CHAPTER 22

Configuring Fibre Channel Routing Services and Protocols

This chapter describes Fibre Channel routing services and protocols.

This chapter includes the following sections:

Information About FSPF

Fabric Shortest Path First (FSPF) is the standard path selection protocol used by Fibre Channel fabrics. The FSPF feature is enabled by default on all Fibre Channel 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 these features:

- Dynamically compute routes throughout a fabric by establishing the shortest and quickest path between any two switches.
- Select 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.

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.

This section includes the following topics:

FSPF Global Configuration

By default, FSPF is enabled on switches in the Cisco MDS 9000 Family.

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 Record Defaults

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. Table 22-1 displays the default settings for switch responses.

Table 22-1 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.

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.

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.

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.

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.

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.

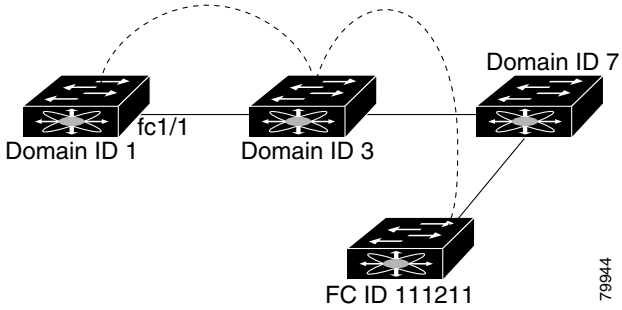
FSPF Routes

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 Figure 22-1).

Figure 22-1 Fibre Channel Routes



Note Other than in VSANs, runtime checks are not performed on configured and suspended static routes.

About Broadcast and Multicast Routing

Broadcast and multicast in a Fibre Channel fabric uses the concept of a distribution tree to reach all switches in the fabric.

FSPF provides the topology information to compute the distribution tree. Fibre Channel defines 256 multicast groups and one broadcast address for each VSAN. Switches in the Cisco MDS 9000 Family only use broadcast routing. By default, they use the principal switch as the root node to derive a loop-free distribution tree for multicast and broadcast routing in a VSAN.

Caution All switches in the fabric should run the same multicast and broadcast distribution tree algorithm to ensure the same distribution tree.

To interoperate with other vendor switches (following FC-SW3 guidelines), the Cisco SAN-OS and Cisco NX-OS Release 4.1(1b) and later releases uses the lowest domain switch as the root to compute the multicast tree in interop mode.

About Multicast Root Switch

By default, the native (non-interop) mode uses the principal switch as the root. If you change the default, be sure to configure the same mode in all switches in the fabric. Otherwise, multicast traffic could encounter potential loop and frame-drop problems.

Note The operational mode can be different from the configured interop mode. The interop mode always uses the lowest domain switch as the root.

Use the **mcast root lowest vsan** command to change the multicast root from the principal switch to lowest domain switch.

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 MDS 9000 Family 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 any given 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.

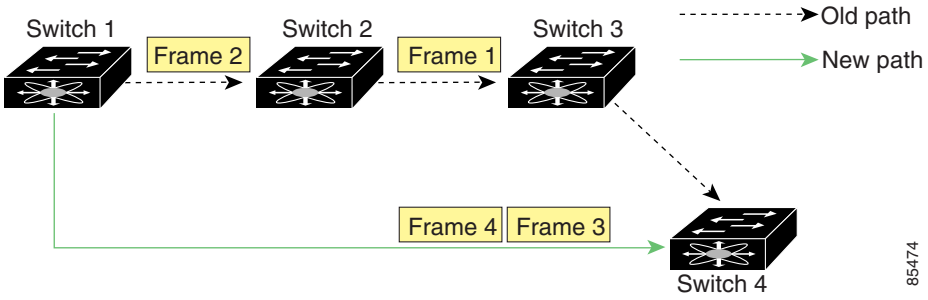
Use IOD only if your environment cannot support out-of-order frame delivery.

Tip 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 22-2 Route Change Delivery



In Figure 22-2, 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.

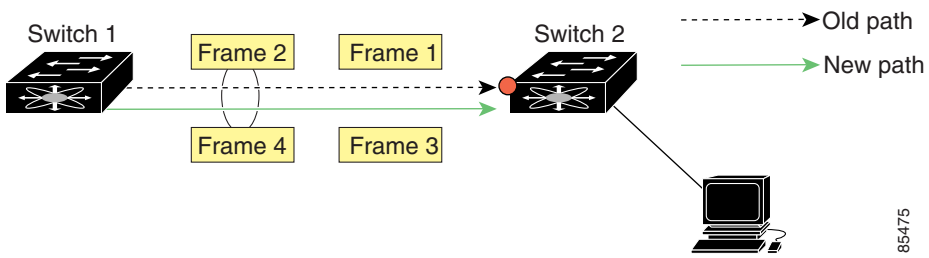
If the in-order guarantee feature is enabled, the frames within the network are treated as follows:

- 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 PortChannel Frames

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

Figure 22-3 Link Congestion Delivery



In Figure 22-3, 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.

The in-order delivery feature attempts to minimize the number of frames dropped during PortChannel link changes when the in-order delivery is enabled by sending a request to the remote switch on the PortChannel to flush all frames for this PortChannel.

Note Both switches on the PortChannel must be running Cisco SAN-OS Release 3.0(1) for this IOD enhancement. For earlier releases, IOD waits for the switch latency period before sending new frames.

When the in-order delivery guarantee feature is enabled and a PortChannel link change occurs, the frames crossing the PortChannel are treated 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 switch latency drop period has elapsed and all old frames are flushed.

Frames that cannot be delivered in order through the old path within the switch latency drop period are dropped. See the "Configuring the Drop Latency Time" section on page 22-17.

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 MDS 9000 Family.

Tip 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 MDS 9000 Family 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 this 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.

About Flow Statistics

If you enable flow counters, you can enable a maximum of 1 K entries for aggregate flow and flow statistics for Generation 1 modules, and 2 K entries for Generation 2 modules. Be sure to assign an unused flow index to a module for each new flow. Flow indexes can be repeated across modules. The number space for flow index is shared between the aggregate flow statistics and the flow statistics.

Generation 1 modules allow a maximum of 1024 flow statements per module. Generation 2 modules allow a maximum of 2048-128 flow statements per module.

Note For each session, fcflow counter will increment only on locally connected devices and should be configured on the switch where the initiator is connected.

Licensing Requirements for FSPF

The following table shows the licensing requirements for this feature:

License	License Description
ENTERPRISE_PKG	The enterprise license is required to enable Fibre Channel routing services and protocols. For a complete explanation of the licensing scheme, see the *Cisco MDS 9000 Family NX-OS Licensing Guide*.

Default Settings

Table 22-2 lists the default settings for FSPF features.

Table 22-2 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.
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.

Table 22-2 Default FSPF Settings (continued)

Parameters	Default
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.

Configuring FSPF

This section includes the following topics:

Configuring FSPF on a VSAN

To configure an FSPF feature for the entire VSAN, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# fspf config vsan 1`	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.

	Command	Purpose
Step 4	`switch-config-(fspf-config)# spf hold-time 10`	Configures the hold time between two route computations in milliseconds (msec) for the entire VSAN. The default value is 0. **Note** If the specified time is shorter, the routing is faster. However, the processor consumption increases accordingly.
Step 5	`switch-config-(fspf-config)# region 7`	Configures the autonomous region for this VSAN and specifies the region ID (7).

To configure an FSPF feature for the entire VSAN, follow these steps:

Step 1 Expand a Fabric, expand a VSAN and select **FSPF** for a VSAN that you want to configure for FSPF.

You see the FSPF configuration in the Information pane.

Step 2 The RegionID, Spf Comp Holdtime, LSR Min Arrival, and LSR Min Interval field values are applied across all interfaces on the VSAN. You can change them here or, if they do not exist create them here.

Step 3 Click **Apply Changes** to save these changes, or click **Undo Changes** to discard any unsaved changes.

Resetting FSPF to the Default Configuration

To return the FSPF VSAN global configuration to its factory default, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# no fspf config vsan 3`	Deletes the FSPF configuration for VSAN 3.

To return the FSPF VSAN global configuration to its factory default, follow these steps:

Step 1 Expand a Fabric, expand a VSAN, and select **FSPF** for a VSAN that you want to configure for FSPF.

You see the FSPF configuration in the Information pane.

Step 2 Check the **SetToDefault** check box for a switch.

Step 3 Click **Apply Changes** to save these changes, or click **Undo Changes** to discard any unsaved changes.

Enabling or Disabling FSPF

To enable or disable FSPF routing protocols, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# fspf enable vsan 7`	Enables the FSPF routing protocol in VSAN 7.
	`switch(config)# no fspf enable vsan 5`	Disables the FSPF routing protocol in VSAN 5.

To enable or disable FSPF, follow these steps:

Step 1 Expand a Fabric, expand a VSAN, and select **FSPF** for a VSAN that you want to configure for FSPF.

You see the FSPF configuration in the Information pane.

Step 2 Set the Status Admin drop-down menu to **up** to enable FSPF or to **down** to disable FSPF.

Step 3 Click **Apply Changes** to save these changes, or click **Undo Changes** to discard any unsaved changes.

Clearing FSPF Counters for the VSAN

To clear the FSPF statistics counters for the entire VSAN, follow this step:

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

Configuring FSPF Link Cost

To configure FSPF link cost, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# interface fc1/4` `switch(config-if)#`	Configures the specified interface, or if already configured, enters configuration mode for the specified interface.
Step 3	`switch(config-if)# fspf cost 5 vsan 90`	Configures the cost for the selected interface in VSAN 90.

To configure FSPF link cost, follow these steps:

Step 1 Expand **Switches**, expand FC **Interfaces,** and then select **Physical**.

You see the interface configuration in the Information pane.

Step 2 Click the **FSPF** tab.

You see the FSPF interface configuration in the Information pane.

Step 3 Double-click in the Cost field of a switch and change the value.

Step 4 Click **Apply Changes** to save these changes, or click **Undo Changes** to discard any unsaved changes.

Configuring Hello Time Intervals

To configure the FSPF Hello time interval, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# interface fc1/4` `switch(config-if)#`	Configures the specified interface, or if already configured, enters configuration mode for the specified interface.
Step 3	`switch(config-if)# fspf hello-interval 15 vsan 175` `switch(config-if)#`	Specifies the hello message interval (15 seconds) to verify the health of the link in VSAN 175. The default is 20 seconds.

To configure the FSPF Hello time interval, follow these steps:

Step 1 Expand **Switches**, expand FC **Interfaces,** and then select **Physical**.

You see the interface configuration in the Information pane.

Step 2 Click the **FSPF** tab.

You see the FSPF interface configuration in the Information pane.

Step 3 Change the Hello Interval field for a switch.

Step 4 Click **Apply Changes** to save these changes, or click **Undo Changes** to discard any unsaved changes.

Configuring Dead Time Intervals

To configure the FSPF dead time interval, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# interface fc1/4` `switch(config-if)#`	Configures the specified interface, or if already configured, enters configuration mode for the specified interface.
Step 3	`switch(config-if)# fspf dead-interval 25 vsan 7` `switch(config-if)#`	Specifies the maximum interval for VSAN 7 before which a hello message must be received on the selected interface before the neighbor is considered lost. The default is 80 seconds.

To configure the FSPF dead time interval, follow these steps:

Step 1 Expand **Switches**, expand FC **Interfaces,** and then select **Physical**.

You see the interface configuration in the Information pane.

Step 2 Click the **FSPF** tab.

You see the FSPF interface configuration in the Information pane.

Step 3 Double-click the Dead Interval field for a switch and provide a new value.

Step 4 Click **Apply Changes** to save these changes, or click **Undo Changes** to discard any unsaved changes.

Configuring Retransmitting Intervals

To configure the FSPF retransmit time interval, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# interface fc1/4` `switch(config-if)#`	Configures the specified interface, or if already configured, enters configuration mode for the specified interface.
Step 3	`switch(config-if)# fspf retransmit-interval 15 vsan 12` `switch(config-if)#`	Specifies the retransmit time interval for unacknowledged link state updates in VSAN 12. The default is 5 seconds.

To configure the FSPF retransmit time interval, follow these steps:

Step 1 Expand **Switches**, expand FC **Interfaces**, and then select **Physical**.

You see the interface configuration in the Information pane.

Step 2 Click the **FSPF** tab.

You see the FSPF interface configuration in the Information pane.

Step 3 Double-click the ReTx Interval field and enter a value.

Step 4 Click **Apply Changes** to save these changes, or click **Undo Changes** to discard any unsaved changes.

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.

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, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# interface fc1/4` `switch(config-if)#`	Configures a specified interface, or if already configured, enters configuration mode for the specified interface.
Step 3	`switch(config-if)# fspf passive vsan 1` `switch(config-if)#`	Disables the FSPF protocol for the specified interface in the specified VSAN.
	`switch(config-if)# no fspf passive vsan 1` `switch(config-if)#`	Reenables the FSPF protocol for the specified interface in the specified VSAN.

To disable FSPF for a specific interface, follow these steps:

Step 1 Expand **Switches**, expand FC **Interfaces,** and then select **Physical**.

You see the interface configuration in the Information pane.

Step 2 Click the **FSPF** tab.

You see the FSPF interface configuration in the Information pane.

Step 3 Set a switch Admin Status drop-down menu to **down**.

Step 4 Click **Apply Changes** to save these changes, or click **Undo Changes** to discard any unsaved changes.

Clearing FSPF Counters for an Interface

To clear the FSPF statistics counters for an interface, follow this step:

	Command	Purpose
Step 1	`switch# clear fspf counters vsan 200 interface fc1/1`	Clears the FSPF statistics counters for the specified interface in VSAN 200.

Configuring Fibre Channel Routes

To configure a Fibre Channel route, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# fcroute 0x111211 interface fc1/1 domain 3 vsan 2` `switch(config)#`	Configures the route for the specified Fibre Channel interface and domain. In this example, interface fc1/1 is assigned an FC ID (0x111211) and a domain ID (3) to the next hop switch.
	`switch(config)# fcroute 0x111211 interface port-channel 1 domain 3 vsan 4` `switch(config)#`	Configures the route for the specified PortChannel interface and domain. In this example, interface port-channel 1 is assigned an FC ID (0x111211) and a domain ID (3) to the next hop switch.
	`switch(config)# fcroute 0x031211 interface fc1/1 domain 3 metric 1 vsan 1` `switch(config-if)#`	Configures the static route for a specific FC ID and next hop domain ID and also assigns the cost of the route. If the remote destination option is not specified, the default is direct.
	`switch(config)# fcroute 0x111112 interface fc1/1 domain 3 metric 3 remote vsan 3`	Adds a static route to the RIB. If this is an active route and the FIB[1] records are free, it is also added to the FIB. If the cost (metric) of the route is not specified, the default is 10.
Step 3	`switch(config)# fcroute 0x610000 0xff0000 interface fc 1/1 domain 1 vsan 2` `switch(config)#`	Configures the netmask for the specified route in interface fc1/1 (or PortChannel). 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.

1. FIB = Forwarding Information Base

If you disable FSPF, you can manually configure a Fibre Channel route.

To configure a Fibre Channel route using Device Manager, follow these steps:

Step 1 Click **FC > Advanced > Routes**.

You see the FC Static Route Configuration dialog box.

Step 2 Click **Create** to create a static route.

You see the Create Route dialog box.

Step 3 Select the VSAN ID that you are configuring this route.

Step 4 Fill in the destination address and destination mask for the device you are configuring a route.

Step 5 Select the interface that you want to use to reach this destination.

Step 6 Select the next hop domain ID and route metric.

Step 7 Select either the **local** or **remote** radio button.

Step 8 Click **Create** to save these changes or click **Close** to discard any unsaved changes.

Setting the Multicast Root Switch

To use the lowest domain switch for the multicast tree computation, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# mcast root lowest vsan 1`	Uses the lowest domain switch to compute the multicast tree.
	`switch(config)# mcast root principal vsan 1`	Defaults to using the principal switch to compute the multicast tree.

To display the configured and operational multicast mode and the selected root domain, use the **show mcast** command.

```
switch# show mcast vsan 1
Multicast root for VSAN 1
       Configured root mode : Principal switch
       Operational root mode : Principal switch
       Root Domain ID : 0xef(239)
```

To use the lowest domain switch for the multicast tree computation, follow these steps:

Step 1 Expand a fabric, expand a VSAN, and then select **Advanced** for the VSAN that you want to configure FSPF on.

You see the advanced Fibre Channel configuration in the Information pane.

Step 2 Click the **Multicast Root** tab.

You see the multicast root configuration in the Information pane.

Step 3 Set the Config Mode drop-down menu to **lowestDomainSwitch**.

Step 4 Click **Apply Changes** to save these changes or click **Undo Changes** to discard any unsaved changes.

Enabling In-Order Delivery Globally

To ensure that the in-order delivery parameters are uniform across all VSANs on an Cisco MDS 9000 Family 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.

Note Enable in-order delivery on the entire switch before performing a downgrade to Cisco MDS SAN-OS Release 1.3(3) or earlier.

To enable in-order delivery for the switch, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# in-order-guarantee`	Enables in-order delivery in the switch.
	`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, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# in-order-guarantee vsan 3452`	Enables in-order delivery in VSAN 3452.
	`switch(config)# no in-order-guarantee vsan 101`	Reverts the switch to the factory defaults and disables the in-order delivery feature in VSAN 101.

To use the lowest domain switch for the multicast tree computation, follow these steps:

Step 1 Expand a fabric and select **All VSANS**.

Step 2 Select the **Attributes** tab.

You see the general VSAN attributes in the Information pane.

Step 3 Check the **InOrder Delivery** check box to enable IOD for the switch.

Step 4 Click **Apply Changes** to save these changes, or click **Undo Changes** to discard any unsaved changes.

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, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# fcdroplatency network 5000`	Configures network drop latency time to be 5000 msec for the network. The valid range is 0 to 60000 msec. The default is 2000 msec. **Note** The network drop latency must be computed as the sum of all switch latencies of the longest path in the network.
	`switch(config)# fcdroplatency network 6000 vsan 3`	Configures network drop latency time to be 6000 msec for VSAN 3.
	`switch(config)# no fcdroplatency network 4500`	Removes the current fcdroplatecy network configuration (4500) and reverts the switch to the factory defaults.
Step 3	`switch(config)# fcdroplatency switch 4000`	Configures switch drop latency time to be 4000 msec for the switch. The valid range is 0 to 60000 msec. The default is 500 msec. **Note** The switch drop latency parameter should have the same value in all the switches in the network.
	`switch(config)# no fcdroplatency switch 4500`	Removes the current fcdroplatecy switch configuration (4500) and reverts the switch to the factory defaults.

To configure the drop latency time for a switch, follow these steps:

Step 1 Expand a fabric and select **All VSANS**.

You see the VSAN configuration in the Information pane.

Step 2 Click the **Attributes** tab.

You see the general VSAN attributes in the Information pane.

Step 3 Double-click the Network Latency field and change the value.

Step 4 Click **Apply Changes** to save these changes, or click **Undo Changes** to discard any unsaved changes.

Configuring Flow Statis tics

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.

This section includes the following sections:

- Counting Aggregated Flow Statistics section, page 22-19

- Counting Individual Flow Statistics section, page 22-19
- Clearing FIB Statistics section, page 22-19

Counting Aggregated Flow Statistics

To count the aggregated flow statistics for a VSAN, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# fcflow stats aggregated module 1 index 1005 vsan 1` `switch(config)#`	Enables the aggregated flow counter.
	`switch(config)# no fcflow stats aggregated module 1 index 1005 vsan 1` `switch(config)#`	Disables the aggregated flow counter.

Counting Individual Flow Statistics

To count the flow statistics for a source and destination FC ID in a VSAN, follow these steps:

	Command	Purpose
Step 1	`switch# config t` `switch(config)#`	Enters configuration mode.
Step 2	`switch(config)# fcflow stats module 1 index 1 0x145601 0x5601ff 0xffffff vsan 1` `switch(config)#`	Enables the flow counter. **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.
	`switch(config)# no fcflow stats aggregated module 2 index 1001 vsan 2` `switch(config)#`	Disables the flow counter.

Clearing FIB Statistics

Use the **clear fcflow stats** command to clear the aggregated flow counter (see Examples 22-1 and 22-2).

Examples

Example 22-1 Clears Aggregated Flow Counters

```
switch# clear fcflow stats aggregated module 2 index 1
```

Example 22-2 Clears Flow Counters for Source and Destination FC IDs

```
switch# clear fcflow stats module 2 index 1
```

Verifying FSPF Configuration

To display FSPF configuration information, perform one of the following tasks:

Command	Purpose
show in-order-guarantee	Displays the In-Order Delivery Status
show fcdroplatency	Displays Latency information
show fcflow stats aggregated module 2	Displays Aggregated Flow Details for the Specified Module
show fcflow stats module 2	Displays Flow Details for the Specified Module
show fcflow stats usage module 2	Displays Flow Index Usage for the Specified Module
show fspf vsan 1	Displays FSPF Information for a Specified VSAN
show fspf database vsan 1	Displays FSPF Database Information
show fspf vsan 1 interface fc1/1	Displays FSPF Interface Information

For detailed information about the fields in the output from these commands, refer to the *Cisco MDS 9000 Family Command Reference*.

This section contains the following topics:

Displaying the FSPF Database

The FSPF database for a specified VSAN includes the following information:

- Link State Record (LSR) type
- Domain ID of the LSR owner
- Domain ID of the advertising router
- LSR age
- LSR incarnation member

- Number of links

To display the FSPF database using Device Manager, follow these steps:

Step 1 Choose **FC > Advanced > FSPF**.

You see the FSPF dialog box.

Step 2 Click the **LSDB LSRs** tab.

You see the FSPF database information.

Step 3 Click **Close** to close the dialog box.

Displaying FSPF Statistics

To view FSPF statistics using DCNM-SAN, follow these steps:

Step 1 Expand a Fabric, expand a VSAN, and then select **FSPF** in the Logical Domains pane.

You see the FSPF configuration dialog box.

Step 2 Click the **Statistics** tab.

You see the FSPF VSAN statistics in the Information pane.

Step 3 Click the **Interface Statistics** tab.

You see the FSPF interface statistics in the Information pane.

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
```

Displaying Latency Information

You can view the configured latency parameters using the **show fcdroplatency** command (see Example 22-3).

Example 22-3 Displays Administrative Distance

```
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
```

Displaying Flow Statistics

Use the **show fcflow stats** commands to view flow statistics (see Example 22-4 to 22-6).

Example 22-4 Displays Aggregated Flow Details for the Specified Module

```
switch# show fcflow stats aggregated module 2
Idx  VSAN # frames # bytes
---- ---- -------- -------
0000 4    387,653  674,235,875
0001 6    34,402   2,896,628
```

Example 22-5 Displays Flow Details for the Specified Module

```
switch# show fcflow stats module 2
Idx  VSAN D ID        S ID        mask      # frames # bytes
---- ---- ----------- ----------- -----     -------- -------
0000 4    032.001.002 007.081.012 ff.ff.ff   387,653  674,235,875
0001 6    004.002.001 019.002.004 ff.00.00   34,402   2,896,628
```

Example 22-6 Displays Flow Index Usage for the Specified Module

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

Displaying Global FSPF Information

Example 22-7 displays global FSPF information for a specific VSAN:

- Domain number of the switch.
- Autonomous region for the switch.
- Min_LS_arrival: minimum time that must elapse before the switch accepts LSR updates.
- Min_LS_interval: minimum time that must elapse before the switch can transmit an LSR.

Tip If the Min_LS_interval is higher than 10 seconds, the graceful shutdown feature is not implemented.

- LS_refresh_time: interval time lapse between refresh LSR transmissions.
- Max_age: maximum time aa LSR can stay before being deleted.

Example 22-7 Displays FSPF Information for a Specified VSAN

```
switch# show fspf vsan 1
FSPF routing for VSAN 1
FSPF routing administration status is enabled
FSPF routing operational status is UP
It is an intra-domain router
Autonomous region is 0
SPF hold time is 0 msec
MinLsArrival = 1000 msec , MinLsInterval = 5000 msec
Local Domain is 0x65(101)
Number of LSRs = 3, Total Checksum = 0x0001288b

Protocol constants :
   LS_REFRESH_TIME = 1800 sec
   MAX_AGE         = 3600 sec

Statistics counters :
   Number of LSR that reached MaxAge = 0
   Number of SPF computations        = 7
   Number of Checksum Errors         = 0
   Number of Transmitted packets :  LSU 65 LSA 55 Hello 474 Retranmsitted LSU 0
   Number of received packets :  LSU 55 LSA 60 Hello 464 Error packets 10
```

Displaying the FSPF Database

Example 22-8 displays a summary of the FSPF database for a specified VSAN. If other parameters are not specified, all LSRs in the database are displayed:

- LSR type
- Domain ID of the LSR owner
- Domain ID of the advertising router
- LSR age
- LSR incarnation member
- Number of links

You could narrow the display to obtain specific information by issuing additional parameters for the domain ID of the LSR owner. For each interface, the following information is also available:

- Domain ID of the neighboring switch
- E port index
- Port index of the neighboring switch
- Link type and cost

Example 22-8 Displays FSPF Database Information

```
switch# show fspf database vsan 1

FSPF Link State Database for VSAN 1 Domain 0x0c(12)
LSR Type                = 1
Advertising domain ID   = 0x0c(12)
LSR Age                 = 1686
LSR Incarnation number  = 0x80000024
LSR Checksum            = 0x3caf
Number of links         = 2
 NbrDomainId      IfIndex   NbrIfIndex    Link Type         Cost
-------------------------------------------------------------------------------
   0x65(101) 0x0000100e     0x00001081               1          500
   0x65(101) 0x0000100f     0x00001080               1          500

FSPF Link State Database for VSAN 1 Domain 0x65(101)
LSR Type                = 1
Advertising domain ID   = 0x65(101)
LSR Age                 = 1685
LSR Incarnation number  = 0x80000028
LSR Checksum            = 0x8443
Number of links         = 6
 NbrDomainId      IfIndex   NbrIfIndex    Link Type         Cost
-------------------------------------------------------------------------------
   0xc3(195) 0x00001085     0x00001095               1          500
   0xc3(195) 0x00001086     0x00001096               1          500
   0xc3(195) 0x00001087     0x00001097               1          500
   0xc3(195) 0x00001084     0x00001094               1          500
    0x0c(12) 0x00001081     0x0000100e               1          500
    0x0c(12) 0x00001080     0x0000100f               1          500

FSPF Link State Database for VSAN 1 Domain 0xc3(195)
LSR Type                = 1
Advertising domain ID   = 0xc3(195)
LSR Age                 = 1686
LSR Incarnation number  = 0x80000033
LSR Checksum            = 0x6799
Number of links         = 4
 NbrDomainId      IfIndex   NbrIfIndex    Link Type         Cost
-------------------------------------------------------------------------------
   0x65(101) 0x00001095     0x00001085               1          500
   0x65(101) 0x00001096     0x00001086               1          500
   0x65(101) 0x00001097     0x00001087               1          500
   0x65(101) 0x00001094     0x00001084               1          500
```

Displaying FSPF Interfaces

Example 22-9 displays the following information for each selected interface.

- Link cost
- Timer values
- Neighbor's domain ID (if known)
- Local interface number
- Remote interface number (if known)
- FSPF state of the interface

- Interface counters

Example 22-9 Displays FSPF Interface Information

```
switch# show fspf vsan 1 interface fc1/1
FSPF interface fc1/1 in VSAN 1
FSPF routing administrative state is active
Interface cost is 500
Timer intervals configured, Hello 20 s, Dead 80 s, Retransmit 5 s
FSPF State is FULL
Neighbor Domain Id is 0x0c(12), Neighbor Interface index is 0x0f100000
Statistics counters :
   Number of packets received : LSU  8  LSA  8  Hello 118  Error packets 0
   Number of packets transmitted : LSU  8  LSA  8  Hello 119  Retransmitted LSU 0
   Number of times inactivity timer expired for the interface = 0
```

Configuration Examples for FSPF

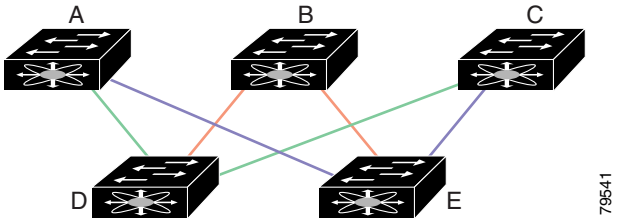
This section provides examples of topologies and applications that demonstrate the benefits of FSPF.

Note The FSPF feature can be used on any topology.

Fault Tolerant Fabric

Figure 22-4 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 22-4 Fault Tolerant Fabric



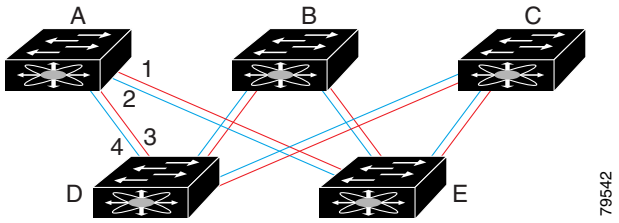
For example, if all links are of equal speed, the FSPF calculates two equal paths from A to C: A-D-C (green) and A-E-C (blue).

Redundant Links

To further improve on the topology in Figure 22-4, each connection between any pair of switches can be replicated; two or more links can be present between a pair of switches. Figure 22-5 shows this arrangement. Because switches in the Cisco MDS 9000 Family support PortChanneling, 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 PortChannel. This configuration also improves the resiliency of the network. The failure of a link in a PortChannel does not trigger a route change, thereby reducing the risks of routing loops, traffic loss, or fabric downtime for route reconfiguration.

Figure 22-5 Fault Tolerant Fabric with Redundant Links



For example, if all links are of equal speed and no PortChannels 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 PortChannels exist, these paths are reduced to two.

Failover Scenarios for PortChannels and FSPF Links

The SmartBits traffic generator was used to evaluate the scenarios displayed in Figure 22-6. Two links between switch 1 and switch 2 exist as either equal-cost ISLs or PortChannels. There is one flow from traffic generator 1 to traffic generator 2. The traffic was tested at 100 percent utilization at 1 Gbps in two scenarios:

- Disabling the traffic link by physically removing the cable (see Table 22-3).
- Shutting down either switch 1 or switch 2 (see Table 22-4).

Figure 22-6 Failover Scenario Using Traffic Generators

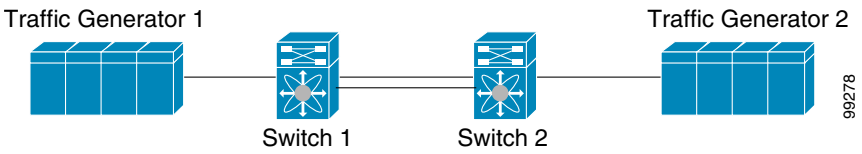


Table 22-3 Physically Removing the Cable for the SmartBits Scenario

PortChannel Scenario		FSPF Scenario (Equal cost ISL)	
Switch 1	**Switch 2**	**Switch 1**	**Switch 2**
110 msec (~2K frame drops)		130+ msec (~4k frame drops)	
100 msec (hold time when a signal loss is reported as mandated by the standard)			

Table 22-4 Shutting Down the Switch for the SmartBits Scenario

PortChannel Scenario		FSPF Scenario (Equal cost ISL)	
Switch 1	**Switch 2**	**Switch 1**	**Switch 2**
~0 msec (~8 frame drops)	110 msec (~2K frame drops)	130+ msec (~4K frame drops)	
No hold time needed	Signal loss on switch 1	No hold time needed	Signal loss on switch 1

Field Descriptions for FSPF

This section displays the field descriptions for this feature.

FSPF General

Field	Description
AdminStatus	The desired state of FSPF on this VSAN.
OperStatus	State of FSPF on this VSAN.
SetToDefault	Enabling this changes each value in this row to its default value. If all the configuration parameters have their default values and if the VSAN is suspended, then the row is deleted automatically.
RegionId	The autonomous region of the local switch on this VSAN.
DomainId	The domain ID of the local switch on this VSAN.
SpfHoldTime	The minimum time between two consecutive SPF computations on this VSAN. The smaller value means that routing will react to the changes faster but the CPU usage is greater.
SpfDelay	The time between when FSPF receives topology updates and when it starts the Shortest Path First (SPF) computation on this VSAN. The smaller value means that routing will react to the changes faster but the CPU usage is greater.
MinLsArrival	The minimum time after accepting a Link State Record (LSR) on this VSAN before accepting another update of the same LSR on the same VSAN. An LSR update that is not accepted because of this time interval is discarded.
MinLsInterval	The minimum time after this switch sends an LSR on this VSAN before it will send another update of the same LSR on the same VSAN.
LsRefreshTime	The interval between transmission of refresh LSRs on this VSAN.
LSRMaxAge	The maximum age an LSR will be retained in the FSPF database on this VSAN. It is removed from the database after MaxAge is reached.
CreateTime	When this entry was last created.
CheckSum	The total checksum of all the LSRs on this VSAN.

FSPF Interfaces

Field	Description
SetToDefault	Enabling this changes each value in this row to its default value. If all the configuration parameters have their default values and if the interface is down, then the row is deleted automatically.
Cost	The administrative cost of sending a frame on this interface on this VSAN. The value 0 means that the cost has not been configured. Once the value has been configured, the value cannot again be 0; so, obviously the value cannot be set to 0. If the value is 0 and the corresponding interface is up, the agent sets a value calculated using the ifSpeed of the interface. Otherwise, the value is used as the cost. The following formula is used to calculate the link cost: Link Cost = { fspfIfCost if fspfIfCost > 0 {(1.0625e12 / Baud Rate) if fspfIfCost == 0 where Baud Rate is the ifSpeed of the interface.
AdminStatus	The desired state of FSPF on this interface on this VSAN.
HelloInterval	Interval between the periodic hello messages sent on this interface on this VSAN to verify the link health. Note that this value must be same on both the interfaces on each end of the link on this VSAN.
DeadInterval	Maximum time for which no hello messages can be received on this interface on this VSAN. After this time, the interface is assumed to be broken and removed from the database. This value must be greater than the hello interval specified on this interface on this VSAN.
RetransmitInterval	Time after which an unacknowledged link update is retransmitted on this interface on this VSAN.
Neighbour State	The state of FSPF's neighbor state machine, which is the operational state of the interaction with the neighbor's interface which is connected to this interface.
Neighbour DomainId	The domain ID of the neighbor on this VSAN.
Neighbour PortIndex	The index, as known by the neighbor, of the neighbor's interface which is connected to this interface on this VSAN.
CreateTime	When this entry was last created.

FSPF Interface Stats

Field	Description
CreateTime	When this entry was last created.
ErrorRxPkts	Number of invalid FSPF control frames received on this interface on this VSAN since the creation of the entry.
InactivityExpirations	Number of times the inactivity timer has expired on this interface on this VSAN since the creation of the entry.

Field	Description
LsuRxPkts	Number of Link State Update (LSU) frames received on this interface on this VSAN since the creation of the entry.
LsuTxPkts	Number of Link State Update (LSU) frames transmitted on this interface on this VSAN since the creation of the entry.
RetransmittedLsuTxPkts	Number of LSU frames retransmitted on this interface on this VSAN since the creation of the entry.
LsaRxPkts	Number of Link State Acknowledgement (LSA) frames received on this interface on this VSAN since the creation of the entry.
LsaTxPkts	Number of Link State Acknowledgement (LSA) frames transmitted on this interface on this VSAN since the creation of the entry.
HelloTxPkts	Number of HELLO frames transmitted on this interface on this VSAN since the creation of the entry.
HelloRxPkts	Number of HELLO frames received on this interface on this VSAN since the creation of the entry.

FSPF LSDB Links

Field	Description
NbrDomainId	The domain ID of the neighbor on the other end of this link on this VSAN.
PortIndex	The source E_port of this link, as indicated by the index value in the LSR received from the switch identified by the domain ID.
NbrPortIndex	The destination E_port of this link, as indicated by the index value in the LSR received from the switch identified by NbrDomainId.
Cost	The cost of sending a frame on this link on this VSAN. Link cost is calculated using a formula link cost = S * (1.0625e12/Baud Rate) where S (value of Cost on the interface on the switch corresponding to the domain Id) is the administratively set cost factor for this interface.

FSPF LSDB LSRs

Field	Description
AdvDomainId	Domain ID of the switch that is advertising the LSR on the behalf of the switch owning it.
Age	Time since this LSR was inserted into the database.
IncarnationNumber	The link state incarnation number of this LSR. This is used to identify most recent instance of an LSR while updating the topology database when an LSR is received. The updating of an LSR includes incrementing its incarnation number prior to transmission of the updated LSR. So most recent LSR is the one with larger incarnation number.

Field	Description
CheckSum	The checksum of the LSR.
Links	Number of entries associated with this LSR.
External	Indicates of this is an external LSR advertised by local switch.

FSPF Statistics

Field	Description
SpfComputations	The number of times the SPF computation has been done on this VSAN since the creation of the entry.
ErrorRxPkts	Number of invalid FSPF control frames received on all the interface on this VSAN since the creation of the entry.
ChecksumErrors	The number of FSPF checksum errors occurred on this on this VSAN since the creation of the entry.
LsuRxPkts	Total number of Link State Update (LSU) frames received on all the interfaces on this VSAN since the creation of the entry.
LsuTxPkts	Total number of Link State Update (LSU) frames transmitted on all the interfaces on this VSAN since the creation of the entry.
RetransmittedLsuTxPkts	Total number of LSU frames retransmitted on all the interfaces on this VSAN since the creation of the entry.
LsaRxPkts	Total number of Link State Acknowledgement (LSA) frames received on all the interfaces on this VSAN since the creation of the entry.
LsaTxPkts	Total number of Link State Acknowledgement (LSA) frames transmitted on all the interfaces on this VSAN since the creation of the entry.
HelloTxPkts	Total number of HELLO frames transmitted on all interfaces on this VSAN since the creation of the entry.
HelloRxPkts	Total number of HELLO frames received on all the interfaces on this VSAN since the creation of the entry.
MaxAgeCount	The number of times any LSR reached fspfMaxAge in this VSAN since the creation of the entry.

Additional References

For additional information related to implementing VSANs, see the following section:

- Related Document section, page 22-30
- Standards section, page 22-31
- RFCs section, page 22-31
- MIBs section, page 22-31

Related Document

Related Topic	Document Title
Cisco MDS 9000 Family Command Reference	*Cisco MDS 9000 Family Command Reference*

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.	–

RFCs

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

MIBs

MIBs	MIBs Link
• CISCO-FC-ROUTE-MIB	To locate and download MIBs, go to the following URL: http://www.cisco.com/en/US/products/ps5989/prod_technical_reference_list.html