# Configuring Fibre Channel Routing Services and Protocols

This chapter contains the following sections:



# Configuring Fibre Channel Routing Services and Protocols

Fabric Shortest Path First (FSPF) is the standard path selection protocol used by Fibre Channel fabrics. The FSPF feature is enabled by default on the E mode and TE mode Fibre Channel interfaces on Cisco Nexus 5000 Series switches. Except in configurations that require special consideration, you do not need to configure any FSPF services. FSPF automatically calculates the best path between any two switches in a fabric. FSPF provides the following capabilities:

- Dynamically computes routes throughout a fabric by establishing the shortest and quickest path between any two switches.
- Selects an alternative path in the event of the failure of a given path. FSPF supports multiple paths and automatically computes an alternative path around a failed link. It provides a preferred route when two equal paths are available.

## Information About FSPF

FSPF is the protocol currently standardized by the T11 committee for routing in Fibre Channel networks. The FSPF protocol has the following characteristics and features:

- Supports multipath routing.
- Bases path status on a link state protocol.
- Routes hop by hop, based only on the domain ID.
- Runs only on E ports or TE ports and provides a loop free topology.
- Runs on a per VSAN basis. Connectivity in a given VSAN in a fabric is guaranteed only for the switches configured in that VSAN.

- Uses a topology database to keep track of the state of the links on all switches in the fabric and associates a cost with each link.
- Guarantees a fast reconvergence time in case of a topology change. Uses the standard Dijkstra algorithm, but there is a static dynamic option for a more robust, efficient, and incremental Dijkstra algorithm. The reconvergence time is fast and efficient as the route computation is done on a per VSAN basis.

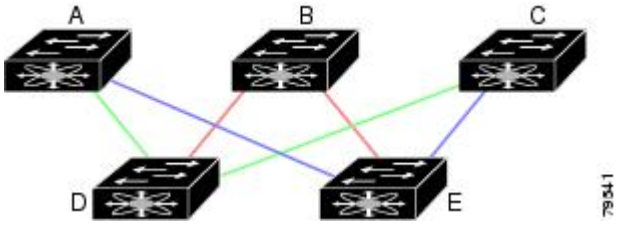
**Note** The FSPF feature can be used on any topology.

## FSPF Examples

### Fault Tolerant Fabric Example

The following figure depicts a fault tolerant fabric using a partial mesh topology. If a link goes down anywhere in the fabric, any switch can still communicate with all others in the fabric. In the same way, if any switch goes down, the connectivity of the rest of the fabric is preserved.

***Figure 1: Fault Tolerant Fabric***




For example, if all links are of equal speed, the FSPF calculates two equal paths from A to C: A-D-C (green) and A-E-C (blue).

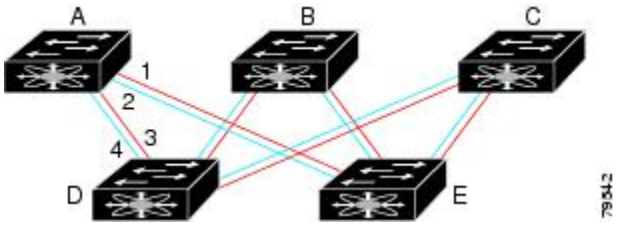
### Redundant Link Example

To improve on the topology, each connection between any pair of switches can be replicated; two or more links can be present between a pair of switches. The following figure shows this arrangement. Because switches in the Cisco Nexus 5000 Series support SAN port channels, each pair of physical links can appear to the FSPF protocol as one single logical link.

By bundling pairs of physical links, FSPF efficiency is considerably improved by the reduced database size and the frequency of link updates. Once physical links are aggregated, failures are not attached to a single link but to the entire SAN port channel. This configuration also improves the resiliency of the network. The

failure of a link in a SAN port channel does not trigger a route change, which reduces the risks of routing loops, traffic loss, or fabric downtime for route reconfiguration.

***Figure 2: Fault Tolerant Fabric with Redundant Links***




For example, if all links are of equal speed and no SAN port channels exist, the FSPF calculates four equal paths from A to C: A1-E-C, A2-E-C, A3-D-C, and A4-D-C. If SAN port channels exist, these paths are reduced to two.

# FSPF Global Configuration

By default, FSPF is enabled on switches in the Cisco Nexus 5000 Series .

Some FSPF features can be globally configured in each VSAN. By configuring a feature for the entire VSAN, you do not have to specify the VSAN number for every command. This global configuration feature also reduces the chance of typing errors or other minor configuration errors.

**Note** FSPF is enabled by default. Generally, you do not need to configure these advanced features.

**Caution** The default for the backbone region is 0 (zero). You do not need to change this setting unless your region is different from the default. If you are operating with other vendors using the backbone region, you can change this default to be compatible with those settings.

## About SPF Computational Hold Times

The SPF computational hold time sets the minimum time between two consecutive SPF computations on the VSAN. Setting this to a small value means that FSPF reacts faster to any fabric changes by recomputing paths on the VSAN. A small SPF computational hold time uses more switch CPU time.

## About Link State Records

Each time a new switch enters the fabric, a link state record (LSR) is sent to the neighboring switches, and then flooded throughout the fabric.

The following table displays the default settings for switch responses.

*Table 1: LSR Default Settings*

| LSR Option | Default | Description |
|---|---|---|
| Acknowledgment interval (RxmtInterval) | 5 seconds | The time a switch waits for an acknowledgment from the LSR before retransmission. |
| Refresh time (LSRefreshTime) | 30 minutes | The time a switch waits before sending an LSR refresh transmission. |
| Maximum age (MaxAge) | 60 minutes | The time a switch waits before dropping the LSR from the database. |

The LSR minimum arrival time is the period between receiving LSR updates on this VSAN. Any LSR updates that arrive before the LSR minimum arrival time are discarded.

The LSR minimum interval time is the frequency at which this switch sends LSR updates on a VSAN.

## Configuring FSPF on a VSAN

To configure an FSPF feature for the entire VSAN, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **fspf config vsan** *vsan-id* | Enters FSPF global configuration mode for the specified VSAN. |
| **Step 3** | switch-config-(fspf-config)# **spf static** | Forces static SPF computation for the dynamic (default) incremental VSAN. |
| **Step 4** | switch-config-(fspf-config)# **spf hold-time** *value* | Configures the hold time between two route computations in milliseconds (msec) for the entire VSAN. The default value is 0.<br>**Note** If the specified time is shorter, the routing is faster. However, the processor consumption increases accordingly. |
| **Step 5** | switch-config-(fspf-config)# **region** *region-id* | Configures the autonomous region for this VSAN and specifies the region ID. |

## Resetting FSPF to the Default Configuration

To return the FSPF VSAN global configuration to its factory default, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **no fspf config vsan** *vsan-id* | Deletes the FSPF configuration for the specified VSAN. |

## Enabling or Disabling FSPF

To enable or disable FSPF routing protocols, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **fspf enable vsan** *vsan-id* | Enables the FSPF routing protocol in the specified VSAN. |
| **Step 3** | switch(config)# **no fspf enable vsan** *vsan-id* | Disables the FSPF routing protocol in the specified VSAN. |

## Clearing FSPF Counters for the VSAN

To clear the FSPF statistics counters for the entire VSAN, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **clear fspf counters vsan** *vsan-id* | Clears the FSPF statistics counters for the specified VSAN. If an interface reference is not specified, all counters are cleared. |

# FSPF Interface Configuration

Several FSPF commands are available on a per-interface basis. These configuration procedures apply to an interface in a specific VSAN.

## About FSPF Link Cost

FSPF tracks the state of links on all switches in the fabric, associates a cost with each link in its database, and then chooses the path with a minimal cost. The cost associated with an interface can be administratively changed to implement the FSPF route selection. The integer value to specify cost can range from 1 to 65,535. The default cost for 1 Gbps is 1000 and for 2 Gbps is 500.

## Configuring FSPF Link Cost

To configure FSPF link cost, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **interface fc** *slot*/*port* | Configures the specified interface, or if already configured, enters configuration mode for the specified interface. |
| **Step 3** | switch(config-if)# **fspf cost** *value* **vsan** *vsan-id* | Configures the cost for the selected interface in the specified VSAN. |

## About Hello Time Intervals

You can set the FSPF Hello time interval to specify the interval between the periodic hello messages sent to verify the health of the link. The integer value can range from 1 to 65,535 seconds.

**Note** This value must be the same in the ports at both ends of the ISL.

## Configuring Hello Time Intervals

To configure the FSPF Hello time interval, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **interface fc** *slot*/*port* | Configures the specified interface, or if already configured, enters configuration mode for the specified interface. |
| **Step 3** | switch(config-if)# **fspf hello-interval** *value* **vsan** *vsan-id* | Specifies the hello message interval to verify the health of the link in VSAN 175. The default is 20 seconds. |

## About Dead Time Intervals

You can set the FSPF dead time interval to specify the maximum interval for which a hello message must be received before the neighbor is considered lost and removed from the database. The integer value can range from 1 to 65,535 seconds.

**Note** This value must be the same in the ports at both ends of the ISL.

**Caution** An error is reported at the command prompt if the configured dead time interval is less than the hello time interval.

## Configuring Dead Time Intervals

To configure the FSPF dead time interval, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **interface fc** *slot*/*port* | Configures the specified interface, or if already configured, enters configuration mode for the specified interface. |
| **Step 3** | switch(config-if)# **fspf dead-interval** *value* **vsan** *vsan-id* | Specifies the maximum interval for the specified VSAN before which a hello message must be received on the selected interface before the neighbor is considered lost. The default is 80 seconds. |

## About Retransmitting Intervals

You can specify the time after which an unacknowledged link state update should be transmitted on the interface. The integer value to specify retransmit intervals can range from 1 to 65,535 seconds.

**Note** This value must be the same on the switches on both ends of the interface.

## Configuring Retransmitting Intervals

To configure the FSPF retransmit time interval, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **interface fc** *slot*/*port* | Configures the specified interface, or if already configured, enters configuration mode for the specified interface. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 3** | switch(config-if)# **fspf retransmit-interval** *value* **vsan** *vsan-id* | Specifies the retransmit time interval for unacknowledged link state updates in the specified VSAN. The default is 5 seconds. |

## About Disabling FSPF for Specific Interfaces

You can disable the FSPF protocol for selected interfaces. By default, FSPF is enabled on all E ports and TE ports. This default can be disabled by setting the interface as passive.

**Note** FSPF must be enabled at both ends of the interface for the protocol to work.

## Disabling FSPF for Specific Interfaces

You can disable the FSPF protocol for selected interfaces. By default, FSPF is enabled on all E ports and TE ports. This default can be disabled by setting the interface as passive.

To disable FSPF for a specific interface, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **interface fc** *slot*/*port* | Configures a specified interface, or if already configured, enters configuration mode for the specified interface. |
| **Step 3** | switch(config-if)# **fspf passive vsan** *vsan-id* | Disables the FSPF protocol for the specified interface in the specified VSAN. |
| **Step 4** | switch(config-if)# **no fspf passive vsan** *vsan-id* | Reenables the FSPF protocol for the specified interface in the specified VSAN. |

## Clearing FSPF Counters for an Interface

To clear the FSPF statistics counters for an interface, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **clear fspf counters vsan** *vsan-id* **interface fc** *slot*/*port* | Clears the FSPF statistics counters for the specified interface in the specified VSAN. |

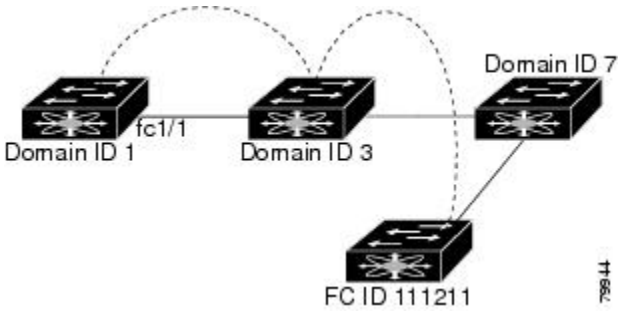
# FSPF Routes

FSPF routes traffic across the fabric, based on entries in the FSPF database. These routes can be learned dynamically, or configured statically.

## About Fibre Channel Routes

Each port implements forwarding logic, which forwards frames based on its FC ID. Using the FC ID for the specified interface and domain, you can configure the specified route (for example, FC ID 111211 and domain ID 3) in the switch with domain ID 1 (see the following figure).

***Figure 3: Fibre Channel Routes***




## Configuring Fibre Channel Routes

To configure a Fibre Channel route, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)#**fcroute** *fcid* **interface fc** *slot*/*port* **domain** *domain-id* **vsan** *vsan-id* | Configures the route for the specified Fibre Channel interface and domain. In this example, the specified interface is assigned an FC ID and a domain ID to the next hop switch. |
| **Step 3** | switch(config)#**fcroute** *fcid* **interface san-port-channel** *port* **domain** *domain-id* **vsan** *vsan-id* | Configures the route for the specified SAN port channel interface and domain. In this example, interface san-port-channel 1 is assigned an FC ID (0x111211) and a domain ID to the next hop switch. |
| **Step 4** | switch(config)# **fcroute** *fcid* **interface fc** *slot*/*port* **domain** *domain-id* **metric** *value* **vsan** *vsan-id* | Configures the static route for a specific FC ID and next hop domain ID and also assigns the cost of the route.<br>If the remote destination option is not specified, the default is direct. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 5** | switch(config)#**fcroute** *fcid* **interface fc** *slot*/*port* **domain** *domain-id* **metric** *value* **remote vsan** *vsan-id* | Adds a static route to the RIB. If this is an active route and the FIBFIB = Forwarding Information Base records are free, it is also added to the FIB.<br>If the cost (metric) of the route is not specified, the default is 10. |
| **Step 6** | switch(config)#**fcroute** *fcid netmask* **interface fc** *slot*/*port* **domain** *domain-id* **vsan** *vsan-id* | Configures the netmask for the specified route the in interface (or SAN port channel). You can specify one of three routes: 0xff0000 matches only the domain, 0xffff00 matches the domain and the area, 0xffffff matches the domain, area, and port. |

# In-Order Delivery

In-order delivery (IOD) of data frames guarantees frame delivery to a destination in the same order that they were sent by the originator.

Some Fibre Channel protocols or applications cannot handle out-of-order frame delivery. In these cases, switches in the Cisco Nexus 5000 Series preserve frame ordering in the frame flow. The source ID (SID), destination ID (DID), and optionally the originator exchange ID (OX ID) identify the flow of the frame.

On a switch with IOD enabled, all frames received by a specific ingress port and destined to a certain egress port are always delivered in the same order in which they were received.

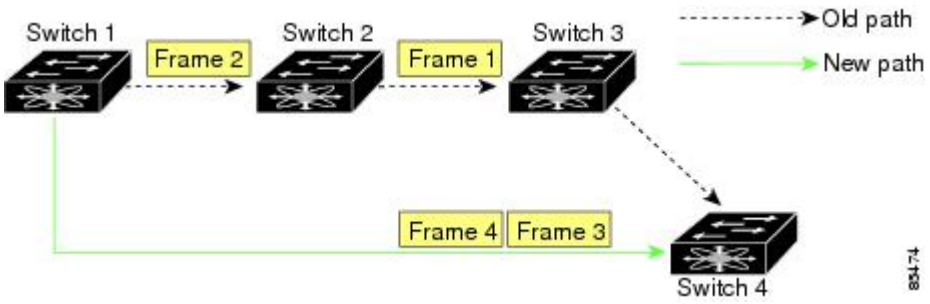
Use IOD only if your environment cannot support out-of-order frame delivery.

If you enable the in-order delivery feature, the graceful shutdown feature is not implemented.

## About Reordering Network Frames

When you experience a route change in the network, the new selected path may be faster or less congested than the old route.

***Figure 4: Route Change Delivery***




In the figure above, the new path from Switch 1 to Switch 4 is faster. In this scenario, Frame 3 and Frame 4 may be delivered before Frame 1 and Frame 2.

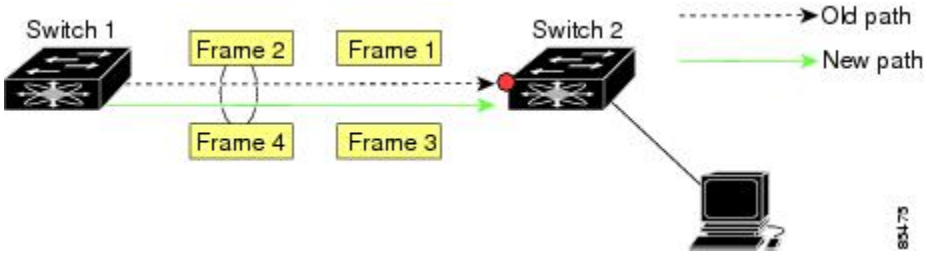
If the in-order guarantee feature is enabled, the frames within the network are delivered as follows:

- Frames in the network are delivered in the order in which they are transmitted.
- Frames that cannot be delivered in order within the network latency drop period are dropped inside the network.

## About Reordering SAN Port Channel Frames

When a link change occurs in a SAN port channel, the frames for the same exchange or the same flow can switch from one path to another faster path.

***Figure 5: Link Congestion Delivery***




In the figure above, the port of the old path (red dot) is congested. In this scenario, Frame 3 and Frame 4 can be delivered before Frame 1 and Frame 2.

When the in-order delivery feature is enabled and a port channel link change occurs, the frames crossing the SAN port channel are delivered as follows:

- Frames using the old path are delivered before new frames are accepted.
- The new frames are delivered through the new path after the network latency drop period has elapsed and all old frames are flushed.

Frames that cannot be delivered in order through the old path within the network latency drop period are dropped.

### Related Topics

- Configuring the Drop Latency Time, page 13

## About Enabling In-Order Delivery

You can enable the in-order delivery feature for a specific VSAN or for the entire switch. By default, in-order delivery is disabled on switches in the Cisco Nexus 5000 Series.

We recommend that you only enable this feature when devices that cannot handle any out-of-order frames are present in the switch. Load-balancing algorithms within the Cisco Nexus 5000 Series switch ensure that frames are delivered in order during normal fabric operation. The load-balancing algorithms based on source FC ID, destination FC ID, and exchange ID are enforced in hardware without any performance degradation. However, if the fabric encounters a failure and the in-order delivery feature is enabled, the recovery will be delayed because of an intentional pausing of fabric forwarding to purge the fabric of resident frames that could potentially be forwarded out-of-order.

## Enabling In-Order Delivery Globally

To ensure that the in-order delivery parameters are uniform across all VSANs on the switch, enable in-order delivery globally.

Only enable in-order delivery globally if this is a requirement across your entire fabric. Otherwise, enable IOD only for the VSANs that require this feature.

To enable in-order delivery for the switch, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **in-order-guarantee** | Enables in-order delivery in the switch. |
| **Step 3** | switch(config)# **no in-order-guarantee** | Reverts the switch to the factory defaults and disables the in-order delivery feature. |

## Enabling In-Order Delivery for a VSAN

When you create a VSAN, that VSAN automatically inherits the global in-order guarantee value. You can override this global value by enabling or disabling in-order guarantee for the new VSAN.

To use the lowest domain switch for the multicast tree computation, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **in-order-guarantee vsan** *vsan-id* | Enables in-order delivery in the specified VSAN. |
| **Step 3** | switch(config)# **no in-order-guarantee vsan** *vsan-id* | Reverts the switch to the factory defaults and disables the in-order delivery feature in the specified VSAN. |

## Displaying the In-Order Delivery Status

Use the **show in-order-guarantee** command to display the present configuration status:

```
switch# show in-order-guarantee
global inorder delivery configuration:guaranteed
VSAN specific settings
vsan 1 inorder delivery:guaranteed
vsan 101 inorder delivery:not guaranteed
vsan 1000 inorder delivery:guaranteed
vsan 1001 inorder delivery:guaranteed
vsan 1682 inorder delivery:guaranteed
vsan 2001 inorder delivery:guaranteed
vsan 2009 inorder delivery:guaranteed
vsan 2456 inorder delivery:guaranteed
vsan 3277 inorder delivery:guaranteed
vsan 3451 inorder delivery:guaranteed
vsan 3452 inorder delivery:guaranteed
```

## Configuring the Drop Latency Time

You can change the default latency time for a network, a specified VSAN in a network, or for the entire switch.

To configure the network and the switch drop latency time, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **fcdroplatency network** *value* | Configures network drop latency time for the network. The valid range is 0 to 60000 msec. The default is 2000 msec.<br>**Note** The network drop latency must be computed as the sum of all switch latencies of the longest path in the network. |
| **Step 3** | switch(config)# **fcdroplatency network** *value* **vsan** *vsan-id* | Configures network drop latency time for the specified VSAN. |
| **Step 4** | switch(config)# **no fcdroplatency network** *value* | Removes the current fcdroplatecy network configuration and reverts the switch to the factory defaults. |

## Displaying Latency Information

You can view the configured latency parameters using the **show fcdroplatency** command, The following example shows how to display network latency information:

```
switch# show fcdroplatency
switch latency value:500 milliseconds
global network latency value:2000 milliseconds
VSAN specific network latency settings
vsan 1 network latency:5000 milliseconds
vsan 2 network latency:2000 milliseconds
vsan 103 network latency:2000 milliseconds
vsan 460 network latency:500 milliseconds
```

# Flow Statistics Configuration

Flow statistics count the ingress traffic in the aggregated statistics table. You can collect two kinds of statistics:

- Aggregated flow statistics to count the traffic for a VSAN.
- Flow statistics to count the traffic for a source and destination ID pair in a VSAN.

## About Flow Statistics

If you enable flow counters, you can enable a maximum of 1000 entries for aggregate flow and flow statistics. Be sure to assign an unused flow index for each new flow. The number space for flow index is shared between the aggregate flow statistics and the flow statistics.

## Counting Aggregated Flow Statistics

To count the aggregated flow statistics for a VSAN, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **fcflow stats aggregated index** *value* **vsan** *vsan-id* | Enables the aggregated flow counter. |
| **Step 3** | switch(config)# **no fcflow stats aggregated index** *value* **vsan** *vsan-id* | Disables the aggregated flow counter. |

## Counting Individual Flow Statistics

To count the flow statistics for a source and destination FC ID in a VSAN, perform this task:

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | switch# **configuration terminal** | Enters configuration mode. |
| **Step 2** | switch(config)# **fcflow stats index** *value dest-fcid source-fcid netmask* **vsan** *vsan-id* | Enables the flow counter.<br>**Note** The source ID and the destination ID are specified in FC ID hex format (for example, 0x123aff). The mask can be one of 0xff0000 or 0xffffff. |
| **Step 3** | switch(config)# **no fcflow stats aggregated index** *value* **vsan** *vsan-id* | Disables the flow counter. |

## Clearing FIB Statistics

Use the **clear fcflow stats** command to clear the aggregated flow counter. The following example clears the aggregated flow counters:

```
switch# clear fcflow stats aggregated index 1
```

The following example clears the flow counters for source and destination FC IDs:

```
switch# clear fcflow stats index 1
```

## Displaying Flow Statistics

Use the **show fcflow stats** commands to view flow statistics. The following example displays the aggregated flow summary:

```
switch# show fcflow stats aggregated
Idx       VSAN     frames
---------- ---------- ----------
         6          1      42871
```

The following example displays the flow statistics:

```
switch# show fcflow stats
```

The following example displays flow index usage:

```
switch# show fcflow stats usage
2 flows configured
Configured flows : 3,7
```

The following example shows how to display global FSPF information for a specific VSAN:

```
switch# show fspf vsan 1
```

The following example shows how to display a summary of the FSPF database for a specified VSAN. If no additional parameters are specified, all LSRs in the database are displayed:

```
switch# show fspf database vsan 1
```

The following example shows how to display FSPF interface information:

```
switch# show fspf vsan 1 interface fc2/1
```

# Default FSPF Settings

The following table lists the default settings for FSPF features.

***Table 2: Default FSPF Settings***

| Parameters | Default |
|---|---|
| FSPF | Enabled on all E ports and TE ports. |
| SPF computation | Dynamic. |
| SPF hold time | 0. |
| Backbone region | 0. |
| Acknowledgment interval (RxmtInterval) | 5 seconds. |
| Refresh time (LSRefreshTime) | 30 minutes. |

| Parameters | Default |
|---|---|
| Maximum age (MaxAge) | 60 minutes. |
| Hello interval | 20 seconds. |
| Dead interval | 80 seconds. |
| Distribution tree information | Derived from the principal switch (root node). |
| Routing table | FSPF stores up to 16 equal cost paths to a given destination. |
| Load balancing | Based on destination ID and source ID on different, equal cost paths. |
| In-order delivery | Disabled. |
| Drop latency | Disabled. |
| Static route cost | If the cost (metric) of the route is not specified, the default is 10. |
| Remote destination switch | If the remote destination switch is not specified, the default is direct. |
| Multicast routing | Uses the principal switch to compute the multicast tree. |