



# Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

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This module contains information about Cisco Express Forwarding and describes the required and optional tasks for configuring a per-destination load-balancing scheme for Cisco Express Forwarding traffic. Load-balancing allows you to optimize resources by distributing traffic over multiple paths.



## Note

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The Cisco ASR 1000 Series Aggregation Services Routers supports only per-destination load-balancing schemes. Cisco ASR 1000 Series Aggregation Services Routers does not support per-packet load-balancing schemes.

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Cisco Express Forwarding is an advanced Layer 3 IP switching technology. It optimizes network performance and scalability for all kinds of networks: those that carry small amounts of traffic and those that carry large amounts of traffic in complex patterns, such as the Internet and networks characterized by intensive web-based applications or interactive sessions.

## Finding Feature Information

For the latest feature information and caveats, see 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 for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic” section on page 13.](#)

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



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## Prerequisites for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

Cisco Express Forwarding or distributed Cisco Express Forwarding must be enabled on your switch or router.

## Information About Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

- [Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding, page 2](#)
- [Cisco Express Forwarding Load-Balancing Overview, page 3](#)
- [Per-Destination Load Balancing for Cisco Express Forwarding Traffic, page 3](#)
- [8-Way Cisco Express Forwarding Per Destination Load Balancing, page 3](#)
- [Load-Balancing Algorithms for Cisco Express Forwarding Traffic, page 4](#)

For links to information about other Cisco Express Forwarding and distributed Cisco Express Forwarding features that you can configure, see the [“Additional References” section on page 11](#).

## Cisco Platform Support for Central Cisco Express Forwarding and Distributed Cisco Express Forwarding

Cisco Express Forwarding is enabled by default on the Cisco ASR 1000 Series Aggregation Services Routers.

To find out if Cisco Express Forwarding is enabled on your platform, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like this:

```
Router# show ip cef
```

Prefix	Next Hop	Interface
[...]		
10.2.61.8/24	192.168.100.1	FastEthernet1/0/0
	192.168.101.1	FastEthernet2/1/0
[...]		

If Cisco Express Forwarding is not enabled on your platform, the output for the **show ip cef** command looks like this:

```
Router# show ip cef
```

```
%CEF not running
```

If Cisco Express Forwarding is not enabled on your platform, use the **ip cef** command to enable (central) Cisco Express Forwarding or the **ip cef distributed** command to enable distributed Cisco Express Forwarding.

## Cisco Express Forwarding Load-Balancing Overview

Cisco Express Forwarding load balancing is based on a combination of source and destination packet information; it allows you to optimize resources by distributing traffic over multiple paths.

## Per-Destination Load Balancing for Cisco Express Forwarding Traffic

Per-destination load balancing allows the router to use multiple paths to achieve load sharing across multiple source-destination host pairs. Packets for a given source-destination host pair are guaranteed to take the same path, even if multiple paths are available. Traffic streams destined for different pairs tend to take different paths.

Per-destination load balancing is enabled by default when you enable Cisco Express Forwarding. To use per-destination load balancing, you do not perform any additional tasks once Cisco Express Forwarding is enabled. Per-destination is the load-balancing method of choice for most situations.

Because per-destination load balancing depends on the statistical distribution of traffic, load sharing becomes more effective as the number of source-destination host pairs increases.

You can use per-destination load balancing to ensure that packets for a given host pair arrive in order. All packets intended for a certain host pair are routed over the same link (or links).



### Note

Per-destination load balancing is the default load-balancing scheme for Cisco Express Forwarding traffic on the Cisco ASR 1000 Series Aggregation Services Routers. No configuration steps are required to enable per-destination load balancing. Additionally, on the Cisco ASR 1000 Series Aggregation Services Routers per-destination load balancing cannot be disabled.

## 8-Way Cisco Express Forwarding Per Destination Load Balancing

Destination IP prefixes are added to the routing table by routing protocols or static routes. Each path is a valid route to reach the destination prefix. The set of active paths is the set of paths with the best cost. The 8-Way Cisco Express Forwarding Load Balancing feature provides the ability to share the traffic to a destination prefix over up to eight active paths (an increase from the previous support of six active paths). The traffic load among the active paths can be distributed by destination.

## Load-Balancing Algorithms for Cisco Express Forwarding Traffic

The following load-balancing algorithms are provided for use with Cisco Express Forwarding traffic. You select a load-balancing algorithm with the **ip cef load-sharing algorithm** command.

- **Original algorithm**—The original Cisco Express Forwarding load-balancing algorithm produces distortions in load sharing across multiple routers because the same algorithm was used on every router. Depending on your network environment, you should select either the universal algorithm (default) or the tunnel algorithm instead.
- **Universal algorithm**—The universal load-balancing algorithm allows each router on the network to make a different load sharing decision for each source-destination address pair, which resolves load-sharing imbalances. The router is set to perform universal load sharing by default.
- **Tunnel algorithm**—The tunnel algorithm is designed to load balance when only a few source and destination pairs are involved.
- **Include-ports algorithm**—The include-ports algorithm allows you to use the Layer 4 source and destination ports as part of the load-balancing decision. This method benefits traffic streams running over equal cost paths that are not load shared because the majority of the traffic is between peer addresses that use different port numbers, such as Real-Time Protocol (RTP) streams.

## How to Configure a Load-Balancing Scheme for Cisco Express Forwarding Traffic



### Note

Per-destination load balancing is the default load-balancing scheme for Cisco Express Forwarding traffic on the Cisco ASR 1000 Series Aggregation Services Routers. No configuration steps are required to enable per-destination load balancing. Additionally, on the Cisco ASR 1000 Series Aggregation Services Routers per-destination load balancing cannot be disabled.

Perform the following tasks to fine-tune load balancing for Cisco Express Forwarding:

- [Selecting a Cisco Express Forwarding Load-Balancing Algorithm, page 4](#) (optional)
- [Verifying the Configuration of a Load-Balancing Scheme for Cisco Express Forwarding, page 8](#) (optional)

## Selecting a Cisco Express Forwarding Load-Balancing Algorithm

Perform one of the following tasks to elect a Cisco Express Forwarding load-balancing algorithm.

- [Selecting a Tunnel Load-Balancing Algorithm for Cisco Express Forwarding Traffic, page 5](#) (optional)
- [Selecting an Include-Ports Layer 4 Load-Balancing Algorithm for Cisco Express Forwarding Traffic, page 6](#) (optional)

The router is set to perform universal load sharing by default.

# Selecting a Tunnel Load-Balancing Algorithm for Cisco Express Forwarding Traffic

Perform the following task to select a tunnel load-balancing algorithm for Cisco Express Forwarding traffic. Select the tunnel algorithm when your network environment contains only a few source and destination pairs.

## SUMMARY STEPS

- 1. `enable`
- 2. `configure terminal`
- 3. `ip cef load-sharing algorithm {original | tunnel [id] | universal [id] | include-ports {source [id] | [destination] [id] | source [id] destination [id]}}`
- 4. `end`

## DETAILED STEPS

	Command or Action	Purpose
Step 1	<code>enable</code>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"><li>• Enter your password if prompted.</li></ul>
Step 2	<code>configure terminal</code>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
Step 3	<pre>ip cef load-sharing algorithm {original   tunnel [id]   universal [id]   include-ports {source [id]   [destination] [id]   source [id] destination [id]}}</pre> <p><b>Example:</b> Router(config)# ip cef load-sharing algorithm tunnel</p>	<p>Selects a Cisco Express Forwarding load-balancing algorithm.</p> <ul style="list-style-type: none"> <li>The <b>original</b> keyword sets the load-balancing algorithm to the original algorithm, based on a source and destination hash.</li> <li>The <b>tunnel</b> keyword sets the load-balancing algorithm to one that can be used in tunnel environments or in environments where there are only a few IP source and destination address pairs.</li> <li>The <i>id</i> argument is a fixed identifier.</li> <li>The <b>universal</b> keyword sets the load-balancing algorithm to one that uses a source and destination and an ID hash.</li> <li>The <b>include-ports source</b> keywords set the load-balancing algorithm to one that uses the source port.</li> <li>The <b>include-ports destination</b> keywords set the load-balancing algorithm to one that uses the destination port.</li> <li>The <b>include-ports source destination</b> keywords set the load-balancing algorithm to one that uses both source and destination ports.</li> </ul>
Step 4	<pre>end</pre> <p><b>Example:</b> Router(config)# end</p>	<p>Exits to privileged EXEC mode.</p>

## Selecting an Include-Ports Layer 4 Load-Balancing Algorithm for Cisco Express Forwarding Traffic

Perform the following task to select an include-ports load-balancing algorithm for Cisco Express Forwarding traffic. Select the include-port algorithm when your network environment contains traffic running over equal-cost paths that is not load shared because the majority of the traffic is between peer addresses with different port numbers, such as RTP streams.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef load-sharing algorithm { original | tunnel [id] | universal [id] | include-ports { source [id] | [destination] [id] | source [id] destination [id] } }**
4. **end**

## DETAILED STEPS

	Command or Action	Purpose
Step 1	<b>enable</b>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
Step 2	<b>configure terminal</b>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.
Step 3	<b>ip cef load-sharing algorithm {original   tunnel [id]   universal [id] include-ports {source [id]   [destination] [id]   source [id] destination [id]}}</b>  <b>Example:</b> Router(config)# ip cef load-sharing algorithm include-ports source destination	Selects a Cisco Express Forwarding load-balancing algorithm. <ul style="list-style-type: none"> <li>The <b>original</b> keyword sets the load-balancing algorithm to the original algorithm, based on a source and destination hash.</li> <li>The <b>tunnel</b> keyword sets the load-balancing algorithm to one that can be used in tunnel environments or in environments where there are only a few IP source and destination address pairs.</li> <li>The <i>id</i> argument is a fixed identifier.</li> <li>The <b>universal</b> keyword sets the load-balancing algorithm to one that uses a source and destination and an ID hash.</li> <li>The <b>include-ports source</b> keyword sets the load-balancing algorithm to one that uses the source port.</li> <li>The <b>include-ports destination</b> keyword sets the load-balancing algorithm to one that uses the destination port.</li> <li>The <b>include-ports source destination</b> keyword sets the load-balancing algorithm to one that uses the source and destination ports.</li> </ul>
Step 4	<b>end</b>  <b>Example:</b> Router(config)# end	Exits to privileged mode.

## Verifying the Configuration of a Load-Balancing Scheme for Cisco Express Forwarding

To verify the configuration of a load-balancing scheme, perform the following task.

### SUMMARY STEPS

1. **enable**
2. **show cef state**
3. **show ip cef adjacency drop detail**
4. **show ipv6 cef detail**
5. **show cef table**
6. **disable**

### DETAILED STEPS

#### Step 1 **enable**

Use this command to enter privileged EXEC mode. Enter your password, if prompted. For example:

```
Router> enable
Router#
```

#### Step 2 **show cef state**

Use this command to verify that load-balancing algorithm is configured, as you expect. For example:

```
Router# show cef state

CEF Status:
  RP instance
  common CEF enabled
IPv4 CEF Status:
  CEF enabled/running
  dCEF disabled/not running
  CEF switching enabled/running
! The load-balancing scheme configured for IPv4 Cisco Express Forwarding traffic, follows:
  universal per-destination load sharing algorithm, id A189DD49 ! <== scheme for IPv4
  traffic
IPv6 CEF Status:
  CEF enabled/running
  dCEF disabled/not running
The load-balancing scheme configured for IPv6 Cisco Express Forwarding traffic, follows:
  original per-destination load sharing algorithm, id A189DD49
```

#### Step 3 **show ip cef adjacency drop detail**

Use this command to verify that a load-balancing scheme is configured for Cisco Express Forwarding. For example:

```
Router# show ip cef adjacency drop detail

IP CEF with switching (Table Version 4), flags=0x0
  4 routes, 0 reresolve, 0 unresolved (0 old, 0 new), peak 0
  4 leaves, 8 nodes, 8832 bytes, 13 inserts, 9 invalidations
  0 load sharing elements, 0 bytes, 0 references
  universal per-destination load sharing algorithm, id 00B999CA ! <== Load-sharing scheme
  3 CEF resets, 0 revisions of existing leaves
```



```

Resolution Timer: Exponential (currently 1s, peak 1s)
0 in-place modifications
refcounts: 533 leaf, 536 node

10.0.0.0/4, version 3
0 packets, 0 bytes, Precedence routine (0)
via 0.0.0.0, 0 dependencies
next hop 0.0.0.0
valid drop adjacency

```

#### Step 4 show ipv6 cef detail

Use this command to verify that a load-balancing scheme is configured for IPv6 Cisco Express Forwarding traffic. For example:

```
Router# show ipv6 cef detail
```

```

IPv6 CEF is enabled and running
VRF Default:
 20 prefixes (20/0 fwd/non-fwd)
Table id 0, version 20, 0 resets
Database epoch:0 (20 entries at this epoch)
.
.
.
4004::/64, epoch 0, per-destination sharing ! <== Per-destination load-sharing configured
  recursive via 172.11.11.1 label 27
    nexthop 10.1.1.3 Ethernet0/0 label 16
  recursive via 172.30.30.1 label 26
    nexthop 10.1.1.3 Ethernet0/0 label 18

```

#### Step 5 show cef table

Use this command to verify that load-sharing build characteristics are configured for Cisco Express Forwarding. For example:

```
Router# show cef table
```

```

Global information:
Output chain build favors:
 platform:      not configured
 CLI:          not configured
 operational:   convergence-speed
Output chain build characteristics:
 Inplace modify ! <== Build characteristic configured for load-sharing
 operational for: load-sharing
Collapse ! <== Build characteristic configured for load-sharing
 operational for: load-sharing
Indirection
 operational for: recursive-prefix
MTRIE information:
TAL: node pools:
 pool[C/8 bits]: 12 allocated (0 failed), 12480 bytes {1 refcount}
1 active IPv4 table (9 prefixes total) out of a maximum of 10000.
VRF          Prefixes      Memory  Flags
Default          9        13520
1 active IPv6 table (1 prefix total) out of a maximum of 10000.
VRF          Prefixes      Memory  Flags
VRF          Prefixes      Memory  Flags
Default          1         208

```

**Step 6    disable**

Use this command to exit to user EXEC mode. For example:

```
Router# disable
Router>
```

---

## Configuration Examples for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

This section provides the following examples for configuring a load-balancing scheme for Cisco Express Forwarding traffic:

- [Example: Selecting a Cisco Express Forwarding Load-Balancing Algorithm, page 10](#)

### Example: Selecting a Cisco Express Forwarding Load-Balancing Algorithm

The router is set to perform universal load balancing by default.

The following examples show how to select a different Cisco Express Forwarding load-balancing algorithm:

- [Example: Selecting a Tunnel Load-Balancing Algorithm for Cisco Express Forwarding Traffic, page 10](#)
- [Example: Selecting an Include-Ports Layer 4 Load-Balancing Algorithm for Cisco Express Forwarding Traffic, page 11](#)

### Example: Selecting a Tunnel Load-Balancing Algorithm for Cisco Express Forwarding Traffic

The following example shows how to select a tunnel load-balancing algorithm for Cisco Express Forwarding:

```
configure terminal
!
ip cef load-sharing algorithm tunnel
end
```

The following example shows how to disable the tunnel load-balancing algorithm:

```
configure terminal
!
no ip cef load-sharing algorithm tunnel
end
```

## Example: Selecting an Include-Ports Layer 4 Load-Balancing Algorithm for Cisco Express Forwarding Traffic

The following example shows how to select an include-ports Layer 4 load-balancing algorithm for Cisco Express Forwarding traffic:

```
configure terminal
!
ip cef load-sharing algorithm include-ports source
end
```

This example sets up load sharing that includes the source port in the load-balancing decision.

To disable the include-ports Layer 4 load-balancing algorithm and return to the default universal mode, enter the following commands:

```
configure terminal
!
no ip cef load-sharing algorithm
end
```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Commands for configuring and managing Cisco Express Forwarding	<a href="#">Cisco IOS IP Switching Command Reference</a>
List of the features documented in the Cisco Express Forwarding modules	<a href="#">Cisco Express Forwarding Features Roadmap</a>
Overview of the Cisco Express Forwarding feature	<a href="#">Cisco Express Forwarding Overview</a>
Tasks for verifying basic Cisco Express Forwarding and distributed Cisco Express Forwarding operation	<a href="#">Configuring Basic Cisco Express Forwarding for Improved Performance, Scalability, and Resiliency in Dynamic Networks</a>
Tasks for enabling or disabling Cisco Express Forwarding or distributed Cisco Express Forwarding	<a href="#">Enabling or Disabling Cisco Express Forwarding or Distributed Cisco Express Forwarding to Customize Switching and Forwarding for Dynamic Networks</a>
Tasks for configuring Cisco Express Forwarding consistency checkers	<a href="#">Configuring Cisco Express Forwarding Consistency Checkers for Route Processors and Line Cards</a>
Tasks for configuring epochs for Cisco Express Forwarding tables	<a href="#">Configuring Epochs to Clear and Rebuild Cisco Express Forwarding and Adjacency Tables</a>
Tasks for configuring and verifying Cisco Express Forwarding network accounting	<a href="#">Configuring Cisco Express Forwarding Network Accounting</a>
Tasks for customizing the display of Cisco Express Forwarding event trace messages	<a href="#">Customizing the Display of Cisco Express Forwarding Event Trace Messages</a>

## Standards

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

## MIBs

MIB	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 IOS XE software releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

## RFCs

RFC	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.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

# Feature Information for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

Table 1 lists the features in this module.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS XE software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

**Note**

Table 1 lists only the Cisco IOS XE software release that introduced support for a given feature in a given Cisco IOS XE software release train. Unless noted otherwise, subsequent releases of that Cisco IOS XE software release train also support that feature.

**Table 1** Feature Information for Configuring a Load-Balancing Scheme for Cisco Express Forwarding Traffic

Feature Name	Releases	Feature Configuration Information
Cisco Express Forwarding Support for Layer 4 Port-Based Load Balancing	Cisco IOS XE Release 2.1	<p>This feature allows Cisco Express Forwarding to include Layer 4 port information in the decision for load sharing on equal cost paths.</p> <p>In Cisco IOS XE Release 2.1, this feature was introduced on the Cisco ASR 1000 Series Aggregation Services Router.</p> <p>The following sections provide information about this feature:</p> <ul style="list-style-type: none"><li>• <a href="#">Load-Balancing Algorithms for Cisco Express Forwarding Traffic, page 4</a></li><li>• <a href="#">Selecting a Cisco Express Forwarding Load-Balancing Algorithm, page 4</a></li></ul> <p>The following commands were modified by this feature: <b>ip cef load-sharing algorithm</b> and <b>show ip cef exact-route</b>.</p>

# Glossary

**adjacency**—A relationship formed between selected neighboring routers and end nodes for the purpose of exchanging routing information. Adjacency is based upon the use of a common media segment by the routers and nodes involved.

**Cisco Express Forwarding**—A Layer 3 switching technology. Cisco Express Forwarding can also refer to central Cisco Express Forwarding mode, one of two modes of Cisco Express Forwarding operation. Cisco Express Forwarding enables a Route Processor to perform express forwarding. Distributed Cisco Express Forwarding is the other mode of Cisco Express Forwarding operation.

**distributed Cisco Express Forwarding**—A mode of Cisco Express Forwarding operation in which line cards maintain identical copies of the forwarding information base (FIB) and adjacency tables. The line cards perform the express forwarding between port adapters; this relieves the Route Processor of involvement in the switching operation.

**FIB**—forwarding information base. A component of Cisco Express Forwarding that is conceptually similar to a routing table or information base. The router uses the FIB lookup table to make destination-based switching decisions during Cisco Express Forwarding operation. The router maintains a mirror image of the forwarding information in an IP routing table.

**LSP**—label switched path. A sequence of hops (Router 0...Router n). A packet travels from R0 to Rn by means of label switching mechanisms. An LSP can be chosen dynamically, based on normal routing mechanisms, or you can configure the LSP manually.

**prefix**—The network address portion of an IP address. A prefix is specified by a network and mask and is generally represented in the format network/mask. The mask indicates which bits are the network bits. For example, 1.0.0.0/16 means that the first 16 bits of the IP address are masked, making them the network bits. The remaining bits are the host bits. In this example, the network number is 10.0.

**RIB**—Routing Information Base. A central repository of routes that contains Layer 3 reachability.

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