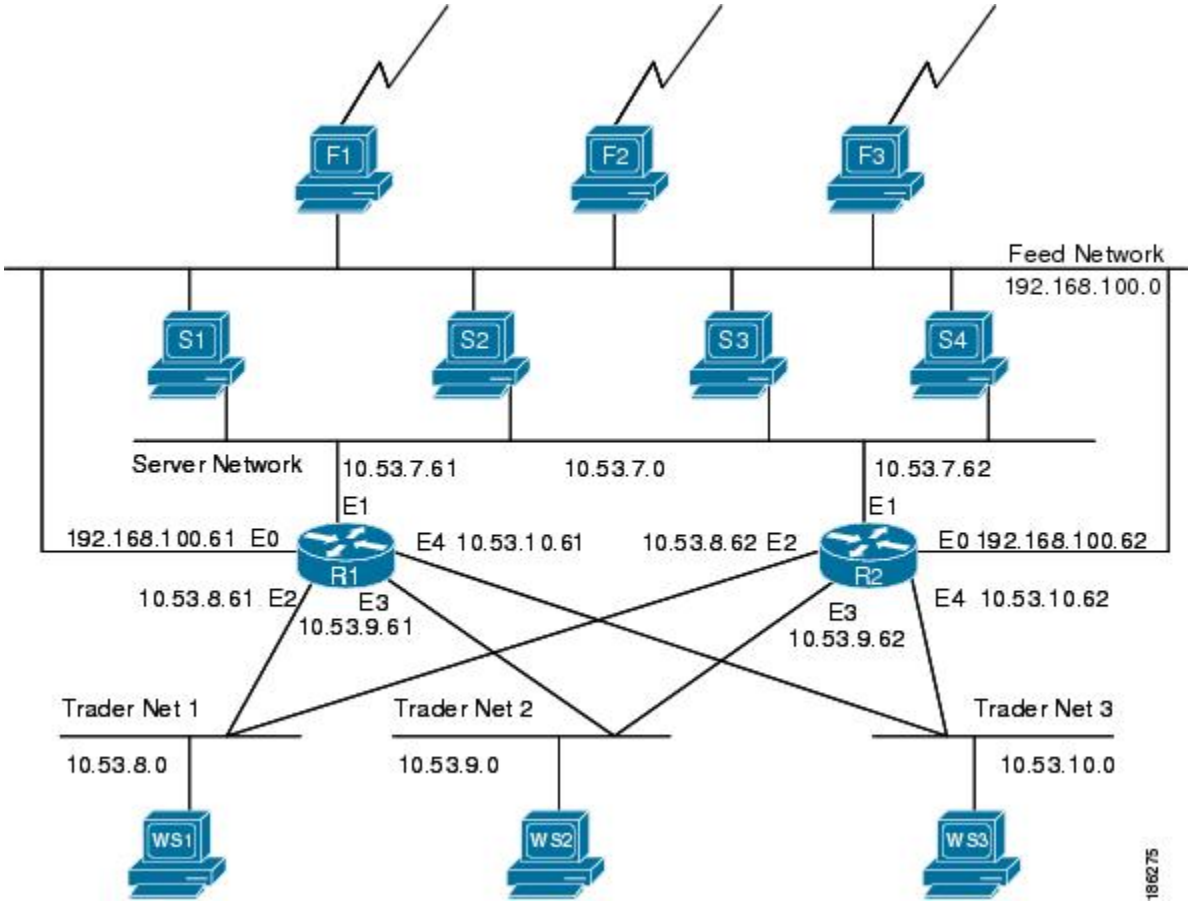
Default IP Broadcast Address

The Cisco IOS software supports sending IP broadcasts on both LANs and WANs. There are several ways to indicate an IP broadcast address. The default is an address consisting of all ones (255.255.255.255), although the software can be configured to generate any form of IP broadcast address such as all zeros (0.0.0.0), and directed broadcasts such as 172.16.255.255. Cisco IOS software can receive and process most IP broadcast addresses.

UDP Broadcast Packet Case Study

This case study is from a trading floor application in a financial company. The workstations (WS1, WS2, and WS3) in the following figure receive financial data from the feed network. The financial data is sent using UDP broadcasts.

Figure 2: Topology that Requires UDP Broadcast Forwarding



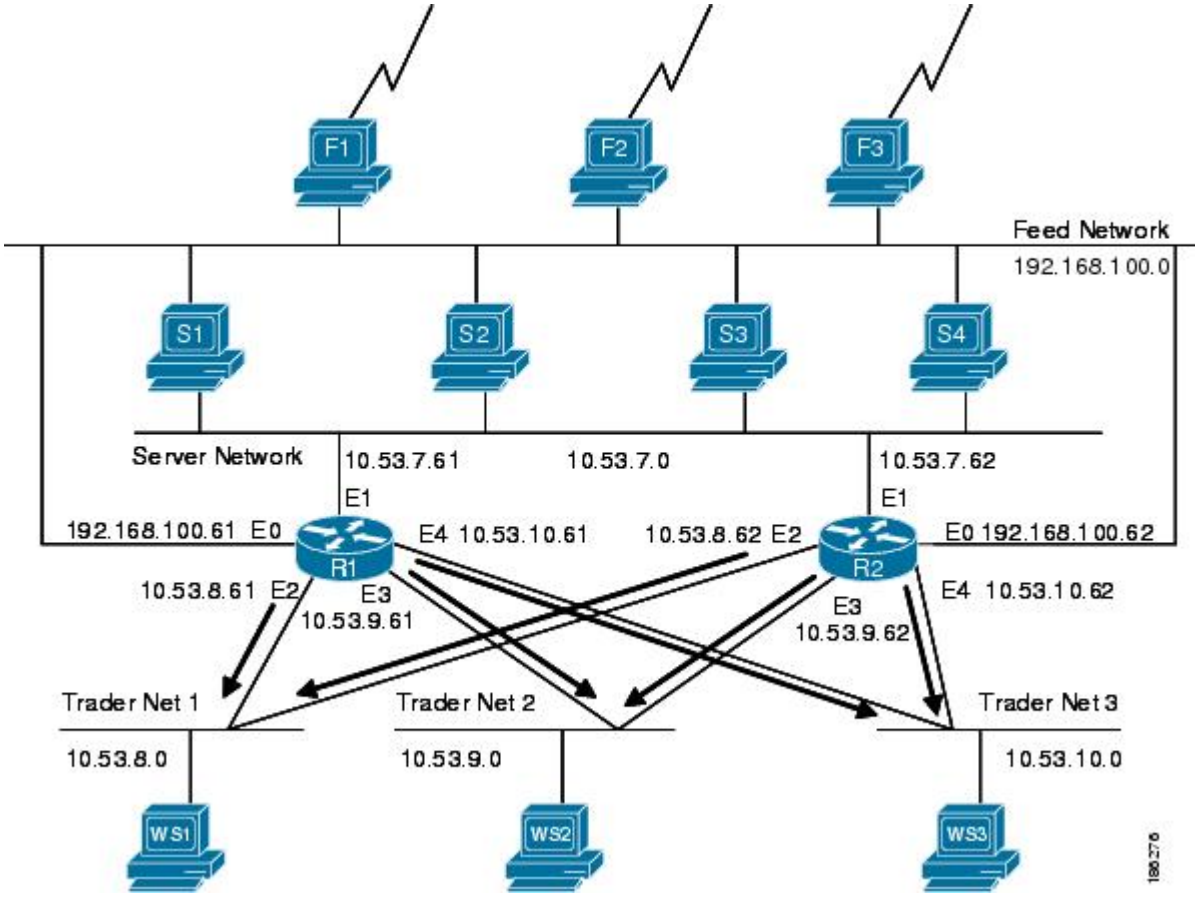
The following sections explain the possible solutions for this application:

UDP Broadcast Packet Forwarding

The first option is UDP broadcast packet using helper addresses. To configure helper addressing, you must specify the **ip helper-address** command on every interface on every router that receives a UDP broadcast that needs to be forwarded. On router 1 and router 2 in the figure below, IP helper addresses can be configured to move data from the server network to the trader networks. However IP helper addressing was determined

not to be an optimal solution for this type of topology because each router receives unnecessary broadcasts from the other router, as shown in the figure below.

Figure 3: Flow of UDP Packets



In this case, router 1 receives each broadcast sent by router 2 three times, one for each segment, and router 2 receives each broadcast sent by router 1 three times, one for each segment. When each broadcast is received, the router must analyze it and determine that the broadcast does not need to be forwarded. As more segments are added to the network, the routers become overloaded with unnecessary traffic, which must be analyzed and discarded.

When IP helper addressing is used in this type of topology, no more than one router can be configured to forward UDP broadcasts (unless the receiving applications can handle duplicate broadcasts). This is because duplicate packets arrive on the trader network. This restriction limits redundancy in the design and can be undesirable in some implementations.

To configure routers to send UDP broadcasts bidirectionally in this type of topology, a second **ip helper address** command must be applied to every router interface that receives UDP broadcasts. As more segments and devices are added to the network, more **ip helper address** commands are required to reach them, so the administration of these routers becomes more complex over time.

Note Bidirectional traffic in this topology significantly impacts router performance.

Although IP helper addressing is well-suited to nonredundant, nonparallel topologies that do not require a mechanism for controlling broadcast loops, IP helper addressing does not work well in this topology. To improve performance, the network designers considered four other alternatives:

- Setting the broadcast address on the servers to all ones (255.255.255.255)—This alternative was dismissed because the servers have more than one interface, causing server broadcasts to be sent back onto the feed network. In addition, some workstation implementations do not allow all 1s broadcasts when multiple interfaces are present.
- Setting the broadcast address of the servers to the major network broadcast IP address--This alternative was dismissed because the TCP/IP implementation on the servers does not allow the use of major network IP broadcast addresses when the network is subnetted.
- Eliminating the subnets and letting the workstations use Address Resolution Protocol (ARP) to learn addresses—This alternative was dismissed because the servers cannot quickly learn an alternative route in the event of a primary router failure.
- UDP broadcast packet flooding—This alternative uses the spanning-tree topology created with transparent bridging to forward UDP broadcast packets in a redundant topology while avoiding loops and duplicate broadcast traffic.

UDP Broadcast Packet Flooding

UDP flooding uses the spanning-tree algorithm to forward packets in a controlled manner. Bridging is enabled on each router interface for the sole purpose of building the spanning tree. The spanning tree prevents loops by stopping a broadcast from being forwarded out an interface on which the broadcast was received. The spanning tree also prevents packet duplication by placing certain interfaces in the blocked state (so that no packets are forwarded) and other interfaces in the forwarding state (so that packets that need to be forwarded are forwarded).

Before you can enable UDP flooding, the router must be running software that supports transparent bridging and bridging must be configured on each interface that is to participate in the flooding. If bridging is not configured for an interface, the interface will receive broadcasts, but the router will not forward those broadcasts and will not use that interface as a destination for sending broadcasts received on a different interface.

When configured for UDP flooding, the router uses the destination address specified by the **ip broadcast-address** command on the output interface to assign a destination address to a flooded UDP datagram. Thus, the destination address might change as the datagram propagates through the network. The source address, however, does not change.

With UDP flooding, both routers shown in the figure below use a spanning-tree to control the network topology for the purpose of forwarding broadcasts. The **bridge protocol** command can specify either the **dec** keyword (for the Digital Equipment Corporation (DEC) spanning-tree protocol) or the **ieee** keyword (for the IEEE Ethernet protocol). All routers in the network must enable the same spanning-tree protocol. The **ip forward-protocol spanning-tree** command uses the database created by the **bridge protocol** command. Only one broadcast packet arrives at each segment, and UDP broadcasts can traverse the network in both directions.

Because bridging is enabled only to build the spanning-tree database, use access lists to prevent the spanning-tree from forwarding non-UDP traffic.

The router configuration specifies a path cost for each interface to determine which interface forwards or blocks packets. The default path cost for Ethernet is 100. Setting the path cost for each interface on router 2 to 50 causes the spanning-tree algorithm to place the interfaces in router 2 in forwarding state. Given the higher path cost (100) for the interfaces in router 1, the interfaces in router 1 are in the blocked state and do not forward the broadcasts. With these interface states, broadcast traffic flows through router 2. If router 2 fails, the spanning-tree algorithm will place the interfaces in router 1 in the forwarding state, and router 1 will forward broadcast traffic.

With one router forwarding broadcast traffic from the server network to the trader networks, you should configure the other router to forward unicast traffic. For that reason, each router enables the ICMP Router Discovery Protocol (IRDP), and each workstation on the trader networks runs the IRDP daemon. On router 1, the **preference** keyword of the **ip irdp** command sets a higher IRDP preference than does the configuration for router 2, which causes each IRDP daemon to use router 1 as its preferred default gateway for unicast traffic forwarding. Users of those workstations can use the **netstat -rn** command to see how the routers are being used.

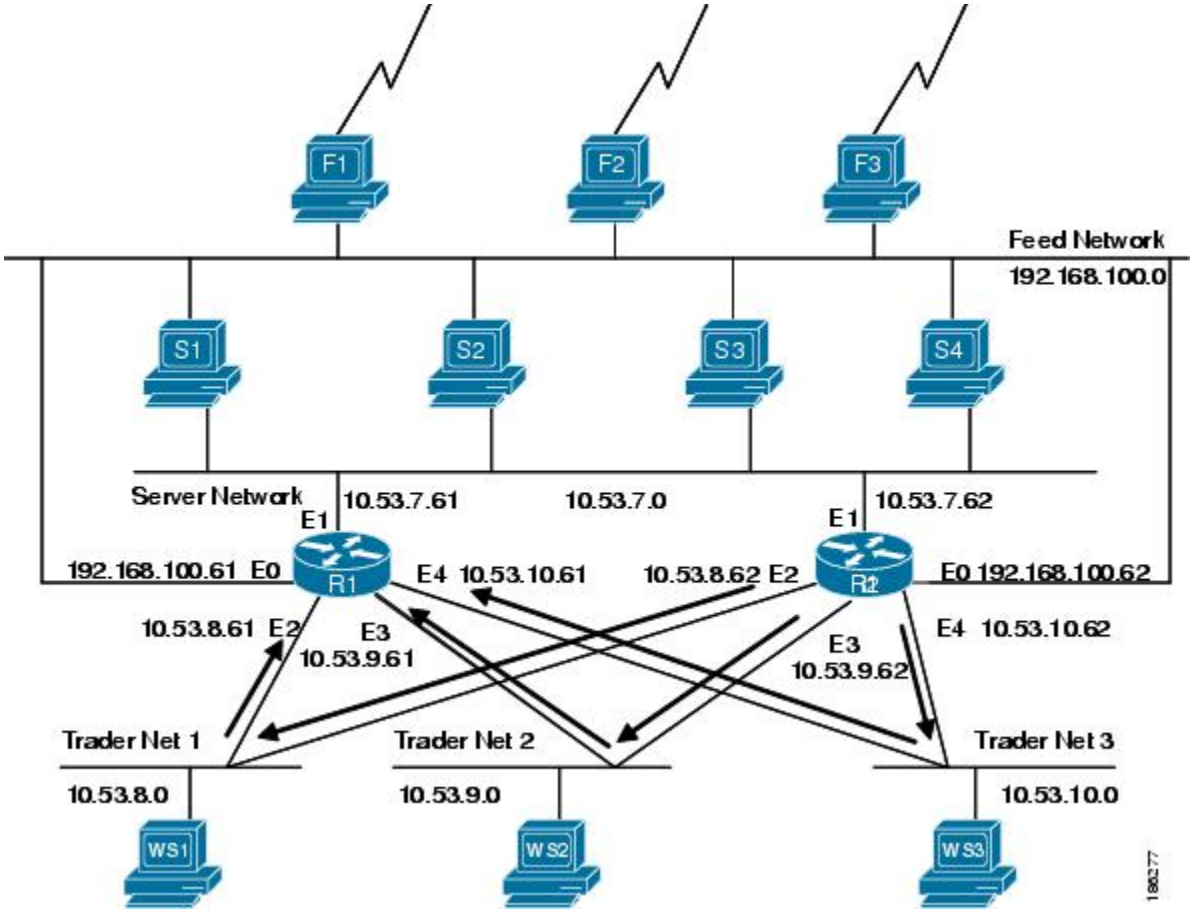
On the routers, the **holdtime**, **maxadvertinterval**, and **minadvertinterval** keywords of the **ip irdp** command reduce the advertising interval from the default so that the IRDP daemons running on the hosts expect to see advertisements more frequently. With the advertising interval reduced, the workstations will adopt router 2 more quickly if router 1 becomes unavailable. With this configuration, when a router becomes unavailable, IRDP offers a convergence time of less than one minute.

IRDP is preferred over the Routing Information Protocol (RIP) and default gateways for the following reasons:

- RIP takes longer to converge.
- Configuration of router 1 as the default gateway on each Sun workstation on the trader networks would allow those Sun workstations to send unicast traffic to router 1, but would not provide an alternative route if router 1 becomes unavailable.

The figure below shows how data flows when the network is configured for UDP flooding.

Figure 4: Data Flow with UDP Flooding and IRDP



Note This topology is broadcast intensive--broadcasts sometimes consume 20 percent of the 10-MB Ethernet bandwidth. However, this is a favorable percentage when compared to the configuration of IP helper addressing, which, in the same network, causes broadcasts to consume up to 50 percent of the 10-MB Ethernet bandwidth.

If the hosts on the trader networks do not support IRDP, Hot Standby Routing Protocol (HSRP), Virtual Router Redundancy Protocol (VRRP), or Gateway Load Balancing Protocol (GLBP) can be used to select which router will handle unicast traffic. These protocols allow the standby router to take over quickly if the primary router becomes unavailable.

Enable turbo flooding on the routers to increase the performance of UDP flooding.

Note Turbo flooding increases the amount of processing that is done at interrupt level, which increases the CPU load on the router. Turbo flooding may not be appropriate on routers that are already under high CPU load or that must also perform other CPU-intensive activities.

How to Configure IP Broadcast Packet Handling

Enabling IP Directed Broadcasts Without an Access List

Perform this task to permit the forwarding of IP directed broadcasts from any source.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **ip address** *address mask*
5. **ip directed-broadcast**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface fastethernet 0/1`	Specifies an interface and enters interface configuration mode.

	Command or Action	Purpose
Step 4	**ip address** *address mask* **Example:** `Router(config-if)# ip address 172.16.10.1 255.255.255.0`	Assigns an IP address to the interface.
Step 5	**ip directed-broadcast** **Example:** `Router(config-if)# ip directed-broadcast`	Enables IP directed broadcasts on the interface. • Configure this command on the interface that is connected to the IP network address of the directed broadcast packets. • In this example the directed broadcast packets are addressed to 172.16.10.255.
Step 6	**end** **Example:** `Router(config-if)# end`	Exits the current configuration mode and returns to privileged EXEC mode.

Enabling IP Directed Broadcasts with an Access List

Perform this task to limit the forwarding of IP directed broadcasts by applying an access list to the **ip directed-broadcast** command.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **access-list** *100-199* **permit ip** *source-address mask destination-address mask*
4. **interface** *type number*
5. **ip address** *address mask*
6. **ip directed-broadcast** *access-list*
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Router> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**access-list** *100-199* **permit ip** *source-address mask destination-address mask* **Example:** `Router(config)# access-list 100 permit ip 10.4.9.167 0.0.0.0 172.16.10.0 0.0.0.255`	Creates an access list to limit the IP directed broadcasts that are forwarded. • In this example the IP directed broadcasts are sent by the host with the IP address of 10.4.9.167 to the IP directed broadcast address 172.16.10.255.
Step 4	**interface** *type number* **Example:** `Router(config)# interface fastethernet 0/0`	Specifies an interface and enters interface configuration mode.
Step 5	**ip address** *address mask* **Example:** `Router(config-if)# ip address 172.16.10.1 255.255.255.0`	Assigns an IP address to the interface.
Step 6	**ip directed-broadcast** *access-list* **Example:** `Router(config-if)# ip directed-broadcast 100`	Enables IP directed broadcasts on the interface for broadcast packets that are allowed by the access list you assigned. Configure this command on the interface that is connected to the IP network address of the directed broadcast packets. • In this example the directed broadcast packets are addressed to 172.16.10.255.
Step 7	**end** **Example:** `Router(config-if)# end`	Exits the current configuration mode and returns to privileged EXEC mode.

Enabling Forwarding of UDP Broadcast Packets to a Specific Host

Perform this task to enable UDP broadcast packet forwarding to a single host.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip forward-protocol udp**
4. **interface** *type number*
5. **ip address** *address mask*
6. **ip helper-address** *address*
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip forward-protocol udp** **Example:** `Router(config)# ip forward-protocol udp`	Enables forwarding of UDP broadcast packets.
Step 4	**interface** *type number* **Example:** `Router(config)# interface fastethernet 0/1`	Specifies an interface and enters interface configuration mode.
Step 5	**ip address** *address mask* **Example:** `Router(config-if)# ip address 172.16.10.1 255.255.255.0`	Assigns an IP address to the interface.

	Command or Action	Purpose
Step 6	**ip helper-address** *address* **Example:** `Router(config-if)# ip helper-address 172.16.10.2`	Enables an IP helper address for the interface that is receiving the UDP broadcast packets. • In this example the IP destination address of the IP UDP broadcast packets is rewritten to 172.16.10.2.
Step 7	**end** **Example:** `Router(config-if)# end`	Exits the current configuration mode and returns to privileged EXEC mode.

Enabling Forwarding of UDP Broadcast Packets to a Range of Hosts

Perform this task to enable UDP broadcast packet forwarding to a range of hosts to allow for load sharing between the destination hosts and to provide redundancy if one or more of the destination hosts fail.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip forward-protocol udp**
4. **interface** *type number*
5. **ip address** *address mask*
6. **ip helper-address** *address*
7. **exit**
8. **interface** *type number*
9. **ip address** *address mask*
10. **ip directed-broadcast**
11. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip forward-protocol udp** **Example:** `Router(config)# ip forward-protocol udp`	Enables forwarding of UDP broadcast packets.
Step 4	**interface** *type number* **Example:** `Router(config)# interface fastethernet 0/0`	Specifies an interface and enters interface configuration mode.
Step 5	**ip address** *address mask* **Example:** `Router(config-if)# ip address 192.168.10.1 255.255.255.0`	Assigns an IP address to the interface.
Step 6	**ip helper-address** *address* **Example:** `Router(config-if)# ip helper-address 172.16.10.255`	Enables an IP helper address for the interface that is receiving the UDP broadcast packets. • In this example an IP directed broadcast address is used. The IP destination address of the IP UDP broadcast packets is rewritten to 172.16.10.255. • All of the hosts on the 172.16.10.0/24 network that support the application or service that the UDP broadcast packets are intended for will respond to the UDP broadcast packets. **Note** This often results in the source of the UDP broadcast packets receiving responses from two or more hosts. In most circumstances the source of the UDP broadcast packets accepts the first response and ignores any subsequent responses. In some situations the source of the UDP broadcast packets cannot handle duplicate responses and reacts by reloading, or other unexpected behavior.
Step 7	**exit** **Example:** `Router(config-if)# exit`	Returns to global configuration mode.

	Command or Action	Purpose
Step 8	**interface** *type number* **Example:** `Router(config)# interface fastethernet 0/1`	Specifies an interface and enters interface configuration mode.
Step 9	**ip address** *address mask* **Example:** `Router(config-if)# ip address 172.16.10.1 255.255.255.0`	Assigns an IP address to the interface.
Step 10	**ip directed-broadcast** **Example:** `Router(config-if)# ip directed-broadcast`	Enables IP directed broadcasts on the interface that is transmitting the UDP broadcasts.
Step 11	**end** **Example:** `Router(config-if)# end`	Exits the current configuration mode and returns to privileged EXEC mode.

Changing the Default IP Broadcast Address for All Interfaces to 0.0.0.0 on Routers Without Nonvolatile Memory

If you router does not have NVRAM, and you need to change the IP broadcast address to 0.0.0.0, you must change the IP broadcast address manually by setting jumpers in the processor configuration register. Setting bit 10 causes the device to use all 0s. Bit 10 interacts with bit 14, which controls the network and host portions of the broadcast address. Setting bit 14 causes the device to include the network and host portions of its address in the broadcast address. The table below shows the combined effect of setting bits 10 and 14.

Table 5: Configuration Register Settings for Broadcast Address Destination

Bit 14	Bit 10	Address (<net><host>)
Out	Out	<ones><ones>
Out	In	<zeros><zeros>
In	In	<net><zeros>
In	Out	<net><ones>

For additional information on setting the hardware jumpers on your router, see the hardware documentation that was supplied with you router.

Changing the Default IP Broadcast Address for All Interfaces to 0.0.0.0 on Routers with Nonvolatile Memory

Cisco IOS-based routers with NVRAM have software configuration registers that allow you to modify several behaviors of the router such as where it looks for images to load, what IP broadcast address it uses, and the console line speed. The factory default value for the configuration register is 0x2102 where *0X* indicates this a hexadecimal number. The **config-register** command is used to modify the settings of the software configuration registers.

Information on configuring other behaviors with the software configuration registers using the **config-register** command is available in the following documentation:

- "Loading and Managing System Images" chapter of the *Cisco IOS Configuration Fundamentals Configuration Guide*
- *Cisco IOS Configuration Fundamentals Command Reference*

Caution You need to be very careful when you change the software configuration registers on your router because if you inadvertently alter the console port line speed, you will not be able to configure the router with a terminal server on the console port unless you know the speed that you set for the console port, and you know how to change the line speed for your terminal application. If your router is configured for alternate access to the CLI such as using Telnet or a web browser, you can use this method to log in to the router and change the software configuration register back to 0x2102.

Perform this task to set the IP broadcast address on every interface to 0.0.0.0 while maintaining the remainder of the default values for the software configuration register settings.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **config-register** *value*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**config-register** *value* **Example:** `Router(config)# config-register 0x2502`	Sets the IP broadcast address to 0.0.0.0 on every interface while maintaining the remainder of the default values for the other software configuration register settings.
Step 4	**end** **Example:** `Router(config)# end`	Exits the current configuration mode and returns to privileged EXEC mode.

Changing the IP Broadcast Address to Any IP Address on One or More Interfaces in a Router

Perform this task if you network requires an IP broadcast address other than 255.255.255.255 or 0.0.0.0, or you want to change the IP broadcast address to 0.0.0.0 on a subset of the interfaces on the router instead of on all of the interfaces on the router.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **ip address** *address mask*
5. **ip broadcast-address** *address*
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface fastethernet 0/1`	Specifies an interface and enters interface configuration mode.
Step 4	**ip address** *address mask* **Example:** `Router(config-if)# ip address 172.16.10.1 255.255.255.0`	Assigns an IP address to the interface.
Step 5	**ip broadcast-address** *address* **Example:** `Router(config-if)# ip broadcast-address 172.16.10.255`	Specifies the IP broadcast address • In this example IP broadcasts are sent to 172.16.10.255.
Step 6	**end** **Example:** `Router(config-if)# end`	Exits the current configuration mode and returns to privileged EXEC mode.

Configuring UDP Broadcast Packet Flooding

Before You Begin

The version of Cisco IOS software on your router must support transparent bridging.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **bridge** *number* **protocol ieee**
4. **ip forward-protocol spanning-tree**
5. **ip forward-protocol turbo-flood**
6. **ip forward-protocol udp**
7. **interface** *type number*
8. **ip address** *address mask*
9. **bridge-group** *number*
10. **interface** *type number*
11. **ip address** *address mask*
12. **bridge-group** *number*
13. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**bridge** *number* **protocol ieee** **Example:** `Router(config)# bridge 1 protocol ieee`	Enables spanning-tree bridging and specifies the bridging protocol.
Step 4	**ip forward-protocol spanning-tree** **Example:** `Router(config)# ip forward-protocol spanning-tree`	Enables using the spanning-tree forwarding table to flood broadcast packets.
Step 5	**ip forward-protocol turbo-flood** **Example:** `Router(config)# ip forward-protocol turbo-flood`	(Optional) Enables fast forwarding of broadcast packets using the spanning-tree forwarding table.

	Command or Action	Purpose
Step 6	**ip forward-protocol udp** **Example:** `Router(config)# ip forward-protocol udp`	Enables forwarding of UDP broadcasts.
Step 7	**interface** *type number* **Example:** `Router(config)# interface fastethernet 0/0`	Specifies an interface and enters interface configuration mode.
Step 8	**ip address** *address mask* **Example:** `Router(config-if)# ip address 192.168.10.1 255.255.255.0`	Assigns an IP address to the interface.
Step 9	**bridge-group** *number* **Example:** `Router(config-if)# bridge-group 1`	Places the interface in the spanning-tree bridge group specified.
Step 10	**interface** *type number* **Example:** `Router(config-if)# interface fastethernet 0/1`	Specifies an interface and enters interface configuration mode.
Step 11	**ip address** *address mask* **Example:** `Router(config-if)# ip address 172.16.10.1 255.255.255.0`	Assigns an IP address to the interface.
Step 12	**bridge-group** *number* **Example:** `Router(config-if)# bridge-group 1`	Places the interface in the spanning-tree bridge group specified.
Step 13	**end** **Example:** `Router(config-if)# end`	Exits the current configuration mode and returns to privileged EXEC mode.

Configuration Examples for IP Broadcast Packet Handling

Example: Enabling IP Directed Broadcasts with an Access List

The following example shows how to enable IP directed broadcasts with an access list to control the directed broadcasts that are forwarded.

```
Router(config)# access-list 100 permit ip 10.4.9.167 0.0.0.0 172.16.10.0 0.0.0.255
Router(config)# interface fastethernet 0/0
Router(config-if)# ip address 172.16.10.1 255.255.255.0
Router(config-if)# ip directed-broadcast 100
```

Example: Configuring UDP Broadcast Packet Flooding

```
Router(config)# bridge 1 protocol ieee
Router(config)# ip forward-protocol spanning-tree
Router(config)# ip forward-protocol turbo-flood
Router(config)# ip forward-protocol udp
Router(config)# interface fastethernet 0/0
Router(config-if)# ip address 192.168.10.1 255.255.255.0
Router(config-if)# bridge-group 1
Router(config)# interface fastethernet 0/1
Router(config-if)# ip address 172.16.10.1 255.255.255.0
Router(config-if)# bridge-group 1
```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases
Currently assigned IP multicast addresses	*Internet Multicast Addresses* http://www.iana.org/assignments/multicast-addresses
Configuration fundamentals configuration tasks	*Cisco IOS Configuration Fundamentals Configuration Guide*
Configuration fundamentals commands	*Cisco IOS Configuration Fundamentals Command Reference*
Cisco IOS bridging and IBM networking configuration tasks	*Cisco IOS Bridging and IBM Networking Configuration Guide*
Cisco IOS bridging and IBM networking commands	*Cisco IOS Bridging and IBM Networking Command Reference*

Related Topic	Document Title
Cisco IOS IP multicast configuration tasks	*Cisco IOS IP Multicast Configuration Guide*
Cisco IOS IP Multicast commands	*Cisco IOS IP Multicast Command Reference*

Standards

Standard	Title
IEEE Spanning-Tree Bridging	802.1D MAC Bridges http://www.ieee802.org/1/pages/802.1D-2003.html

MIBs

MIB	MIBs Link
—	No new or modified MIBs are supported, and support for existing MIBs has not been modified.

RFCs

RFC	Title
RFC 1812	*Requirements for IP Version 4 Routers* http://www.ietf.org/rfc/rfc1812.txt
RFC 2131	*Dynamic Host Configuration Protocol* http://www.ietf.org/rfc/rfc2131.txt .

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

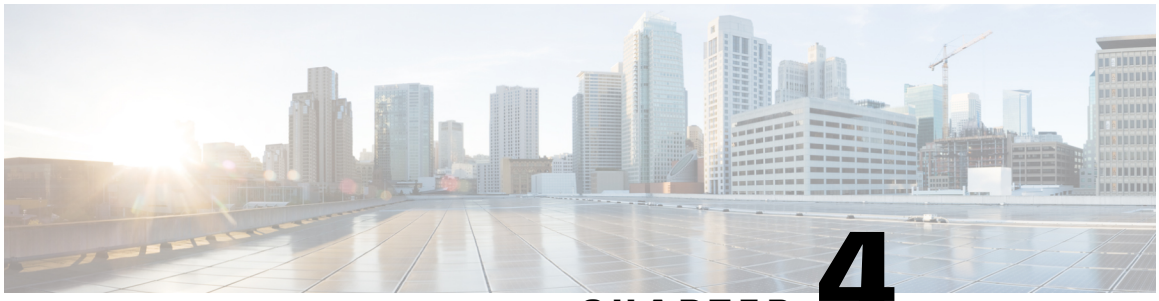
Feature Information for IP Broadcast Packet Handling

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

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

Table 6: Feature Information for IP Broadcast Packet Handling

Feature Name	Releases	Feature Information
Flooding Packets Using spanning-tree	15.0(1)SY	Enables the forwarding of UDP broadcast packets using the spanning-tree forwarding table. The following commands were introduced or modified by this feature: **ip forward-protocol spanning-tree**, **ip forward-protocol turbo-flood**.
IP Directed Broadcasts	15.0(1)SY	Enables the translation of a directed broadcast to physical broadcasts. The following command was introduced or modified by this feature: **ip directed-broadcast**.
Specifying an IP Broadcast Address	15.0(1)SY	Specifies the IP broadcast address for an interface. The following command was introduced or modified by this feature: **ip broadcast-address**.
UDP Broadcast Packet Forwarding	15.0(1)SY	Enables the forwarding of UDP broadcast packets. The following commands were introduced or modified by this feature: **ip forward-protocol**, **ip helper-address**.



CHAPTER 4

Configuring TCP

TCP is a protocol that specifies the format of data and acknowledgments used in data transfer. TCP is a connection-oriented protocol because participants must establish a connection before data can be transferred. By performing flow control and error correction, TCP guarantees reliable, in-sequence delivery of packets. TCP is considered a reliable protocol because it will continue to request an IP packet that is dropped or received out of order until it is received. This module explains concepts related to TCP and how to configure TCP in a network.

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 www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for TCP

TCP Time Stamp, TCP Selective Acknowledgment, and TCP Header Compression

Because TCP time stamps are always sent and echoed in both directions and the time-stamp value in the header is always changing, TCP header compression will not compress the outgoing packet. To allow TCP header compression over a serial link, the TCP time-stamp option is disabled. If you want to use TCP header compression over a serial line, TCP time stamp and TCP selective acknowledgment must be disabled. Both features are disabled by default. Use the **no ip tcp selective-ack** command to disable the TCP selective acknowledgment once it is enabled.

Restrictions for TCP

The TCP Keepalive timer parameters can be configured only on vty and TTY applications.

Information About TCP

TCP Services

TCP provides reliable transmission of data in an IP environment. TCP corresponds to the transport layer (Layer 4) of the Open Systems Interconnection (OSI) reference model. Among the services that TCP provides are stream data transfer, reliability, efficient flow control, full-duplex operation, and multiplexing.

With stream data transfer, TCP delivers an unstructured stream of bytes that are identified by sequence numbers. This service benefits applications because they do not have to divide data into blocks before handing it off to TCP. Instead, TCP groups bytes into segments and passes them to IP for delivery.

TCP offers reliability by providing connection-oriented, end-to-end reliable packet delivery through an internetwork. It does this by sequencing bytes with a forwarding acknowledgment number that indicates to the destination the next byte that the source expects to receive. Bytes that are not acknowledged within a specified time period are retransmitted. The reliability mechanism of TCP allows devices to handle lost, delayed, duplicate, or misread packets. A timeout mechanism allows devices to detect lost packets and request retransmission.

TCP offers efficient flow control, which means that the receiving TCP process indicates the highest sequence number that it can receive without overflowing its internal buffers when sending acknowledgments back to the source.

TCP offers full-duplex operation, and TCP processes can both send and receive data at the same time.

TCP multiplexing allows numerous simultaneous upper-layer conversations to be multiplexed over a single connection.

TCP Connection Establishment

To use reliable transport services, TCP hosts must establish a connection-oriented session with one another. Connection establishment is performed by using a “three-way handshake” mechanism.

A three-way handshake synchronizes both ends of a connection by allowing both sides to agree upon the initial sequence numbers. This mechanism guarantees that both sides are ready to transmit data. The three-way handshake is necessary so that packets are not transmitted or retransmitted during session establishment or after session termination.

Each host randomly chooses a sequence number, which is used to track bytes within the stream that the host is sending. The three-way handshake proceeds in the following manner:

- The first host (Host A) initiates a connection by sending a packet with the initial sequence number (X) and the synchronize/start (SYN) bit set to indicate a connection request.
- The second host (Host B) receives the SYN, records the sequence number X, and replies by acknowledging (ACK) the SYN (with an ACK = X + 1). Host B includes its own initial sequence number (SEQ = Y). An ACK = 20 means that the host has received bytes 0 through 19 and expects byte 20 next. This technique is called forward acknowledgment.
- Host A acknowledges all bytes that Host B has sent with a forward acknowledgment indicating the next byte Host A expects to receive (ACK = Y + 1). Data transfer can then begin.

TCP Connection Attempt Time

You can set the amount of time the software will wait before attempting to establish a TCP connection. The connection attempt time is a host parameter and pertains to traffic that originated at the device and not to traffic going through the device. To set the TCP connection attempt time, use the **ip tcp synwait-time** command in global configuration mode. The default is 30 seconds.

TCP Selective Acknowledgment

The TCP Selective Acknowledgment feature improves performance if multiple packets are lost from one TCP window of data.

Prior to this feature, because of limited information available from cumulative acknowledgments, a TCP sender could learn about only one lost packet per-round-trip time. An aggressive sender could choose to resend packets early, but such re-sent segments might have already been successfully received.

The TCP selective acknowledgment mechanism helps improve performance. The receiving TCP host returns selective acknowledgment packets to the sender, informing the sender of data that has been received. In other words, the receiver can acknowledge packets received out of order. The sender can then resend only missing data segments (instead of everything since the first missing packet).

Prior to selective acknowledgment, if TCP lost packets 4 and 7 out of an 8-packet window, TCP would receive acknowledgment of only packets 1, 2, and 3. Packets 4 through 8 would need to be re-sent. With selective acknowledgment, TCP receives acknowledgment of packets 1, 2, 3, 5, 6, and 8. Only packets 4 and 7 must be re-sent.

TCP selective acknowledgment is used only when multiple packets are dropped within one TCP window. There is no performance impact when the feature is enabled but not used. Use the **ip tcp selective-ack** command in global configuration mode to enable TCP selective acknowledgment.

Refer to RFC 2018 for more details about TCP selective acknowledgment.

TCP Time Stamp

The TCP time-stamp option provides improved TCP round-trip time measurements. Because the time stamps are always sent and echoed in both directions and the time-stamp value in the header is always changing, TCP header compression will not compress the outgoing packet. To allow TCP header compression over a serial link, the TCP time-stamp option is disabled. Use the **ip tcp timestamp** command to enable the TCP time-stamp option.

Refer to RFC 1323 for more details on TCP time stamps.

TCP Maximum Read Size

The maximum number of characters that TCP reads from the input queue for Telnet and relogin at one time is very large (the largest possible 32-bit positive number) by default. To change the TCP maximum read size value, use the **ip tcp chunk-size** command in global configuration mode.

Note We do not recommend that you change this value.

TCP Path MTU Discovery

Path MTU Discovery is a method for maximizing the use of the available bandwidth in the network between endpoints of a TCP connection, which is described in RFC 1191. IP Path MTU Discovery allows a host to dynamically discover and cope with differences in the maximum allowable maximum transmission unit (MTU) size of the various links along the path. Sometimes a device is unable to forward a datagram because it requires fragmentation (the packet is larger than the MTU that you set for the interface with the **interface** configuration command), but the "do not fragment" (DF) bit is set. The intermediate gateway sends a "Fragmentation needed and DF bit set" Internet Control Message Protocol (ICMP) message to the sending host, alerting the host to the problem. On receiving this message, the host reduces its assumed path MTU and consequently sends a smaller packet that will fit the smallest packet size of all links along the path.

By default, TCP Path MTU Discovery is disabled. Existing connections are not affected irrespective of whether this feature is enabled or disabled.

Customers using TCP connections to move bulk data between systems on distinct subnets would benefit most by enabling this feature. Customers using remote source-route bridging (RSRB) with TCP encapsulation, serial tunnel (STUN), X.25 Remote Switching (also known as XOT or X.25 over TCP), and some protocol translation configurations might also benefit from enabling this feature.

Use the **ip tcp path-mtu-discovery** global configuration command to enable Path MTU Discovery for connections initiated by the device when the device is acting as a host.

For more information about Path MTU Discovery, refer to the "Configuring IP Services" module of the *IP Application Services Configuration Guide*.

TCP Window Scaling

The TCP Window Scaling feature adds support for the Window Scaling option in RFC 1323,*TCP Extensions for High Performance*. A larger window size is recommended to improve TCP performance in network paths with large bandwidth-delay product characteristics that are called Long Fat Networks (LFNs). The TCP Window Scaling enhancement provides LFN support.

The window scaling extension expands the definition of the TCP window to 32 bits and then uses a scale factor to carry this 32-bit value in the 16-bit window field of the TCP header. The window size can increase to a scale factor of 14. Typical applications use a scale factor of 3 when deployed in LFNs.

The TCP Window Scaling feature complies with RFC 1323. The maximum window size was increased to 1,073,741,823 bytes. The larger scalable window size will allow TCP to perform better over LFNs. Use the **ip tcp window-size** command in global configuration mode to configure the TCP window size.

TCP Sliding Window

A TCP sliding window provides an efficient use of network bandwidth because it enables hosts to send multiple bytes or packets before waiting for an acknowledgment.

In TCP, the receiver specifies the current window size in every packet. Because TCP provides a byte-stream connection, window sizes are expressed in bytes. A window is the number of data bytes that the sender is allowed to send before waiting for an acknowledgment. Initial window sizes are indicated at connection setup, but might vary throughout the data transfer to provide flow control. A window size of zero means “Send no data.” The default TCP window size is 4128 bytes. We recommend that you keep the default value unless your device is sending large packets (greater than 536 bytes). Use the **ip tcp window-size** command to change the default window size.

In a TCP sliding-window operation, for example, the sender might have a sequence of bytes to send (numbered 1 to 10) to a receiver who has a window size of five. The sender then places a window around the first five bytes and transmits them together. The sender then waits for an acknowledgment.

The receiver responds with an ACK = 6, indicating that it has received bytes 1 to 5 and is expecting byte 6 next. In the same packet, the receiver indicates that its window size is 5. The sender then moves the sliding window five bytes to the right and transmits bytes 6 to 10. The receiver responds with an ACK = 11, indicating that it is expecting sequenced byte 11 next. In this packet, if the receiver indicates that its window size is 0, the sender cannot send any more bytes until the receiver sends another packet with a window size greater than 0.

TCP Outgoing Queue Size

The default TCP outgoing queue size per connection is five segments if the connection has a TTY associated with it (such as a Telnet connection). If no TTY connection is associated with a connection, the default queue size is 20 segments. Use the **ip tcp queuemax** command to change the five-segment default value.

TCP Congestion Avoidance

The TCP Congestion Avoidance feature enables the monitoring of acknowledgment packets to the TCP sender when multiple packets are lost in a single window of data. Previous to introduction of this feature, the sender would exit Fast-Recovery mode, wait for three or more duplicate acknowledgment packets before retransmitting

the next unacknowledged packet, or wait for the retransmission timer to start slowly. This delay could lead to performance issues.

Implementation of RFC 2581 and RFC 3782 addresses the modifications to the Fast-Recovery algorithm that incorporates a response to partial acknowledgments received during Fast Recovery, improving performance in situations where multiple packets are lost in a single window of data.

This feature is an enhancement to the existing Fast Recovery algorithm. No commands are used to enable or disable this feature.

The output of the **debug ip tcp transactions** command has been enhanced to monitor acknowledgment packets by showing the following conditions:

- TCP entering Fast Recovery mode.
- Duplicate acknowledgments being received during Fast Recovery mode.
- Partial acknowledgments being received.

TCP Explicit Congestion Notification

The TCP Explicit Congestion Notification (ECN) feature allows an intermediate router to notify end hosts of impending network congestion. It also provides enhanced support for TCP sessions associated with applications, such as Telnet, web browsing, and transfer of audio and video data that are sensitive to delay or packet loss. The benefit of this feature is the reduction of delay and packet loss in data transmissions. Use the **ip tcp ecn** command in global configuration mode to enable TCP ECN.

TCP MSS Adjustment

The TCP MSS Adjustment feature enables the configuration of the maximum segment size (MSS) for transient packets that traverse a device, specifically TCP segments with the SYN bit set. Use the **ip tcp adjust-mss** command in interface configuration mode to specify the MSS value on the intermediate device of the SYN packets to avoid truncation.

When a host (usually a PC) initiates a TCP session with a server, the host negotiates the IP segment size by using the MSS option field in the TCP SYN packet. The value of the MSS field is determined by the MTU configuration on the host. The default MSS value for a PC is 1500 bytes.

The PPP over Ethernet (PPPoE) standard supports a Maximum Transmission Unit (MTU) of only 1492 bytes. The disparity between the host and PPPoE MTU size can cause the device in between the host and the server to drop 1500-byte packets and terminate TCP sessions over the PPPoE network. Even if the path MTU (which detects the correct MTU across the path) is enabled on the host, sessions may be dropped because system administrators sometimes disable ICMP error messages that must be relayed from the host for path MTU to work.

The **ip tcp adjust-mss** command helps prevent TCP sessions from being dropped by adjusting the MSS value of the TCP SYN packets.

The **ip tcp adjust-mss** command is effective only for TCP connections passing through the device.

In most cases, the optimum value for the *max-segment-size* argument of the **ip tcp adjust-mss** command is 1452 bytes. This value plus the 20-byte IP header, the 20-byte TCP header, and the 8-byte PPPoE header add up to a 1500-byte packet that matches the MTU size for the Ethernet link.

See the "Configuring the MSS Value and MTU for Transient TCP SYN Packets" section for configuration instructions.

TCP Applications Flags Enhancement

The TCP Applications Flags Enhancement feature enables the user to display additional flags with reference to TCP applications. There are two types of flags: status and option. The status flags indicate the status of TCP connections such as passive open, active open, retransmission timeout, and app closed for listening. The additional flags indicate the state of set options such as whether a VPN routing and forwarding instance (VRF) is set, whether a user is idle, and whether a keepalive timer is running. Use the **show tcp** command to display TCP application flags.

TCP Show Extension

The TCP Show Extension feature introduces the capability to display addresses in IP format instead of the hostname format and to display the VRF table associated with the connection. To display the status for all endpoints with addresses in IP format, use the **show tcp brief numeric** command.

TCP MIB for RFC 4022 Support

The TCP MIB for RFC 4022 Support feature introduces support for RFC 4022, *Management Information Base for the Transmission Control Protocol (TCP)*. RFC 4022 is an incremental change of the TCP MIB to improve the manageability of TCP.

To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:

http://www.cisco.com/go/mibs

TCP Keepalive Timer

The TCP Keepalive Timer feature provides a mechanism to identify dead connections.

When a TCP connection on a routing device is idle for too long, the device sends a TCP keepalive packet to the peer with only the Acknowledgment (ACK) flag turned on. If a response packet (a TCP ACK packet) is not received after the device sends a specific number of probes, the connection is considered dead and the device initiating the probes frees resources used by the TCP connection.

The following parameters are used to configure TCP keepalive:

- TCP Keepalive idle time—The value of this parameter indicates the time for which a TCP connection can be idle before the connection initiates keepalive probes.
- TCP Keepalive retries—The value of this parameter is the number of unacknowledged probes that a device can send before declaring the connection as dead and tearing it down.
- TCP Keepalive interval—The time between subsequent probe retries.

How to Configure TCP

Configuring TCP Performance Parameters

Before You Begin

Both sides of the network link must be configured to support window scaling or the default of 65,535 bytes will be applied as the maximum window size. To support Explicit Congestion Notification (ECN), the remote peer must be ECN-enabled because the ECN capability is negotiated during a three-way handshake with the remote peer.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip tcp synwait-time** *seconds*
4. **ip tcp path-mtu-discovery** [**age-timer** {*minutes* | **infinite**}]
5. **ip tcp selective-ack**
6. **ip tcp timestamp**
7. **ip tcp chunk-size** *characters*
8. **ip tcp window-size** *bytes*
9. **ip tcp ecn**
10. **ip tcp queuemax** *packets*
11. **end**

DETAILED STEPS

	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	**ip tcp synwait-time** *seconds* **Example:** `Device(config)# ip tcp synwait-time 60`	(Optional) Sets the amount of time the Cisco software will wait before attempting to establish a TCP connection. • The default is 30 seconds.

	Command or Action	Purpose
Step 4	**ip tcp path-mtu-discovery** [**age-timer** {*minutes* | **infinite**}] **Example:** `Device(config)# ip tcp path-mtu-discovery age-timer 11`	(Optional) Enables Path MTU Discovery. • **age-timer —**Time interval, in minutes, TCP reestimates the Maximum Transmission Unit (MTU) with a larger Maximum Segment Size (MSS). The default is 10 minutes. The maximum is 30 minutes. • **infinite—**Disables the age timer.
Step 5	**ip tcp selective-ack** **Example:** `Device(config)# ip tcp selective-ack`	(Optional) Enables TCP selective acknowledgment.
Step 6	**ip tcp timestamp** **Example:** `Device(config)# ip tcp timestamp`	(Optional) Enables the TCP time stamp.
Step 7	**ip tcp chunk-size** *characters* **Example:** `Device(config)# ip tcp chunk-size 64000`	(Optional) Sets the TCP maximum read size for Telnet or rlogin. **Note** We do not recommend that you change this value.
Step 8	**ip tcp window-size** *bytes* **Example:** `Device(config)# ip tcp window-size 75000`	(Optional) Sets the TCP window size. • The *bytes* argument can be set to an integer from 68 to 1073741823. To enable window scaling to support Long Flat Networks (LFNs), the TCP window size must be more than 65535. The default window size is 4128 if window scaling is not configured. **Note** With CSCsw45317, the *bytes* argument can be set to an integer from 68 to 1073741823.
Step 9	**ip tcp ecn** **Example:** `Device(config)# ip tcp ecn`	(Optional) Enables ECN for TCP.
Step 10	**ip tcp queuemax** *packets* **Example:** `Device(config)# ip tcp queuemax 10`	(Optional) Sets the TCP outgoing queue size.
Step 11	**end** **Example:** `Device(config)# end`	Exits to privileged EXEC mode.

Configuring the MSS Value and MTU for Transient TCP SYN Packets

Perform this task to configure the maximum size segment (MSS) for transient packets that traverse a device, specifically TCP segments with the SYN bit set, and to configure the MTU size of IP packets.

If you are configuring the **ip mtu** command on the same interface as the **ip tcp adjust-mss** command, we recommend that you use the following commands and values:

- **ip tcp adjust-mss 1452**
- **ip mtu 1492**

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **ip tcp adjust-mss** *max-segment-size*
5. **ip mtu** *bytes*
6. **end**

DETAILED STEPS

	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** *type number* **Example:** `Device(config)# interface GigabitEthernet 1/0/0`	Configures an interface type and enters interface configuration mode.
Step 4	**ip tcp adjust-mss** *max-segment-size* **Example:** `Device(config-if)# ip tcp adjust-mss 1452`	Adjusts the MSS value of TCP SYN packets going through a device. • The *max-segment-size* argument is the maximum segment size, in bytes. The range is from 500 to 1460.

	Command or Action	Purpose
Step 5	**ip mtu** *bytes* **Example:** `Device(config-if)# ip mtu 1492`	Sets the MTU size of IP packets, in bytes, sent on an interface.
Step 6	**end** **Example:** `Device(config-if)# end`	Exits to global configuration mode.

Verifying TCP Performance Parameters

SUMMARY STEPS

1. **show tcp** [*line-number*] [**tcb** *address*]
2. **show tcp brief** [**all** | **numeric**]
3. **debug ip tcp transactions**
4. **debug ip tcp congestion**

DETAILED STEPS

Step 1 **show tcp** [*line-number*] [**tcb** *address*]

Displays the status of TCP connections. The arguments and keyword are as follows:

- *line-number*—(Optional) Absolute line number of the Telnet connection status.
- **tcb**—(Optional) Transmission control block (TCB) of the Explicit Congestion Notification (ECN)-enabled connection.
- *address*—(Optional) TCB hexadecimal address. The valid range is from 0x0 to 0xFFFFFFFF.

The following sample output from the **show tcp tcb** command displays detailed information about an ECN-enabled connection that uses a hexadecimal address format:

Example:

```
Device# show tcp tcb 0x62CD2BB8

Connection state is LISTEN, I/O status: 1, unread input bytes: 0
Connection is ECN enabled
Local host: 10.10.10.1, Local port: 179
Foreign host: 10.10.10.2, Foreign port: 12000
Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)
Event Timers (current time is 0x4F31940):
Timer          Starts    Wakeups            Next
Retrans             0          0             0x0
TimeWait            0          0             0x0
```

```
AckHold             0          0             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0
iss:          0 snduna:          0 sndnxt:          0     sndwnd:      0
irs:          0 rcvnxt:          0 rcvwnd:       4128  delrcvwnd:      0
SRTT: 0 ms, RTTO: 2000 ms, RTV: 2000 ms, KRTT: 0 ms
minRTT: 60000 ms, maxRTT: 0 ms, ACK hold: 200 ms
Flags: passive open, higher precedence, retransmission timeout
TCB is waiting for TCP Process (67)
Datagrams (max data segment is 516 bytes):
Rcvd: 6 (out of order: 0), with data: 0, total data bytes: 0
Sent: 0 (retransmit: 0, fastretransmit: 0), with data: 0, total data
bytes: 0
```

Cisco Software Modularity

The following sample output from the **show tcp tcb** command displays a Software Modularity image:

Example:

```
Device# show tcp tcb 0x1059C10

Connection state is ESTAB, I/O status: 0, unread input bytes: 0
Local host: 10.4.2.32, Local port: 23
Foreign host: 10.4.2.39, Foreign port: 11000
VRF table id is: 0
Current send queue size: 0 (max 65536)
Current receive queue size: 0 (max 32768)  mis-ordered: 0 bytes
Event Timers (current time is 0xB9ACB9):
Timer          Starts    Wakeups            Next(msec)
Retrans             6          0                 0
SendWnd             0          0                 0
TimeWait            0          0                 0
AckHold             8          4                 0
KeepAlive          11          0           7199992
PmtuAger            0          0                 0
GiveUp              0          0                 0
Throttle            0          0                 0
irs:    1633857851  rcvnxt: 1633857890  rcvadv: 1633890620  rcvwnd:  32730
iss:    4231531315  snduna: 4231531392  sndnxt: 4231531392  sndwnd:   4052
sndmax: 4231531392  sndcwnd:     10220
SRTT: 84 ms,  RTTO: 650 ms,  RTV: 69 ms,  KRTT: 0 ms
minRTT: 0 ms,  maxRTT: 200 ms, ACK hold: 200 ms
Keepalive time: 7200 sec, SYN wait time: 75 sec
Giveup time: 0 ms, Retransmission retries: 0, Retransmit forever: FALSE
State flags: none
Feature flags: Nagle
Request flags: none
Window scales: rcv 0, snd 0, request rcv 0, request snd 0
Timestamp option: recent 0, recent age 0, last ACK sent          0
Datagrams (in bytes): MSS 1460, peer MSS 1460, min MSS 1460, max MSS 1460
Rcvd: 14 (out of order: 0), with data: 10, total data bytes: 38
Sent: 10 (retransmit: 0, fastretransmit: 0), with data: 5, total data bytes: 76
Header prediction hit rate: 72 %
Socket states: SS_ISCONNECTED, SS_PRIV
Read buffer flags: SB_WAIT, SB_SEL, SB_DEL_WAKEUP
Read notifications: 4
Write buffer flags: SB_DEL_WAKEUP
Write notifications: 0
Socket status: 0
```

Step 2 **show tcp brief** [**all** | **numeric**]

(Optional) Displays addresses in IP format.

Use the **show tcp brief** command to display a concise description of TCP connection endpoints. Use the optional **all** keyword to display the status for all endpoints with addresses in a Domain Name System (DNS) hostname format. If

this keyword is not used, endpoints in the LISTEN state are not shown. Use the optional **numeric** keyword to display the status for all endpoints with addresses in IP format.

Note If the **ip domain-lookup** command is enabled on the device, and you execute the **show tcp brief** command, the response time of the device to display the output will be very slow. To get a faster response, you should disable the **ip domain-lookup** command.

The following is sample output from the **show tcp brief** command while a user is connected to the system by using Telnet:

Example:

```
Device# show tcp brief

TCB       Local Address           Foreign Address        (state)
609789AC  Device.cisco.com.23     cider.cisco.com.3733   ESTAB
```

The following example shows the IP activity after the **numeric** keyword is used to display addresses in IP format:

Example:

```
Device# show tcp brief numeric

TCB           Local Address          Foreign Address     (state)
6523A4FC      10.1.25.3.11000        10.1.25.3.23         ESTAB
65239A84      10.1.25.3.23           10.1.25.3.11000      ESTAB
653FCBBC      *.1723 *.* LISTEN
```

Step 3 **debug ip tcp transactions**

Use the **debug ip tcp transactions** command to display information about significant TCP transactions such as state changes, retransmissions, and duplicate packets. The TCP/IP network isolated above the data link layer might encounter performance issues. The **debug ip tcp transactions** command can be useful in debugging these performance issues.

The following is sample output from the **debug ip tcp transactions** command:

Example:

```
Device# debug ip tcp transactions

TCP: sending SYN, seq 168108, ack 88655553
TCP0: Connection to 10.9.0.13:22530, advertising MSS 966
TCP0: state was LISTEN -> SYNRCVD [23 -> 10.9.0.13(22530)]
TCP0: state was SYNSENT -> SYNRCVD [23 -> 10.9.0.13(22530)]
TCP0: Connection to 10.9.0.13:22530, received MSS 956
TCP0: restart retransmission in 5996
TCP0: state was SYNRCVD -> ESTAB [23 -> 10.9.0.13(22530)]
TCP2: restart retransmission in 10689
TCP2: restart retransmission in 10641
TCP2: restart retransmission in 10633
TCP2: restart retransmission in 13384 -> 10.0.0.13(16151)]
TCP0: restart retransmission in 5996 [23 -> 10.0.0.13(16151)]
```

The following line from the **debug ip tcp transactions** command sample output shows that TCP has entered Fast Recovery mode:

Example:

```
fast re-transmit - sndcwnd - 512, snd_last - 33884268765
```

The following lines from the **debug ip tcp transactions** command sample output show that a duplicate acknowledgment is received when TCP is in Fast Recovery mode (first line) and a partial acknowledgment has been received (second line):

Example:

```
TCP0:ignoring second congestion in same window sndcwn - 512, snd_1st - 33884268765
TCP0:partial ACK received sndcwnd:338842495
```

Step 4 **debug ip tcp congestion**

Use the **debug ip tcp congestion** command to display information about TCP congestion events. The TCP/IP network isolated above the data link layer might encounter performance issues. The **debug ip tcp congestion** command can be used to debug these performance issues. The command also displays information related to variations in the TCP send window, congestion window, and congestion threshold window.

The following is sample output from the **debug ip tcp congestion** command:

Example:

```
Device# debug ip tcp congestion

*May 20 22:49:49.091: Setting New Reno as congestion control algorithm
*May 22 05:21:47.281: Advance cwnd by 12
*May 22 05:21:47.281: TCP85FD0C10: sndcwnd: 1472
*May 22 05:21:47.285: Advance cwnd by 3
*May 22 05:21:47.285: TCP85FD0C10: sndcwnd: 1475
*May 22 05:21:47.285: Advance cwnd by 3
*May 22 05:21:47.285: TCP85FD0C10: sndcwnd: 1478
*May 22 05:21:47.285: Advance cwnd by 9
*May 22 05:21:47.285: TCP85FD0C10: sndcwnd: 1487
*May 20 22:50:32.559: [New Reno] sndcwnd: 8388480 ssthresh: 65535 snd_mark: 232322
*May 20 22:50:32.559: 10.168.10.10:42416 <---> 10.168.30.11:49100 congestion window changes
*May 20 22:50:32.559: cwnd from 8388480 to 2514841, ssthresh from 65535 to 2514841
```

For Cisco TCP, New Reno is the default congestion control algorithm. However, an application can also use Binary Increase Congestion Control (BIC) as the congestion control algorithm. The following is sample output from the **debug ip tcp congestion** command using BIC:

Example:

```
Device# debug ip tcp congestion

*May 22 05:21:42.281: Setting BIC as congestion control algorithm
*May 22 05:21:47.281: Advance cwnd by 12
*May 22 05:21:47.281: TCP85FD0C10: sndcwnd: 1472
*May 22 05:21:47.285: Advance cwnd by 3
*May 22 05:21:47.285: TCP85FD0C10: sndcwnd: 1475
*May 22 05:21:47.285: Advance cwnd by 3
*May 22 05:21:47.285: TCP85FD0C10: sndcwnd: 1478
*May 22 05:21:47.285: Advance cwnd by 9
*May 22 05:21:47.285: TCP85FD0C10: sndcwnd: 1487
*May 20 22:50:32.559: [BIC] sndcwnd: 8388480 ssthresh: 65535 bic_last_max_cwnd: 0 last_cwnd: 8388480
*May 20 22:50:32.559: 10.168.10.10:42416 <---> 10.168.30.11:49100 congestion window changes
*May 20 22:50:32.559: cwnd from 8388480 to 2514841, ssthresh from 65535 to 2514841
*May 20 22:50:32.559: bic_last_max_cwnd changes from 0 to 8388480
```

Configuring Keepalive Parameters

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip tcp keepalive interval** *seconds*
4. **ip tcp keepalive retries** *number-of-retries*
5. **end**
6. **show running-config**

DETAILED STEPS

	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`	Enables global configuration mode.
Step 3	**ip tcp keepalive interval** *seconds* **Example:** `Device(config)# ip tcp keepalive interval 23`	Configures the keepalive interval.
Step 4	**ip tcp keepalive retries** *number-of-retries* **Example:** `Device(config)# ip tcp keepalive retries 5`	Configures the number of unacknowledged probes that can be sent before declaring the connection as dead.
Step 5	**end** **Example:** `Device(config)# end`	Exits global configuration mode.
Step 6	**show running-config** **Example:** `Device# show running-config`	(Optional) Displays the running configuration.

Configuration Examples for TCP

Example: Verifying the Configuration of TCP ECN

The following example shows how to verify whether TCP ECN is configured:

```
Device# show running-config

Building configuration...
.
.
.
ip tcp ecn ! ECN is configured.
.
.
.
```

The following example shows how to verify whether TCP is ECN-enabled on a specific connection (local host):

```
Device# show tcp tcb 123456A

!Local host
!
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Enabled
Local host: 10.1.25.31, Local port: 11002
Foreign host: 10.1.25.34, Foreign port: 23
```

The following example shows how to display concise information about one address:

```
Device# show tcp brief

!
TCB          Local address            Foreign Address        (state)
609789C      Router.example.com.23      cider.example.com.3733    ESTAB
```

The following example shows how to enable IP TCP ECN debugging:

```
Device# debug ip tcp ecn
!
TCP ECN debugging is on
!
Device# telnet 10.1.25.31

Trying 10.1.25.31 ...
!
01:43:19: 10.1.25.35:11000 <---> 10.1.25.31:23   out ECN-setup SYN
01:43:21: 10.1.25.35:11000 <---> 10.1.25.31:23   congestion window changes
01:43:21: cwnd from 1460 to 1460, ssthresh from 65535 to 2920
01:43:21: 10.1.25.35:11000 <---> 10.1.25.31:23   in non-ECN-setup SYN-ACK
```

Before a TCP connection can use ECN, a host sends an ECN-setup SYN (synchronization) packet to a remote end that contains an Echo Congestion Experience (ECE) and Congestion window reduced (CWR) bit set in the header. Setting the ECE and CWR bits indicates to the remote end that the sending TCP is ECN capable, rather than an indication of congestion. The remote end sends an ECN-setup SYN-ACK (acknowledgment) packet to the sending host.

In this example the “out ECN-setup SYN” text means that a SYN packet with the ECE and CWR bit set was sent to the remote end. The “in non-ECN-setup SYN-ACK” text means that the remote end did not favorably acknowledge the ECN request and, therefore, the session is not ECN capable.

The following output shows that ECN capabilities are enabled at both ends. In response to the ECN-setup SYN, the other end favorably replied with an ECN-setup SYN-ACK message. This connection is now ECN capable for the rest of the session.

```
Device# telnet 10.10.10.10

Trying 10.10.10.10 ... Open
Password required, but none set
!
1d20h: 10.1.25.34:11003 <---> 10.1.25.35:23   out ECN-setup SYN
1d20h: 10.1.25.34:11003 <---> 10.1.25.35:23   in ECN-setup SYN-ACK
```

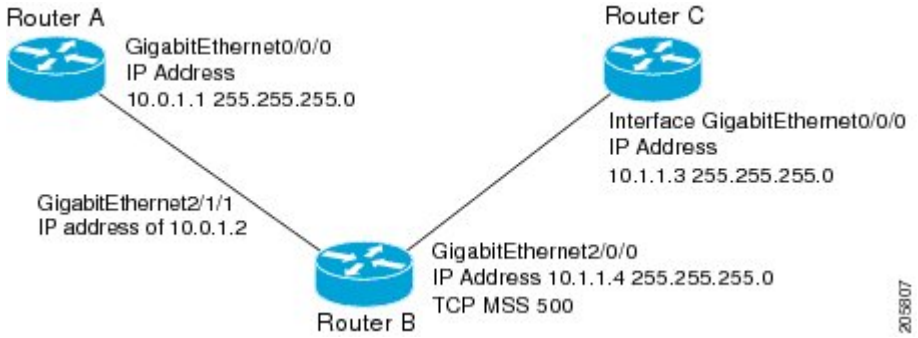
The following example shows how to verify that the hosts are connected:

```
Device# show debugging
!
TCP:
  TCP Packet debugging is on
  TCP ECN debugging is on
!
Device# telnet 10.1.25.234
!
Trying 10.1.25.234 ...
!
00:02:48: 10.1.25.31:11001 <---> 10.1.25.234:23   out ECN-setup SYN
00:02:48: tcp0: O CLOSED 10.1.25.234:11001 10.1.25.31:23 seq 1922220018
        OPTS 4 ECE CWR SYN  WIN 4128
00:02:50: 10.1.25.31:11001 <---> 10.1.25.234:23   congestion window changes
00:02:50: cwnd from 1460 to 1460, ssthresh from 65535 to 2920
00:02:50: tcp0: R SYNSENT 10.1.25.234:11001 10.1.25.31:23 seq 1922220018
        OPTS 4 ECE CWR SYN  WIN 4128
00:02:54: 10.1.25.31:11001 <---> 10.1.25.234:23   congestion window changes
00:02:54: cwnd from 1460 to 1460, ssthresh from 2920 to 2920
00:02:54: tcp0: R SYNSENT 10.1.25.234:11001 10.1.25.31:23 seq 1922220018
        OPTS 4 ECE CWR SYN  WIN 4128
00:03:02: 10.1.25.31:11001 <---> 10.1.25.234:23   congestion window changes
00:03:02: cwnd from 1460 to 1460, ssthresh from 2920 to 2920
00:03:02: tcp0: R SYNSENT 10.1.25.234:11001 10.1.25.31:23 seq 1922220018
        OPTS 4 ECE CWR SYN  WIN 4128
00:03:18: 10.1.25.31:11001 <---> 10.1.25.234:23   SYN with ECN disabled
00:03:18: 10.1.25.31:11001 <---> 10.1.25.234:23   congestion window changes
00:03:18: cwnd from 1460 to 1460, ssthresh from 2920 to 2920
00:03:18: tcp0: O SYNSENT 10.1.25.234:11001 10.1.25.31:23 seq 1922220018
        OPTS 4 SYN  WIN 4128
00:03:20: 10.1.25.31:11001 <---> 10.1.25.234:23   congestion window changes
00:03:20: cwnd from 1460 to 1460, ssthresh from 2920 to 2920
00:03:20: tcp0: R SYNSENT 10.1.25.234:11001 10.1.25.31:23 seq 1922220018
        OPTS 4 SYN  WIN 4128
00:03:24: 10.1.25.31:11001 <---> 10.1.25.234:23   congestion window changes
00:03:24: cwnd from 1460 to 1460, ssthresh from 2920 to 2920
00:03:24: tcp0: R SYNSENT 10.1.25.234:11001 10.1.25.31:23 seq 1922220018
        OPTS 4 SYN  WIN 4128
00:03:32: 10.1.25.31:11001 <---> 10.1.25.234:23   congestion window changes
00:03:32: cwnd from 1460 to 1460, ssthresh from 2920 to 2920
00:03:32: tcp0: R SYNSENT 10.1.25.234:11001 10.1.25.31:23 seq 1922220018
        OPTS 4 SYN  WIN 4128
!Connection timed out; remote host not responding
```

Example: Configuring the TCP MSS Adjustment

The following example shows how to configure and verify the interface adjustment value for the example topology displayed in the figure below:

Figure 5: Example Topology for TCP MSS Adjustment



Configure the interface adjustment value on router B:

```
Router_B(config)# interface GigabitEthernet 2/0/0
Router_B(config-if)# ip tcp adjust-mss 500
```

Telnet from router A to router C with B having the Maximum Segment Size (MSS) adjustment configured:

```
Router_A# telnet 192.168.1.1

Trying 192.168.1.1... Open
```

Observe the debug output from router C:

```
Router_C# debug ip tcp transactions

Sep 5 18:42:46.247: TCP0: state was LISTEN -> SYNRCVD [23 -> 10.0.1.1(38437)]
Sep 5 18:42:46.247: TCP: tcb 32290C0 connection to 10.0.1.1:38437, peer MSS 500, MSS is 500
Sep 5 18:42:46.247: TCP: sending SYN, seq 580539401, ack 6015751
Sep 5 18:42:46.247: TCP0: Connection to 10.0.1.1:38437, advertising MSS 500
Sep 5 18:42:46.251: TCP0: state was SYNRCVD -> ESTAB [23 -> 10.0.1.1(38437)]
```

The MSS gets adjusted to 500 on Router B as configured.

The following example shows the configuration of a Point-to-Point Protocol over Ethernet (PPPoE) client with the MSS value set to 1452:

```
Device(config)# vpdn enable
Device(config)# no vpdn logging
Device(config)# vpdn-group 1
Device(config-vpdn)# request-dialin
Device(config-vpdn-req-in)# protocol pppoe
Device(config-vpdn-req-in)# exit
Device(config-vpdn)# exit
Device(config)# interface GigabitEthernet 0/0/0
Device(config-if)# ip address 192.168.100.1.255.255.255.0
Device(config-if)# ip tcp adjust-mss 1452
Device(config-if)# ip nat inside
Device(config-if)# exit
Device(config)# interface ATM 0
Device(config-if)# no ip address
Device(config-if)# no atm ilmi-keepalive
```

```
Device(config-if)# pvc 8/35
Device(config-if)# pppoe client dial-pool-number 1
Device(config-if)# dsl equipment-type CPE
Device(config-if)# dsl operating-mode GSHDSL symmetric annex B
Device(config-if)# dsl linerate AUTO
Device(config-if)# exit
Device(config)# interface Dialer 1
Device(config-if)3 ip address negotiated
Device(config-if)# ip mtu 1492
Device(config-if)# ip nat outside
Device(config-if)# encapsulation ppp
Device(config-if)# dialer pool 1
Device(config-if)# dialer-group 1
Device(config-if)# ppp authentication pap callin
Device(config-if)# ppp pap sent-username sohodyn password 7 141B1309000528
Device(config-if)# ip nat inside source list 101 Dialer1 overload
Device(config-if)# exit
Device(config)# ip route 0.0.0.0.0.0.0.0 Dialer1
Device(config)# access-list permit ip 192.168.100.0.0.0.0.255 any
```

The following example shows the configuration of interface adjustment value for IPv6 traffic:

```
Device> enable
Device# configure terminal
Device(config)# interface GigabitEthernet 0/0/0
Device(config)# ipv6 tcp adjust-mss 1452
Device(config)# end
```

Example: Configuring the TCP Application Flags Enhancement

The following output shows the flags (status and option) displayed using the **show tcp** command:

```
Device# show tcp
.
.
.
Status Flags: passive open, active open, retransmission timeout
 App closed
Option Flags: vrf id set
IP Precedence value: 6
.
.
.
SRTT: 273 ms, RTTO: 490 ms, RTV: 217 ms, KRTT: 0 ms
minRTT: 0 ms, maxRTT: 300 ms, ACK hold: 200 ms
```

Example: Displaying Addresses in IP Format

The following example shows the IP activity by using the **numeric** keyword to display the addresses in IP format:

```
Device# show tcp brief numeric

TCB           Local Address          Foreign Address     (state)
6523A4FC      10.1.25.3.11000        10.1.25.3.23         ESTAB
65239A84      10.1.25.3.23           10.1.25.3.11000      ESTAB
653FCBBC      *.1723 *.* LISTEN
```

Example: Configuring Keepalive Parameters

The following example shows how to configure TCP keepalive parameters.

```
Device# configure terminal
Device(config)# ip tcp keepalive interval 2
Device(config)# ip tcp keepalive retries 5
```

The following is a sample output of the **show running-config** command:

```
Device# show running-config

ip tcp keepalive retries 5
ip tcp keepalive interval 2
```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases
IP Application Services commands	IP Application Services Command Reference

Standards and RFCs

Standard/RFC	Title
RFC 793	Transmission Control Protocol
RFC 1191	Path MTU discovery
RFC 1323	TCP Extensions for High Performance
RFC 2018	TCP Selective Acknowledgment Options
RFC 2581	TCP Congestion Control
RFC 3168	The Addition of Explicit Congestion Notification (ECN) to IP
RFC 3782	The NewReno Modification to TCP's Fast Recovery Algorithm
RFC 4022	Management Information Base for the Transmission Control Protocol (TCP)

MIBs

MIB	MIBs Link
CISCO-TCP-MIB	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for TCP

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

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

Table 7: Feature Information for TCP

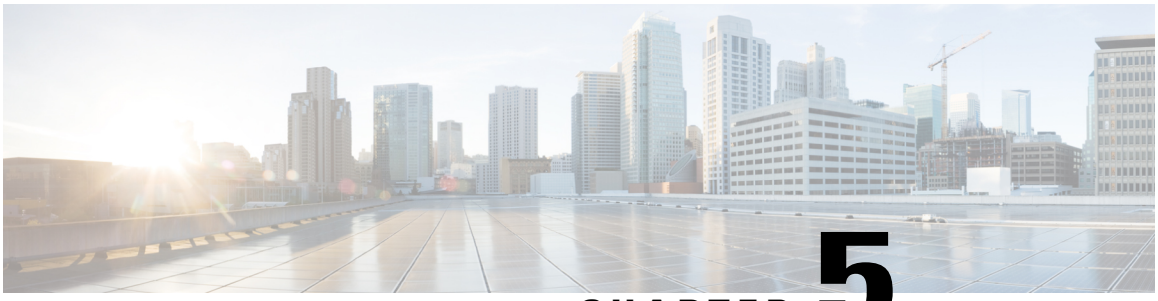
Feature Name	Releases	Feature Information
TCP Application Flags Enhancement	12.2(31)SB2 12.4(2)T	The TCP Applications Flags Enhancement feature enables the user to display additional flags with reference to TCP applications. There are two types of flags: status and option. The status flags indicate the status of TCP connections such as retransmission timeouts, application closed, and synchronized (SYNC) handshakes for listening. The additional flags indicate the state of set options such as whether a VPN routing and forwarding instance (VRF) is set, whether a user is idle, and whether a keepalive timer is running. The following command was modified by this feature: **show tcp**.

Feature Name	Releases	Feature Information
TCP Congestion Avoidance	12.3(7)T	The TCP Congestion Avoidance feature enables the monitoring of acknowledgment packets to the TCP sender when multiple packets are lost in a single window of data. Before this feature was introduced, the sender would exit Fast-Recovery mode, wait for three or more duplicate acknowledgment packets before retransmitting the next unacknowledged packet, or wait for the retransmission timer to start slowly. This delay could lead to performance issues. Implementation of RFC 2581 and RFC 3782 addresses the modifications to the Fast-Recovery algorithm that incorporates a response to partial acknowledgments received during Fast Recovery, improving performance in situations where multiple packets are lost in a single window of data. This feature is an enhancement to the existing Fast Recovery algorithm. No commands are used to enable or disable this feature. The output of the **debug ip tcp transactions** command monitors acknowledgment packets by displaying the following conditions: • TCP entering Fast Recovery mode. • Duplicate acknowledgments being received during Fast Recovery mode. • Partial acknowledgments being received. The following command was modified by this feature: **debug ip tcp transactions**.

Feature Name	Releases	Feature Information
TCP Explicit Congestion Notification	12.3(7)T	The TCP Explicit Congestion Notification (ECN) feature allows an intermediate router to notify end hosts of impending network congestion. It also provides enhanced support for TCP sessions associated with applications such as Telnet, web browsing, and transfer of audio and video data, that are sensitive to delay or packet loss. The benefit of this is the reduction of delay and packet loss in data transmissions. The following commands were introduced or modified by this feature: **debug ip tcp ecn**, **ip tcp ecn**, **show debugging**, **show tcp**.
TCP MIB for RFC4022 Support	12.2(33)XN	The TCP MIB for RFC 4022 Support feature introduces support for RFC 4022, *Management Information Base for the Transmission Control Protocol (TCP)*. RFC 4022 is an incremental change of the TCP MIB to improve the manageability of TCP. There are no new or modified commands for this feature.

Feature Name	Releases	Feature Information
TCP MSS Adjust	12.2(4)T 12.2(8)T 12.2(18)ZU2 12.2(28)SB 12.2(33)SRA 12.2(33)SXH 15.0(1)S	The TCP MSS Adjust feature enables the configuration of the maximum segment size (MSS) for transient packets that traverse a device, specifically TCP segments in the SYN bit set. In 12.2(4)T, this feature was introduced. In 12.2(8)T, the command that was introduced by this feature was changed from **ip adjust-mss** to **ip tcp adjust-mss**. In 12.2(28)SB and 12.2(33)SRA, this feature was enhanced to be configurable on subinterfaces. The following command was introduced by this feature: **ip tcp adjust-mss**.
TCP Show Extension	12.2(31)SB2 12.4(2)T	The TCP Show Extension feature introduces the capability to display addresses in IP format instead of hostname format and to display the VRF table associated with the connection. The following command was modified by this feature: **show tcp brief**.
TCP Window Scaling	12.2(8)T 12.2(31)SB2	The TCP Window Scaling feature adds support for the Window Scaling option in RFC 1323. A larger window size is recommended to improve TCP performance in network paths with large bandwidth, long-delay characteristics that are called Long Fat Networks (LFNs). This TCP Window Scaling enhancement provides that support. The following command was introduced or modified by this feature: **ip tcp window-size**.

Feature Name	Releases	Feature Information
TCP Keepalive Timer	15.2(4)M	The TCP Keepalive Timer feature introduces the capability to identify dead connections between multiple routing devices. The following command was introduced or modified by this feature: **ip tcp keepalive**.



CHAPTER 5

Configuring UDP Forwarding Support for IP Redundancy Virtual Router Groups

User Datagram Protocol (UDP) forwarding is a feature used in Cisco IOS software to forward broadcast and multicast packets received for a specific IP address. Virtual Router Group (VRG) support, implemented with the Hot Standby Routing Protocol (HSRP), allows a set of routers to be grouped as a logical router that answers to a well-known IP address. The UDP Forwarding Support for IP Redundancy Virtual Router Groups feature enables UDP forwarding to be VRG aware; this results in packets getting forwarde only to the active router in the VRG.

This module explains the concepts related UDP forwarding and VRG support and describes how to configure UDP forwarding support for IP Redundancy Virtual Router Groups in a network.

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 www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for UDP Forwarding Support for IP Redundancy Virtual Router Groups

- The UDP Forwarding Support for Virtual Router Groups feature is available only on platforms that support VRGs.

Information About UDP Forwarding Support for IP Redundancy Virtual Router Groups

Benefits of the UDP Forwarding Support for Virtual Router Groups Feature

Forwarding is limited to the active router in the VRG instead of all routers within the VRG. Prior to the implementation of this feature, the only VRG support was HSRP. Within a VRG that is formed by HSRP, the forwarding of UDP-based broadcast and multicast packets is done by all the routers within the VRG. This process can cause some DHCP servers to operate incorrectly. The UDP Forwarding Support for VRGs feature limits forwarding to the active router in the VRG.

VRG awareness is achieved with IP Redundancy Service (IRS). The IRS application programming interface (API) provides notification updates of a specific VRG, addition and deletion of a VRG, and querying of the current state of a VRG. A state change notification is provided to avoid the performance impact of querying the state of the VRG each time it is needed. The UDP forwarding code caches the VRG state for each required helper address that is defined. Each time the UDP forwarding code needs to execute, it checks the current state of the VRG associated with the helper address and forwards packets only to VRGs that are active.

How to Configure UDP Forwarding Support for IP Redundancy Virtual Router Groups

Configuring UDP Forwarding Support for IP Redundancy Virtual Router Groups

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no shutdown**
5. **ip address** *ip-address mask*
6. **ip helper-address** *address* **redundancy** *vrg-name*
7. **standby** *group-number* **ip** *ip-address*
8. **standby** *group-number* **name** *group-name*
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface fastethernet 0/0`	Specifies an interface and enters interface configuration mode.
Step 4	**no shutdown** **Example:** `Router(config-if)# no shutdown`	Restarts a disabled interface.

	Command or Action	Purpose
Step 5	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip address 172.16.10.1 255.255.255.0`	Sets a primary address for the interface.
Step 6	**ip helper-address** *address* **redundancy** *vrg-name* **Example:** `Router(config-if)# ip helper-address 10.1.1.1 redundancy vrg1`	Enables UDP forwarding support for the VRG.
Step 7	**standby** *group-number* **ip** *ip-address* **Example:** `Router(config-if)# standby 1 ip 172.16.10.254`	Activates HSRP.
Step 8	**standby** *group-number* **name** *group-name* **Example:** `Router(config-if)# standby 1 name vrg1`	Configures the name of the standby group.
Step 9	**end** **Example:** `Router(config-if)# end`	Exits the current configuration mode and returns to privileged EXEC mode.

Configuration Examples for UDP Forwarding Support for IP Redundancy Virtual Router Groups

Example: Configuring UDP Forwarding Support for IP Redundancy Virtual Router Groups

The following example shows how to configure UDP Forwarding Support for IP Redundancy Virtual Router Groups:

```
Router(config)# interface fastethernet 0/0
Router(config-if)# no shutdown
Router(config-if)# ip address 172.16.10.1 255.255.255.0
Router(config-if)# ip helper-address 10.1.1.1 redundancy vrg1
Router(config-if)# standby 1 ip 172.16.10.254
Router(config-if)# standby 1 name vrg1
Router(config-if)# end
```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases
IP application services commands: complete command syntax, command mode, command history, defaults, usage guidelines, and examples	*Cisco IOS IP Application Services Command Reference*

Standards

Standard	Title
No new or modified standards are supported, and support for existing standards has not been modified	—

MIBs

MIB	MIBs Link
No new or modified MIBs are supported, and support for existing MIBs has not been modified	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
No new or modified RFCs are supported, and support for existing RFCs has not been modified	—

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

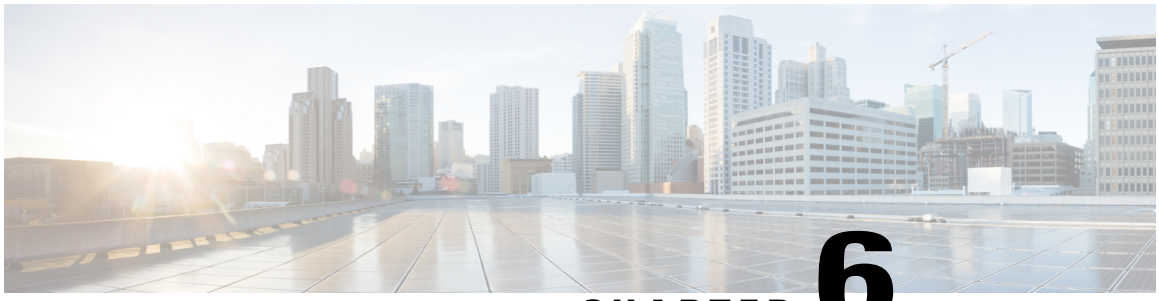
Feature Information for UDP Forwarding Support for IP Redundancy Virtual Router Groups

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

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

Table 8: Feature Information for UDP Forwarding Support for IP Redundancy Virtual Router Groups

Feature Name	Releases	Feature Information
UDP Forwarding Support for IP Redundancy Virtual Router Group	Cisco IOS XE 3.1.0SG 12.2(50)SY 12.2(15)T 15.0(1)SY 15.2(1)S	UDP forwarding is a feature used in Cisco IOS software to forward broadcast and multicast packets received for a specific IP address. Virtual Router Group (VRG) support is implemented with the Hot Standby Routing Protocol (HSRP) and it allows a set of routers to be grouped as a logical router that answers to a well-known IP address. The UDP Forwarding Support for IP Redundancy Virtual Router Groups feature enables UDP forwarding to be VRG aware, resulting in forwarding only to the active router in the VRG. The following command was introduced or modified: **ip helper-address**.



CHAPTER 6

Object Tracking: IPv6 Route Tracking

The Object Tracking: IPv6 Route Tracking feature expands the Enhanced Object Tracking (EOT) functionality to allow the tracking of IP version 6 (IPv6) routes.

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 www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for Object Tracking: IPv6 Route Tracking

Object Tracking: IPv6 Route Tracking is not Stateful Switchover (SSO)-aware and cannot be used with Hot Standby Router Protocol (HSRP), Virtual Router Redundancy Protocol (VRRP), or Gateway Load Balancing Protocol (GLBP) in SSO mode.

Information About Object Tracking: IPv6 Route Tracking

Enhanced Object Tracking and IPv6 Route Tracking

Enhanced Object Tracking (EOT) provides complete separation between the objects to be tracked and the action to be taken by a client when a tracked object changes. Thus, several clients such as Hot Standby Router Protocol (HSRP), Virtual Router Redundancy Protocol (VRRP), or Gateway Load Balancing Protocol (GLBP) can register interest with a tracking process, track the same object, and each take different a action when the object changes.

Each tracked object is identified by a unique number that is specified on the tracking CLI. Client processes use this number to track a specific object.

A tracking process periodically polls tracked objects and notes any change in value. The changes in the tracked object are communicated to interested client processes, either immediately or after a specified delay. The object values are reported as either up or down.

The Object Tracking: IPv6 Route Tracking feature expands EOT functionality to allow the tracking of IPv6 routes.

How to Configure Object Tracking: IPv6 Route Tracking

Tracking the IPv6-Routing State of an Interface

SUMMARY STEPS

1. **track timer interface** {*seconds* | **msec** *milliseconds*}
2. **track** *object-number* **interface** *type number* **ipv6 routing**
3. **carrier-delay**
4. **delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*}
5. **end**
6. **show track** *object-number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**track timer interface** {*seconds* | **msec** *milliseconds*} **Example:** `Device(config)# track timer interface 5`	(Optional) Specifies the interval that a tracking process polls the tracked interface. • The default interval that the tracking process polls interface objects is 1 second.

	Command or Action	Purpose
		Note All polling frequencies can be configured down to 500 milliseconds, overriding the minimum 1-second interval configured using the **msec** keyword and *milliseconds* argument.
Step 2	**track** *object-number* **interface** *type number* **ipv6 routing** **Example:** `Device(config)# track 1 interface GigabitEthernet 0/0/1 ipv6 routing`	Tracks the IPv6-routing state of an interface and enters tracking configuration mode. • IPv6-route tracking tracks an IPv6 route in the routing table and the ability of an interface to route IPv6 packets.
Step 3	**carrier-delay** **Example:** `Device(config-track)# carrier-delay`	(Optional) Enables enhanced object tracking to consider the carrier-delay timer when tracking the status of an interface.
Step 4	**delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*} **Example:** `Device(config-track)# delay up 30`	(Optional) Specifies a period of time (in seconds) to delay communicating state changes of a tracked object. **Note** The **up** keyword specifies the time to delay the notification of an up event. The **down** keyword specifies the time to delay the notification of a down event.
Step 5	**end** **Example:** `Device(config-track)# end`	Returns to privileged EXEC mode.
Step 6	**show track** *object-number* **Example:** `Device# show track 1`	Displays tracking information. • Use this command to verify the configuration.

Tracking the Threshold of IPv6-Route Metrics

SUMMARY STEPS

1. **track timer ipv6 route** {*seconds* | **msec** *milliseconds*}
2. **track resolution ipv6 route** {**bgp** | **eigrp** | **isis** | **ospf** | **static** } *resolution-value*
3. **track** *object-number* **ipv6 route** *ipv6-address*/*prefix-length* **metric threshold**
4. **delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*}
5. **ipv6 vrf** *vrf-name*
6. **threshold metric** {**up** *number* [**down** *number*] | **down** *number* [**up** *number*]}
7. **end**
8. **show track** *object-number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**track timer ipv6 route** {*seconds* | **msec** *milliseconds*} **Example:** `Device(config)# track timer ipv6 route 20`	(Optional) Specifies the interval that a tracking process polls the tracked object. • The default interval that the tracking process polls IPv6-route objects is 15 seconds. **Note** All polling frequencies can be configured down to 500 milliseconds, overriding the minimum 1-second interval configured using the **msec** keyword and *milliseconds* argument.
Step 2	**track resolution ipv6 route** {**bgp** | **eigrp** | **isis** | **ospf** | **static** } *resolution-value* **Example:** `Device(config)# track resolution ipv6 route eigrp 300`	(Optional) Specifies resolution parameters for a tracked object. • Use this command to change the default metric resolution values.
Step 3	**track** *object-number* **ipv6 route** *ipv6-address*/*prefix-length* **metric threshold** **Example:** `Device(config)# track 6 ipv6 route 2001:DB8:0:ABCD::1/10 metric threshold`	Tracks the scaled metric value of an IPv6 route to determine if it is above or below a threshold and enters tracking configuration mode. • The default down value is 255, which equates to an inaccessible route. • The default up value is 254.
Step 4	**delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*}	(Optional) Specifies a period of time (in seconds) to delay communicating state changes of a tracked object.

	Command or Action	Purpose
	Example: `Device(config-track)# delay up 30`	**Note** The **up** keyword specifies the time to delay the notification of an up event. The **down** keyword specifies the time to delay the notification of a down event.
Step 5	**ipv6 vrf** *vrf-name* **Example:** `Device(config-track)# ipv6 vrf VRF1`	(Optional) Tracks an IPv6 route in a specific VPN virtual routing and forwarding (VRF) table.
Step 6	**threshold metric** {**up** *number* [**down** *number*] | **down** *number* [**up** *number*]} **Example:** `Device(config-track)# threshold metric up 254 down 255`	(Optional) Sets a metric threshold other than the default value. **Note** The **up** keyword specifies the up threshold. The state is up if the scaled metric for that route is less than or equal to the up threshold. The default up threshold is 254. The **down** keyword specifies the down threshold. The state is down if the scaled metric for that route is greater than or equal to the down threshold. The default down threshold is 255.
Step 7	**end** **Example:** `Device(config-track)# end`	Returns to privileged EXEC mode.
Step 8	**show track** *object-number* **Example:** `Device# show track 6`	(Optional) Displays tracking information. • Use this command to verify the configuration.

Tracking IPv6-Route Reachability

Perform this task to track the reachability of an IPv6 route. A tracked object is considered up when a routing table entry exists for the route and the route is accessible.

SUMMARY STEPS

1. **track timer ipv6 route** {*seconds* | **msec** *milliseconds*}
2. **track** *object-number* **ip route** *ip-address*/*prefix-length* **reachability**
3. **delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*}
4. **ipv6 vrf** *vrf-name*
5. **end**
6. **show track** *object-number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**track timer ipv6 route** {*seconds* | **msec** *milliseconds*} **Example:** `Device(config)# track timer ipv6 route 20`	(Optional) Specifies the interval that a tracking process polls the tracked object. • The default interval that the tracking process polls IPv6-route objects is 15 seconds. **Note** All polling frequencies can be configured down to 500 milliseconds, overriding the minimum 1-second interval configured using the **msec** keyword and *milliseconds* argument.
Step 2	**track** *object-number* **ip route** *ip-address*/*prefix-length* **reachability** **Example:** `Device(config)# track 4 ipv6 route 2001:DB8:0:AB82::1/10 reachability`	Tracks the reachability of an IPv6 route and enters tracking configuration mode.
Step 3	**delay** {**up** *seconds* [**down** *seconds*] | [**up** *seconds*] **down** *seconds*} **Example:** `Device(config-track)# delay up 30`	(Optional) Specifies a period of time (in seconds) to delay communicating state changes of a tracked object. **Note** The **up** keyword specifies the time to delay the notification of an up event. The **down** keyword specifies the time to delay the notification of a down event.
Step 4	**ipv6 vrf** *vrf-name* **Example:** `Device(config-track)# ipv6 vrf VRF2`	(Optional) Configures a VPN virtual routing and forwarding (VRF) table.
Step 5	**end** **Example:** `Device(config-track)# end`	Returns to privileged EXEC mode.
Step 6	**show track** *object-number* **Example:** `Device# show track 4`	(Optional) Displays tracking information. • Use this command to verify the configuration.

Configuration Examples for Object Tracking: IPv6 Route Tracking

Example: Tracking the IPv6-Routing State of an Interface

The following example shows how to configure tracking for IPv6 routing on the GigabitEthernet 0/0/1 interface:

```
Device(config)# track timer interface 5
Device(config)# track 1 interface GigabitEthernet 0/0/1 ipv6 routing
Device(config-track)# carrier-delay
Device(config-track)# delay up 30
Device(config-track)# end
```

Example: Tracking the Threshold of IPv6-Route Metrics

The following example shows how to configure tracking for IPv6 metric thresholds:

```
Device(config)# track timer ipv6 route 20
Device(config)# track resolution ipv6 route eigrp 300
Device(config)# track 6 ipv6 route 2001:DB8:0:ABCD::1/10 metric threshold
Device(config-track)# delay up 30
Device(config-track)# ipv6 vrf VRF1
Device(config-track)# threshold metric up 254 down 255
Device(config-track)# end
```

Example: Tracking IPv6-Route Reachability

The following example shows how to configure tracking for IPv6-route reachability:

```
Device(config)# track timer ipv6 route 20
Device(config)# track 4 ipv6 route 2001:DB8:0:AB82::1/10 reachability
Device(config-track)# delay up 30
Device(config-track)# ipv6 vrf VRF2
Device(config-track)# end
```

Additional References for Object Tracking: IPv6 Route Tracking

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
Object tracking	*Configuring Enhanced Object Tracking*
IP Application Services commands	*Cisco IOS IP Application Services Command Reference*

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for Object Tracking: IPv6 Route Tracking

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

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

Table 9: Feature Information for Object Tracking: IPv6 Route Tracking

Feature Name	Releases	Feature Information
Object Tracking: IPv6 Route Tracking	15.3(3)S	This feature expands Enhanced Object Tracking (EOT) functionality to allow the tracking of IPv6 routes.