EtherSwitch Network Module

This document explains how to configure the EtherSwitch network module. This network module is supported on Cisco 2600 series, Cisco 3600 series, and Cisco 3700 series routers. The EtherSwitch network module is a modular, high-density voice network module that provides Layer 2 switching across Ethernet ports. The EtherSwitch network module has sixteen 10/100 switched Ethernet ports with integrated inline power and QoS features that are designed to extend Cisco AVVID-based voice-over-IP (VoIP) networks to small branch offices.

Feature History for the EtherSwitch Module Feature

Release	Modification
12.2(2)XT	This feature was introduced on the Cisco 2600 series, Cisco 3600 series, and Cisco 3700 series routers.
12.2(8)T	This feature was integrated into Cisco IOS Release 12.2(8)T.
12.2(15)ZJ	Added switching software enhancements: IEEE 802.1x, QoS (including Layer 2/Layer 3 CoS/DSCP mapping and rate limiting), security ACL, IGMP snooping, per-port storm control, and fallback bridging support for switch virtual interfaces (SVIs).
12.3(4)T	The switching software enhancements from Cisco IOS Release 12.2(15)ZJ were integrated into Cisco IOS Release 12.3(4)T.

Finding Support Information for Platforms and Cisco IOS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS software image support. Access Cisco Feature Navigator at http://www.cisco.com/go/fn. You must have an account on Cisco.com. If you do not have an account or have forgotten your username or password, click **Cancel** at the login dialog box and follow the instructions that appear.

Contents

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Prerequisites for the EtherSwitch Network Module

- Cisco IOS Release 12.3 or later release
- Basic configuration of the Cisco 2600 series, Cisco 3600 series, or Cisco 3700 series router

In addition, complete the following tasks before configuring this feature:

- Configure IP routing

  For more information on IP routing, refer to the *Cisco IOS IP Configuration Guide*.
- Set up the call agents

  For more information on setting up call agents, refer to the documentation that accompanies the call agents used in your network configuration.

Restrictions for the EtherSwitch Network Module

The following functions are not supported by the EtherSwitch network module:

- CGMP client, CGMP fast-leave
- Dynamic ports
- Dynamic access ports
- Secure ports
- Dynamic trunk protocol
- Dynamic VLANs
- GARP, GMRP, and GVRP
- ISL tagging (The chip does not support ISL.)
- Layer 3 switching onboard
- Monitoring of VLANs
- Multi-VLAN ports Network Port
- Shared STP instances
- STP uplink fast for clusters
- VLAN-based SPAN
- VLAN Query Protocol
- VTP Pruning Protocol
- Web-based management interface

Information About the EtherSwitch Network Module

To configure the EtherSwitch network module, you should understand the following concepts:

EtherSwitch Network Module: Benefits

- Statistical gains by combining multiple traffic types over a common IP infrastructure.
- Long distance savings
- Support for intra-chassis stacking
- Voice connectivity over data applications
- IPSec, ACL, VPN and Firewall options
- New broadband WAN options

The Interface Range Specification feature makes configuration easier for these reasons:

- Identical commands can be entered once for a range of interfaces, rather than being entered separately for each interface.
- Interface ranges can be saved as macros.

Ethernet Switching in Cisco AVVID Architecture

The EtherSwitch network module is designed to work as part of the Cisco Architecture for Voice, Video, and Integrated Data (AVVID) solution. The EtherSwitch network module has sixteen 10/100 switched Ethernet ports with integrated inline power and QoS features that allow for extending Cisco AVVID-based voice-over-IP (VoIP) networks to small branch offices.

The 16-port EtherSwitch network module has sixteen 10/100BASE-TX ports and an optional 10/100/1000BASE-T Gigabit Ethernet port. The 36-port EtherSwitch network module has thirty six 10/100BASE-TX ports and two optional 10/100/1000BASE-T Gigabit Ethernet ports. The gigabit Ethernet can be used as an uplink port to a server or as a stacking link to another 16- or 36-port EtherSwitch network module in the same system. The 36-port EtherSwitch network module requires a double-wide slot. An optional power module can also be added to provide inline power for IP telephones.

As an access gateway switch, the EtherSwitch network module can be deployed as a component of a centralized call-processing network using a centrally deployed Cisco CallManager (CCM). Instead of deploying and managing key systems or PBXs in small branch offices, applications are centrally located at the corporate headquarters or data center and are accessed via the IP WAN.

By default, the EtherSwitch network module provides the following settings with respect to Cisco AVVID:

- All switch ports are in access VLAN 1.
- All switch ports are static access ports, not 802.1Q trunk ports.
- Default voice VLAN is not configured on the switch.
- Inline power is automatically supplied on the 10/100 ports.

VLANs

Virtual local-area networks (VLANs) are a group of end stations with a common set of requirements, independent of physical location. VLANs have the same attributes as a physical LAN but allow you to group end stations even if they are not located physically on the same LAN segment.

VLAN Trunk Protocol

VLAN Trunk Protocol (VTP) is a Layer 2 messaging protocol that maintains VLAN configuration consistency by managing the addition, deletion, and renaming of VLANs within a VTP domain. A VTP domain (also called a VLAN management domain) is made up of one or more switches that share the same VTP domain name and that are interconnected with trunks. VTP minimizes misconfigurations and configuration inconsistencies that can result in a number of problems, such as duplicate VLAN names, incorrect VLAN-type specifications, and security violations. Before you create VLANs, you must decide whether to use VTP in your network. With VTP, you can make configuration changes centrally on one or more switches and have those changes automatically communicated to all the other switches in the network.

VTP Domain

A VTP domain (also called a VLAN management domain) is made up of one or more interconnected switches that share the same VTP domain name. A switch can be configured to be in only one VTP domain. You make global VLAN configuration changes for the domain using either the command-line interface (CLI) or Simple Network Management Protocol (SNMP).

By default, the switch is in VTP server mode and is in an un-named domain state until the switch receives an advertisement for a domain over a trunk link or until you configure a management domain. You cannot create or modify VLANs on a VTP server until the management domain name is specified or learned.

If the switch receives a VTP advertisement over a trunk link, it inherits the management domain name and the VTP configuration revision number. The switch ignores advertisements with a different management domain name or an earlier configuration revision number.

If you configure the switch as VTP transparent, you can create and modify VLANs, but the changes affect only the individual switch.

When you make a change to the VLAN configuration on a VTP server, the change is propagated to all switches in the VTP domain. VTP advertisements are transmitted out all trunk connections using IEEE 802.1Q encapsulation.

VTP maps VLANs dynamically across multiple LAN types with unique names and internal index associations. Mapping eliminates excessive device administration required from network administrators.

VTP Modes

You can configure a switch to operate in any one of these VTP modes:

- Server—In VTP server mode, you can create, modify, and delete VLANs and specify other configuration parameters (such as VTP version) for the entire VTP domain. VTP servers advertise their VLAN configuration to other switches in the same VTP domain and synchronize their VLAN configuration with other switches based on advertisements received over trunk links. VTP server is the default mode.
- Client—VTP clients behave the same way as VTP servers, but you cannot create, change, or delete VLANs on a VTP client.
- Transparent—VTP transparent switches do not participate in VTP. A VTP transparent switch does not advertise its VLAN configuration and does not synchronize its VLAN configuration based on received advertisements. However, in VTP version 2, transparent switches do forward VTP advertisements that they receive out their trunk interfaces.

VTP Advertisements

Each switch in the VTP domain sends periodic advertisements out each trunk interface to a reserved multicast address. VTP advertisements are received by neighboring switches, which update their VTP and VLAN configurations as necessary.

The following global configuration information is distributed in VTP advertisements:

- VLAN IDs (801.Q)
- VTP domain name
- VTP configuration revision number
- VLAN configuration, including maximum transmission unit (MTU) size for each VLAN
- Frame format

VTP Version 2

If you use VTP in your network, you must decide whether to use VTP version 1 or version 2. VTP version 2 supports the following features not supported in version 1:

Unrecognized Type-Length-Value (TLV) Support—A VTP server or client propagates configuration changes to its other trunks, even for TLVs it is not able to parse. The unrecognized TLV is saved in NVRAM.

Version-Dependent Transparent Mode—In VTP version 1, a VTP transparent switch inspects VTP messages for the domain name and version, and forwards a message only if the version and domain name match. Since only one domain is supported in the NM-16ESW software, VTP version 2 forwards VTP messages in transparent mode, without checking the version.

Consistency Checks—In VTP version 2, VLAN consistency checks (such as VLAN names and values) are performed only when you enter new information through the CLI or SNMP. Consistency checks are not performed when new information is obtained from a VTP message, or when information is read from NVRAM. If the digest on a received VTP message is correct, its information is accepted without consistency checks.

VTP Configuration Guidelines and Restrictions

Follow these guidelines and restrictions when implementing VTP in your network:

- All switches in a VTP domain must run the same VTP version.
- You must configure a password on each switch in the management domain when in secure mode.
- A VTP version 2-capable switch can operate in the same VTP domain as a switch running VTP version 1, provided that VTP version 2 is disabled on the VTP version 2-capable switch. (VTP version 2 is disabled by default).
- Do not enable VTP version 2 on a switch unless all switches in the same VTP domain are version 2-capable. When you enable VTP version 2 on a switch, all version 2-capable switches in the domain enable VTP version 2.
- The Cisco IOS **end** command and the **Ctrl**-**Z** keystrokes are not supported in VLAN database mode.
- The VLAN database stored on internal Flash is supported.
- Use the **squeeze flash** command to remove old copies of overwritten VLAN databases.

Inline Power for Cisco IP Phones

The EtherSwitch network module can supply inline power to a Cisco 7960 IP phone, if required. The Cisco 7960 IP phone can also be connected to an AC power source and supply its own power to the voice circuit. When the Cisco 7960 IP phone is supplying its own power, a EtherSwitch network module can forward IP voice traffic to and from the phone.

A detection mechanism on the EtherSwitch network module determines whether it is connected to a Cisco 7960 IP phone. If the switch senses that there is *no* power on the circuit, the switch supplies the power. If there is power on the circuit, the switch does not supply it.

You can configure the switch to never supply power to the Cisco 7960 IP phone and to disable the detection mechanism.

Using the Spanning Tree Protocol with the EtherSwitch network module

Spanning Tree Protocol (STP) is a Layer 2 link management protocol that provides path redundancy while preventing undesirable loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two stations. Spanning tree operation is transparent to end stations, which cannot detect whether they are connected to a single LAN segment or to a switched LAN of multiple segments.

The EtherSwitch network module uses STP (the IEEE 802.1D bridge protocol) on all VLANs. By default, a single instance of STP runs on each configured VLAN (provided that you do not manually disable STP). You can enable and disable STP on a per-VLAN basis.

When you create fault-tolerant internetworks, you must have a loop-free path between all nodes in a network. The spanning tree algorithm calculates the best loop-free path throughout a switched Layer 2 network. Switches send and receive spanning tree frames at regular intervals. The switches do not forward these frames but use the frames to construct a loop-free path.

Multiple active paths between end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages and switches might learn endstation MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network.

Spanning Tree Protocol (STP) defines a tree with a root switch and a loop-free path from the root to all switches in the Layer 2 network. STP forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning tree algorithm recalculates the spanning tree topology and activates the standby path.

When two ports on a switch are part of a loop, the spanning tree port priority and port path cost setting determine which port is put in the forwarding state and which port is put in the blocking state. The spanning tree port priority value represents the location of an interface in the network topology and how well located it is to pass traffic. The spanning tree port path cost value represents media speed.

Bridge Protocol Data Units

The stable active spanning tree topology of a switched network is determined by the following:

- The unique bridge ID (bridge priority and MAC address) associated with each VLAN on each switch
- The spanning tree path cost to the root bridge
- The port identifier (port priority and MAC address) associated with each Layer 2 interface

The Bridge Protocol Data Units (BPDU) are transmitted in one direction from the root switch, and each switch sends configuration BPDUs to communicate and compute the spanning tree topology. Each configuration BPDU contains the following minimal information:

- The unique bridge ID of the switch that the transmitting switch believes to be the root switch
- The spanning tree path cost to the root
- The bridge ID of the transmitting bridge
- Message age
- The identifier of the transmitting port
- Values for the hello, forward delay, and max-age protocol timers

When a switch transmits a BPDU frame, all switches connected to the LAN on which the frame is transmitted receive the BPDU. When a switch receives a BPDU, it does not forward the frame but instead uses the information in the frame to calculate a BPDU, and, if the topology changes, initiate a BPDU transmission.

A BPDU exchange results in the following:

- One switch is elected as the root switch.
- The shortest distance to the root switch is calculated for each switch based on the path cost.
- A designated bridge for each LAN segment is selected. This is the switch closest to the root bridge through which frames are forwarded to the root.
- A root port is selected. This is the port providing the best path from the bridge to the root bridge.
- Ports included in the spanning tree are selected.
- The Root Bridge is elected.

For each VLAN, the switch with the highest bridge priority (the lowest numerical priority value) is elected as the root switch. If all switches are configured with the default priority (32768), the switch with the lowest MAC address in the VLAN becomes the root switch.

The spanning tree root switch is the logical center of the spanning tree topology in a switched network. All paths that are not needed to reach the root switch from anywhere in the switched network are placed in spanning tree blocking mode.

BPDUs contain information about the transmitting bridge and its ports, including bridge and MAC addresses, bridge priority, port priority, and path cost. Spanning tree uses this information to elect the root bridge and root port for the switched network, as well as the root port and designated port for each switched segment.

STP Timers

Table 1 describes the STP timers that affect the entire spanning tree performance.

Table 1 STP Timers

Timer	Purpose
Hello timer	Determines how often the switch broadcasts hello messages to other switches.
Forward delay timer	Determines how long each of the listening and learning states will last before the port begins forwarding.
Maximum age timer	Determines the amount of time protocol information received on a port is stored by the switch.

Spanning Tree Port States

Propagation delays can occur when protocol information passes through a switched LAN. As a result, topology changes can take place at different times and at different places in a switched network. When a Layer 2 interface changes directly from nonparticipation in the spanning tree topology to the forwarding state, it can create temporary data loops. Ports must wait for new topology information to propagate through the switched LAN before starting to forward frames. They must allow the frame lifetime to expire for frames that have been forwarded using the old topology.

Each Layer 2 interface on a switch using spanning tree exists in one of the following five states:

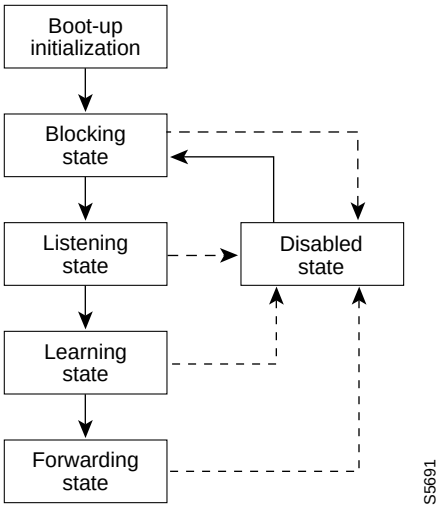
- Blocking—The Layer 2 interface does not participate in frame forwarding.
- Listening—First transitional state after the blocking state when spanning tree determines that the Layer 2 interface should participate in frame forwarding.
- Learning—The Layer 2 interface prepares to participate in frame forwarding.
- Forwarding—The Layer 2 interface forwards frames.
- Disabled—The Layer 2 interface does not participate in spanning tree and is not forwarding frames.

A Layer 2 interface moves through these five states as follows:

- From initialization to blocking
- From blocking to listening or to disabled
- From listening to learning or to disabled
- From learning to forwarding or to disabled
- From forwarding to disabled

Figure 1 illustrates how a port moves through the five stages.

Figure 1 STP Port States



Boot-up Initialization

When you enable spanning tree, every port in the switch, VLAN, or network goes through the blocking state and the transitory states of listening and learning at power up. If properly configured, each Layer 2 interface stabilizes to the forwarding or blocking state.

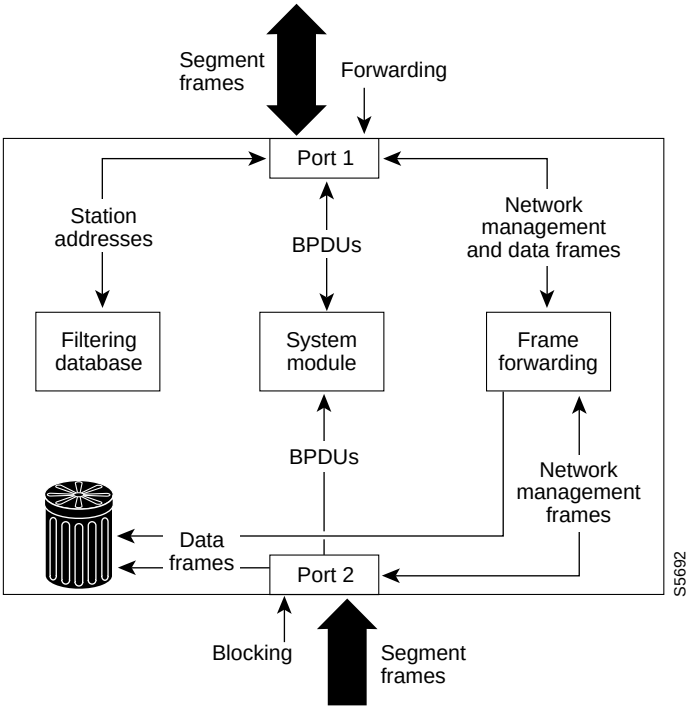
When the spanning tree algorithm places a Layer 2 interface in the forwarding state, the following process occurs:

1. The Layer 2 interface is put into the listening state while it waits for protocol information that suggests that it should go to the blocking state.
2. The Layer 2 interface waits for the forward delay timer to expire, moves the Layer 2 interface to the learning state, and resets the forward delay timer.
3. In the learning state, the Layer 2 interface continues to block frame forwarding as it learns end station location information for the forwarding database.
4. The Layer 2 interface waits for the forward delay timer to expire and then moves the Layer 2 interface to the forwarding state, where both learning and frame forwarding are enabled.

Blocking State

A Layer 2 interface in the blocking state does not participate in frame forwarding, as shown in Figure 2. After initialization, a BPDU is sent out to each Layer 2 interface in the switch. A switch initially assumes it is the root until it exchanges BPDUs with other switches. This exchange establishes which switch in the network is the root or root bridge. If only one switch is in the network, no exchange occurs, the forward delay timer expires, and the ports move to the listening state. A port always enters the blocking state following switch initialization.

Figure 2 Interface 2 in Blocking State



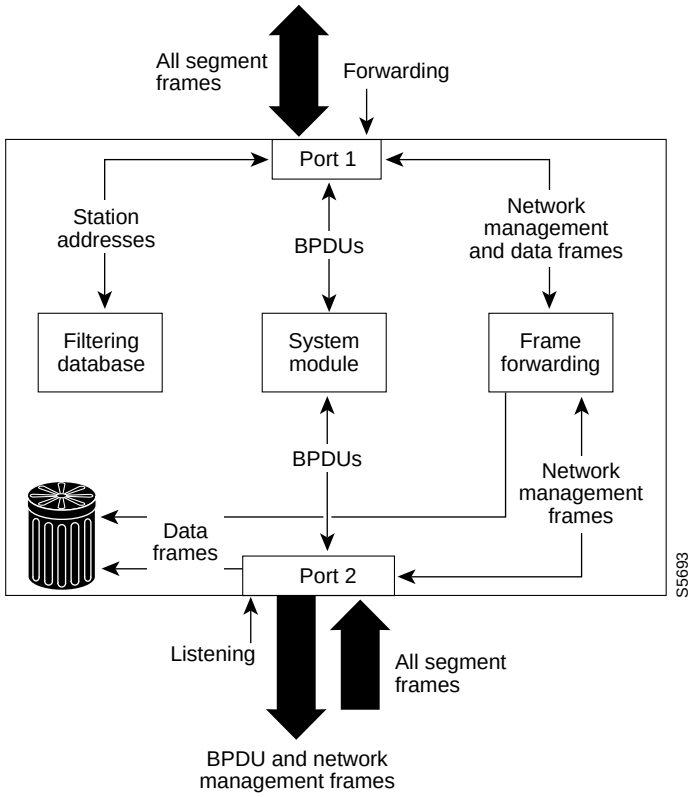
A Layer 2 interface in the blocking state performs as follows:

- Discards frames received from the attached segment.
- Discards frames switched from another interface for forwarding.
- Does not incorporate end station location into its address database. (There is no learning on a blocking Layer 2 interface, so there is no address database update.)
- Receives BPDUs and directs them to the system module.
- Does not transmit BPDUs received from the system module.
- Receives and responds to network management messages.

Listening State

The listening state is the first transitional state a Layer 2 interface enters after the blocking state. The Layer 2 interface enters this state when STP determines that the Layer 2 interface should participate in frame forwarding. Figure 3 shows a Layer 2 interface in the listening state.

Figure 3 Interface 2 in Listening State



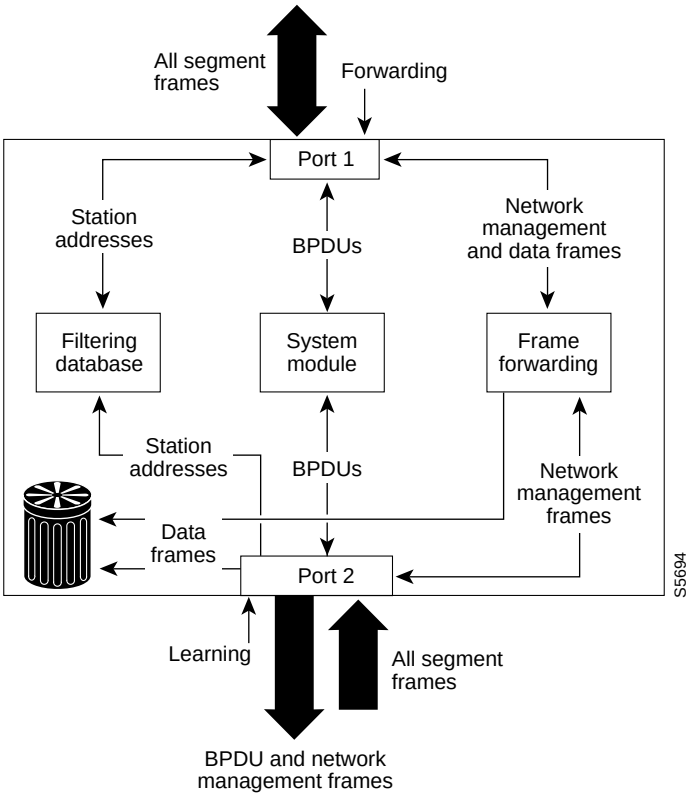
A Layer 2 interface in the listening state performs as follows:

- Discards frames received from the attached segment.
- Discards frames switched from another interface for forwarding.
- Does not incorporate end station location into its address database. (There is no learning at this point, so there is no address database update.)
- Receives BPDUs and directs them to the system module.
- Receives, processes, and transmits BPDUs received from the system module.
- Receives and responds to network management messages.

Learning State

A Layer 2 interface in the learning state prepares to participate in frame forwarding. The Layer 2 interface enters the learning state from the listening state. Figure 4 shows a Layer 2 interface in the learning state.

Figure 4 Interface 2 in Learning State



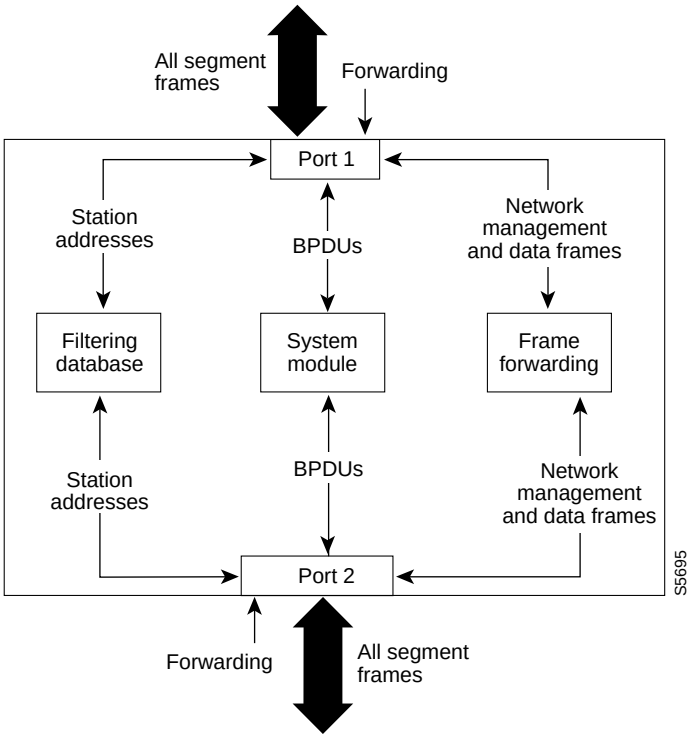
A Layer 2 interface in the learning state performs as follows:

- Discards frames received from the attached segment.
- Discards frames switched from another interface for forwarding.
- Incorporates end station location into its address database.
- Receives BPDUs and directs them to the system module.
- Receives, processes, and transmits BPDUs received from the system module.
- Receives and responds to network management messages.

Forwarding State

A Layer 2 interface in the forwarding state forwards frames, as shown in Figure 5. The Layer 2 interface enters the forwarding state from the learning state.

Figure 5 Interface 2 in Forwarding State



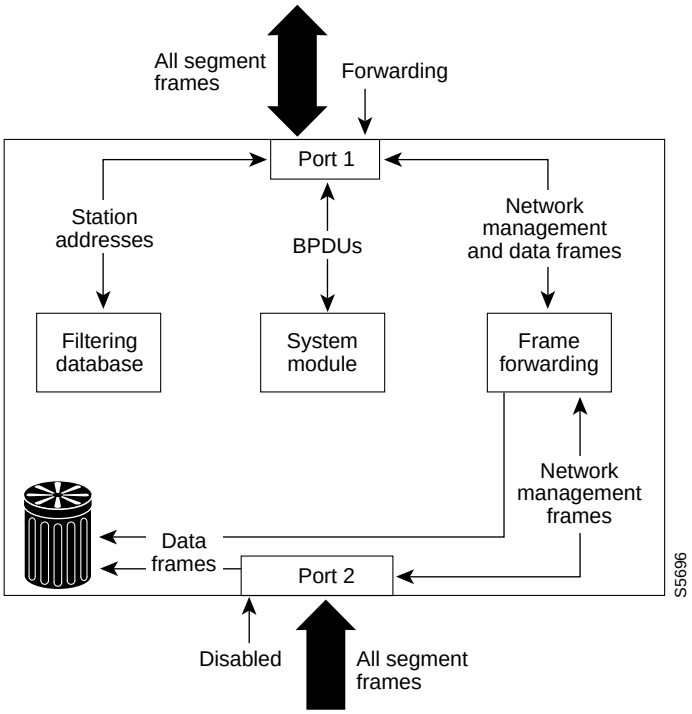
A Layer 2 interface in the forwarding state performs as follows:

- Forwards frames received from the attached segment.
- Forwards frames switched from another Layer 2 interface for forwarding.
- Incorporates end station location information into its address database.
- Receives BPDUs and directs them to the system module.
- Processes BPDUs received from the system module.
- Receives and responds to network management messages.

Disabled State

A Layer 2 interface in the disabled state does not participate in frame forwarding or spanning tree, as shown in Figure 6. A Layer 2 interface in the disabled state is virtually nonoperational.

Figure 6 Interface 2 in Disabled State



A disabled Layer 2 interface performs as follows:

- Discards frames received from the attached segment.
- Discards frames switched from another Layer 2 interface for forwarding.
- Does not incorporate end station location into its address database. (There is no learning, so there is no address database update.)
- Does not receive BPDUs.
- Does not receive BPDUs for transmission from the system module.

MAC Address Allocation

The MAC address allocation manager has a pool of MAC addresses that are used as the bridge IDs for the VLAN spanning trees. In Table 2 you can view the number of VLANs allowed for each platform.

Table 2 Number of VLANs Allowed by Platform

Platform	Maximum Number of VLANs Allowed
Cisco 3640 or higher	64 VLANs
Cisco 2600	32 VLANs

MAC addresses are allocated sequentially, with the first MAC address in the range assigned to VLAN 1, the second MAC address in the range assigned to VLAN 2, and so forth.

For example, if the MAC address range is 00-e0-1e-9b-2e-00 to 00-e0-1e-9b-31-ff, the VLAN 1 bridge ID is 00-e0-1e-9b-2e-00, the VLAN 2 bridge ID is 00-e0-1e-9b-2e-01, the VLAN 3 bridge ID is 00-e0-1e-9b-2e-02, and so forth.

Default Spanning Tree Configuration

Table 3 shows the default Spanning Tree configuration values.

Table 3 Spanning Tree Default Configuration

Feature	Default Value
Enable state	Spanning tree enabled for all VLANs
Bridge priority	32768
Spanning tree port priority (configurable on a per-interface basis; used on interfaces configured as Layer 2 access ports)	128
Spanning tree port cost (configurable on a per-interface basis; used on interfaces configured as Layer 2 access ports)	Fast Ethernet: 19 Ethernet: 100 Gigabit Ethernet: 19 when operated in 100-Mb mode, and 4 when operated in 1000-Mb mode
Spanning tree VLAN port priority (configurable on a per-VLAN basis; used on interfaces configured as Layer 2 trunk ports)	128
Spanning tree VLAN port cost (configurable on a per-VLAN basis; used on interfaces configured as Layer 2 trunk ports)	Fast Ethernet: 10 Ethernet: 10
Hello time	2 seconds
Forward delay time	15 seconds
Maximum aging time	20 seconds

Spanning Tree Port Priority

In the event of a loop, spanning tree considers port priority when selecting an interface to put into the forwarding state. You can assign higher priority values to interfaces that you want spanning tree to select first, and lower priority values to interfaces that you want spanning tree to select last. If all interfaces have the same priority value, spanning tree puts the interface with the lowest interface number in the forwarding state and blocks other interfaces. The possible priority range is 0 to 255, configurable in increments of 4 (the default is 128).

Cisco IOS software uses the port priority value when the interface is configured as an access port and uses VLAN port priority values when the interface is configured as a trunk port.

Spanning Tree Port Cost

The spanning tree port path cost default value is derived from the media speed of an interface. In the event of a loop, spanning tree considers port cost when selecting an interface to put into the forwarding state. You can assign lower cost values to interfaces that you want spanning tree to select first and higher

cost values to interfaces that you want spanning tree to select last. If all interfaces have the same cost value, spanning tree puts the interface with the lowest interface number in the forwarding state and blocks other interfaces.

The possible cost range is 0 to 65535 (the default is media-specific).

Spanning tree uses the port cost value when the interface is configured as an access port and uses VLAN port cost values when the interface is configured as a trunk port.

BackboneFast

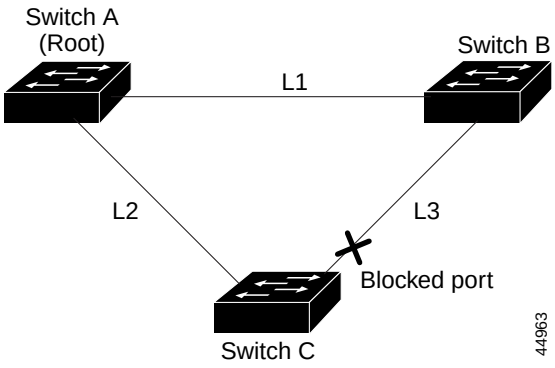
BackboneFast is initiated when a root port or blocked port on a switch receives inferior BPDUs from its designated bridge. An inferior BPDU identifies one switch as both the root bridge and the designated bridge. When a switch receives an inferior BPDU, it means that a link to which the switch is not directly connected (an *indirect* link) has failed (that is, the designated bridge has lost its connection to the root switch). Under STP rules, the switch ignores inferior BPDUs for the configured maximum aging time specified by the **spanning-tree max-age** global configuration command.

The switch tries to determine if it has an alternate path to the root switch. If the inferior BPDU arrives on a blocked port, the root port and other blocked ports on the switch become alternate paths to the root switch. (Self-looped ports are not considered alternate paths to the root switch.) If the inferior BPDU arrives on the root port, all blocked ports become alternate paths to the root switch. If the inferior BPDU arrives on the root port and there are no blocked ports, the switch assumes that it has lost connectivity to the root switch, causes the maximum aging time on the root to expire, and becomes the root switch according to normal STP rules.

If the switch has alternate paths to the root switch, it uses these alternate paths to transmit a new kind of Protocol Data Unit (PDU) called the Root Link Query PDU. The switch sends the Root Link Query PDU on all alternate paths to the root switch. If the switch determines that it still has an alternate path to the root, it causes the maximum aging time on the ports on which it received the inferior BPDU to expire. If all the alternate paths to the root switch indicate that the switch has lost connectivity to the root switch, the switch causes the maximum aging times on the ports on which it received an inferior BPDU to expire. If one or more alternate paths can still connect to the root switch, the switch makes all ports on which it received an inferior BPDU its designated ports and moves them out of the blocking state (if they were in the blocking state), through the listening and learning states, and into the forwarding state.

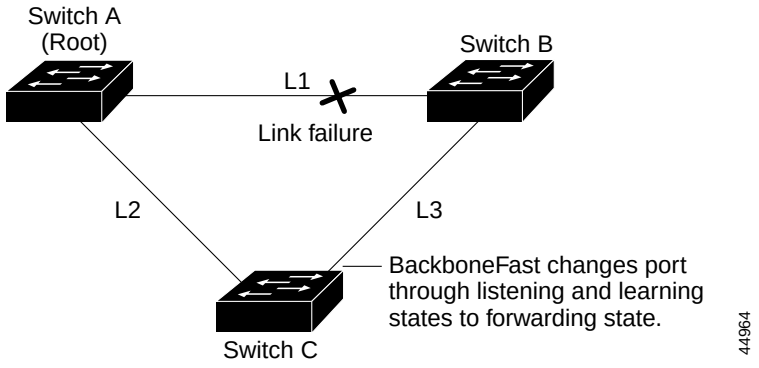
Figure 7 shows an example topology with no link failures. Switch A, the root switch, connects directly to Switch B over link L1 and to Switch C over link L2. The interface on Switch C that connects directly to Switch B is in the blocking state.

Figure 7 BackboneFast Example Before Indirect Link Failure



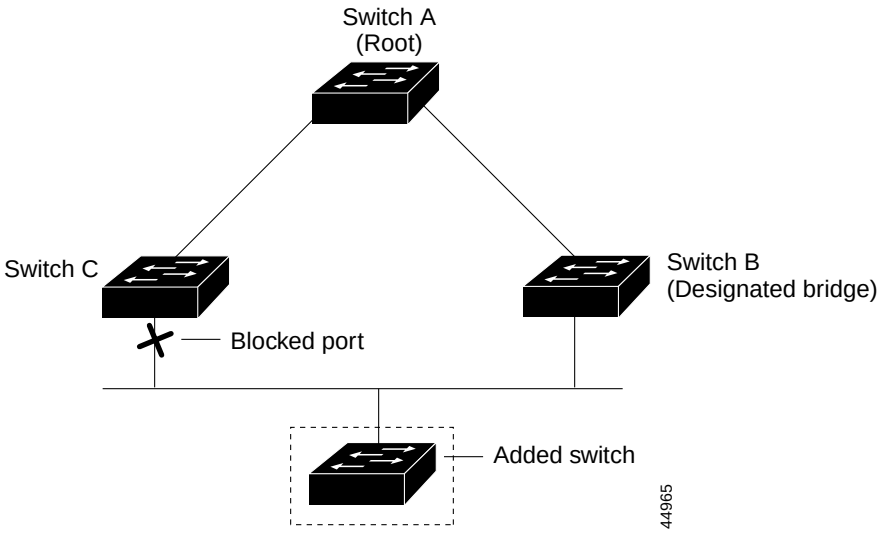
If link L1 fails, Switch C cannot detect this failure because it is not connected directly to link L1. However, because Switch B is directly connected to the root switch over L1, it detects the failure, elects itself the root, and begins sending BPDUs to Switch C, identifying itself as the root. When Switch C receives the inferior BPDUs from Switch B, Switch C assumes that an indirect failure has occurred. At that point, BackboneFast allows the blocked port on Switch C to move immediately to the listening state without waiting for the maximum aging time for the port to expire. BackboneFast then changes the interface on Switch C to the forwarding state, providing a path from Switch B to Switch A. This switchover takes approximately 30 seconds, twice the Forward Delay time if the default Forward Delay time of 15 seconds is set. Figure 8 shows how BackboneFast reconfigures the topology to account for the failure of link L1.

Figure 8 BackboneFast Example After Indirect Link Failure



If a new switch is introduced into a shared-medium topology as shown in Figure 9, BackboneFast is not activated because the inferior BPDUs did not come from the recognized designated bridge (Switch B). The new switch begins sending inferior BPDUs that say it is the root switch. However, the other switches ignore these inferior BPDUs, and the new switch learns that Switch B is the designated bridge to Switch A, the root switch.

Figure 9 Adding a Switch in a Shared-Medium Topology



Layer 2 Ethernet Switching

EtherSwitch network modules support simultaneous, parallel connections between Layer 2 Ethernet segments. Switched connections between Ethernet segments last only for the duration of the packet. New connections can be made between different segments for the next packet.

The EtherSwitch network module solves congestion problems caused by high-bandwidth devices and a large number of users by assigning each device (for example, a server) to its own 10-, 100-, or 1000-Mbps segment. Because each Ethernet interface on the switch represents a separate Ethernet segment, servers in a properly configured switched environment achieve full access to the bandwidth.

Because collisions are a major bottleneck in Ethernet networks, an effective solution is full-duplex communication. Normally, Ethernet operates in half-duplex mode, which means that stations can either receive or transmit. In full-duplex mode, two stations can transmit and receive at the same time. When packets can flow in both directions simultaneously, effective Ethernet bandwidth doubles to 20 Mbps for 10-Mbps interfaces and to 200 Mbps for Fast Ethernet interfaces.

Switching Frames Between Segments

Each Ethernet interface on an EtherSwitch network module can connect to a single workstation or server, or to a hub through which workstations or servers connect to the network.

On a typical Ethernet hub, all ports connect to a common backplane within the hub, and the bandwidth of the network is shared by all devices attached to the hub. If two stations establish a session that uses a significant level of bandwidth, the network performance of all other stations attached to the hub is degraded.

To reduce degradation, the switch treats each interface as an individual segment. When stations on different interfaces need to communicate, the switch forwards frames from one interface to the other at wire speed to ensure that each session receives full bandwidth.

To switch frames between interfaces efficiently, the switch maintains an address table. When a frame enters the switch, it associates the MAC address of the sending station with the interface on which it was received.

Building the Address Table

The EtherSwitch network module builds the address table by using the source address of the frames received. When the switch receives a frame for a destination address not listed in its address table, it floods the frame to all interfaces of the same virtual local-area network (VLAN) except the interface that received the frame. When the destination station replies, the switch adds its relevant source address and interface ID to the address table. The switch then forwards subsequent frames to a single interface without flooding to all interfaces. The address table can store at least 8,191 address entries without flooding any entries. The switch uses an aging mechanism, defined by a configurable aging timer; so if an address remains inactive for a specified number of seconds, it is removed from the address table.

Note Default parameters on the aging timer are recommended.

VLAN Trunks

A trunk is a point-to-point link between one or more Ethernet switch interfaces and another networking device such as a router or a switch. Trunks carry the traffic of multiple VLANs over a single link and allow you to extend VLANs across an entire network and supports only one encapsulation on all Ethernet interfaces: 802.1Q-802.1Q is an industry-standard trunking encapsulation. You can configure a trunk on a single Ethernet interface or on an EtherChannel bundle.

Layer 2 Interface Modes

Two Ethernet interface modes can be configured. Using the **switchport** command with the **mode access** keywords puts the interface into nontrunking mode. The interface will stay in access mode regardless of what the connected port mode is. Only access VLAN traffic will travel on the access port and untagged (802.3).

Using the **switchport** command with the **mode trunk** keywords puts the interface into permanent trunking mode.

Table 4 Default Layer 2 Ethernet Interface Configuration

Feature	Default Value
Interface mode	switchport mode access or trunk
Trunk encapsulation	switchport trunk encapsulation dot1q
Allowed VLAN range	VLANs 1-1005
Default VLAN (for access ports)	VLAN 1
Native VLAN (for 802.1Q trunks)	VLAN 1
Spanning Tree Protocol (STP)	Enabled for all VLANs
STP port priority	128
STP port cost	100 for 10-Mbps Ethernet interfaces 19 for 10/100-Mbps Fast Ethernet interfaces 19 for Gigabit Ethernet interfaces operated in 100-Mb mode 4 for Gigabit Ethernet interfaces operated in 1000-Mb mode

When you connect a Cisco switch to a device other than a Cisco device through an 802.1Q trunk, the Cisco switch combines the spanning tree instance of the VLAN trunk with the spanning tree instance of the other 802.1Q switch. However, spanning tree information for each VLAN is maintained by Cisco switches separated by a cloud of 802.1Q switches that are not Cisco switches. The 802.1Q cloud separating the Cisco switches that is not Cisco devised, is treated as a single trunk link between the switches.

Make sure that the native VLAN for an 802.1Q trunk is the same on both ends of the trunk link. If the VLAN on one end of the trunk is different from the VLAN on the other end, spanning tree loops might result. Inconsistencies detected by a Cisco switch mark the line as broken and block traffic for the specific VLAN.

Disabling spanning tree on the VLAN of an 802.1Q trunk without disabling spanning tree on every VLAN in the network can potentially cause spanning tree loops. Cisco recommends that you leave spanning tree enabled on the VLAN of an 802.1Q trunk or that you disable spanning tree on every VLAN in the network. Make sure that your network is loop-free before disabling spanning tree.

Layer 2 Interface Configuration Guidelines and Restrictions

Follow these guidelines and restrictions when configuring Layer 2 interfaces:

In a network of Cisco switches connected through 802.1Q trunks, the switches maintain one instance of spanning tree for each VLAN allowed on the trunks. 802.1Q switches that are not Cisco switches, maintain only one instance of spanning tree for all VLANs allowed on the trunks.

Cisco Discovery Protocol

Cisco Discovery Protocol (CDP) is a protocol that runs over Layer 2 (the data link layer) on all Cisco routers, bridges, access servers, and switches. CDP allows network management applications to discover Cisco devices that are neighbors of already known devices, in particular, neighbors running lower-layer, transparent protocols. With CDP, network management applications can learn the device type and the SNMP agent address of neighboring devices. This feature enables applications to send SNMP queries to neighboring devices.

CDP runs on all LAN and WAN media that support Subnetwork Access Protocol (SNAP). Each CDP-configured device sends periodic messages to a multicast address. Each device advertises at least one address at which it can receive SNMP messages. The advertisements also contain the time-to-live, or hold-time information, which indicates the length of time a receiving device should hold CDP information before discarding it.

Port Security

You can use port security to block input to an Ethernet, Fast Ethernet, or Gigabit Ethernet port when the MAC address of the station attempting to access the port is different from any of the MAC addresses specified for that port. Alternatively, you can use port security to filter traffic destined to or received from a specific host based on the host MAC address.

802.1x Authentication

This section describes how to configure IEEE 802.1x port-based authentication to prevent unauthorized devices (clients) from gaining access to the network. As LANs extend to hotels, airports, and corporate lobbies, insecure environments could be created.

Understanding 802.1x Port-Based Authentication

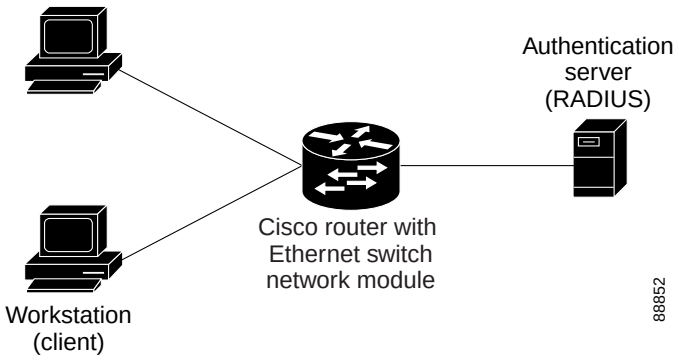
The IEEE 802.1x standard defines a client/server-based access control and authentication protocol that restricts unauthorized devices from connecting to a LAN through publicly accessible ports. The authentication server authenticates each client connected to a switch port before making available any services offered by the switch or the LAN.

Until the client is authenticated, 802.1x access control allows only Extensible Authentication Protocol over LAN (EAPOL) traffic through the port to which the client is connected. After authentication is successful, normal traffic can pass through the port.

Device Roles

With 802.1x port-based authentication, the devices in the network have specific roles as shown in Figure 10.

Figure 10 802.1x Device Roles



- *Client*—the device (workstation) that requests access to the LAN and switch services and responds to the requests from the switch. The workstation must be running 802.1x-compliant client software such as that offered in the Microsoft Windows XP operating system. (The client is the *supplicant* in the IEEE 802.1x specification.)

  Note To resolve Windows XP network connectivity and 802.1x authentication issues, read the Microsoft Knowledge Base article at this URL: http://support.microsoft.com/support/kb/articles/Q303/5/97.ASP

- *Authentication server*—performs the actual authentication of the client. The authentication server validates the identity of the client and notifies the switch whether or not the client is authorized to access the LAN and switch services. Because the switch acts as the proxy, the authentication service is transparent to the client. In this release, the Remote Authentication Dial-In User Service (RADIUS) security system with Extensible Authentication Protocol (EAP) extensions is the only supported authentication server; it is available in Cisco Secure Access Control Server version 3.0. RADIUS operates in a client/server model in which secure authentication information is exchanged between the RADIUS server and one or more RADIUS clients.

- *Switch* (edge switch or wireless access point)—controls the physical access to the network based on the authentication status of the client. The switch acts as an intermediary (proxy) between the client and the authentication server, requesting identity information from the client, verifying that information with the authentication server, and relaying a response to the client. The switch includes the RADIUS client, which is responsible for encapsulating and decapsulating the Extensible Authentication Protocol (EAP) frames and interacting with the authentication server.

  When the switch receives EAPOL frames and relays them to the authentication server, the Ethernet header is stripped and the remaining EAP frame is reencapsulated in the RADIUS format. The EAP frames are not modified or examined during encapsulation, and the authentication server must support EAP within the native frame format. When the switch receives frames from the authentication server, the server's frame header is removed, leaving the EAP frame, which is then encapsulated for Ethernet and sent to the client.

  The devices that can act as intermediaries include the Catalyst 3550 multilayer switch, Catalyst 2950 switch, or a wireless access point. These devices must be running software that supports the RADIUS client and 802.1x.

Authentication Initiation and Message Exchange

The switch or the client can initiate authentication. If you enable authentication on a port by using the **dot1x port-control auto** interface configuration command, the switch must initiate authentication when it determines that the port link state changes from down to up. It then sends an EAP-request/identity frame to the client to request its identity (typically, the switch sends an initial identity/request frame followed by one or more requests for authentication information). Upon receipt of the frame, the client responds with an EAP-response/identity frame.

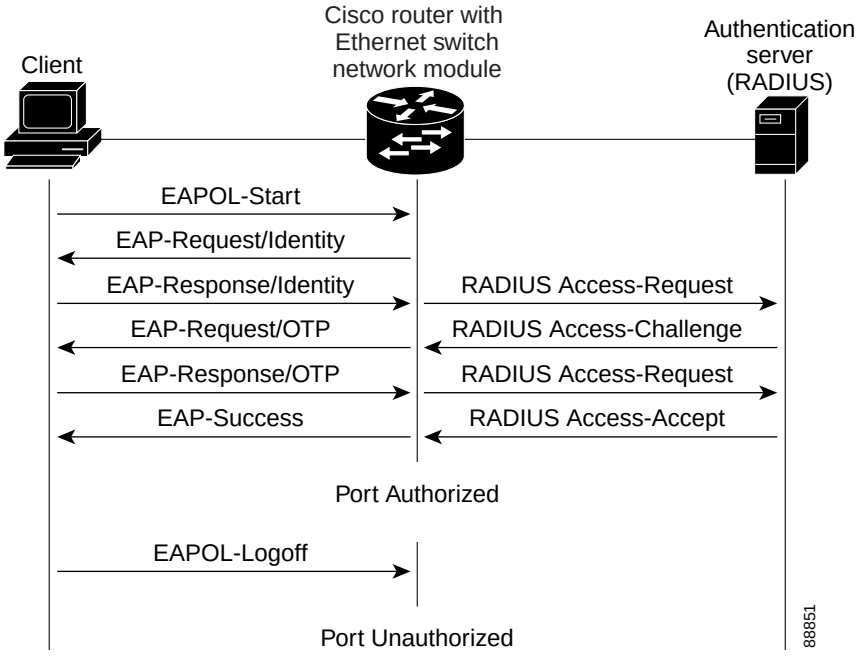
However, if during bootup, the client does not receive an EAP-request/identity frame from the switch, the client can initiate authentication by sending an EAPOL-start frame, which prompts the switch to request the client's identity.

Note If 802.1x is not enabled or supported on the network access device, any EAPOL frames from the client are dropped. If the client does not receive an EAP-request/identity frame after three attempts to start authentication, the client transmits frames as if the port is in the authorized state. A port in the authorized state effectively means that the client has been successfully authenticated.

When the client supplies its identity, the switch begins its role as the intermediary, passing EAP frames between the client and the authentication server until authentication succeeds or fails. If the authentication succeeds, the switch port becomes authorized.

The specific exchange of EAP frames depends on the authentication method being used. Figure 11 shows a message exchange initiated by the client using the One-Time-Password (OTP) authentication method with a RADIUS server.

Figure 11 Message Exchange



Ports in Authorized and Unauthorized States

The switch port state determines whether or not the client is granted access to the network. The port starts in the *unauthorized* state. While in this state, the port disallows all ingress and egress traffic except for 802.1x packets. When a client is successfully authenticated, the port changes to the *authorized* state, allowing all traffic for the client to flow normally.

If a client that does not support 802.1x is connected to an unauthorized 802.1x port, the switch requests the client's identity. In this situation, the client does not respond to the request, the port remains in the unauthorized state, and the client is not granted access to the network.

In contrast, when an 802.1x-enabled client connects to a port that is not running 802.1x, the client initiates the authentication process by sending the EAPOL-start frame. When no response is received, the client sends the request for a fixed number of times. Because no response is received, the client begins sending frames as if the port is in the authorized state.

If the client is successfully authenticated (receives an Accept frame from the authentication server), the port state changes to authorized, and all frames from the authenticated client are allowed through the port. If the authentication fails, the port remains in the unauthorized state, but authentication can be retried. If the authentication server cannot be reached, the switch can retransmit the request. If no response is received from the server after the specified number of attempts, authentication fails, and network access is not granted.

When a client logs off, it sends an EAPOL-logoff message, causing the switch port to change to the unauthorized state.

If the link state of a port changes from up to down, or if an EAPOL-logoff frame is received, the port returns to the unauthorized state.

Supported Topologies

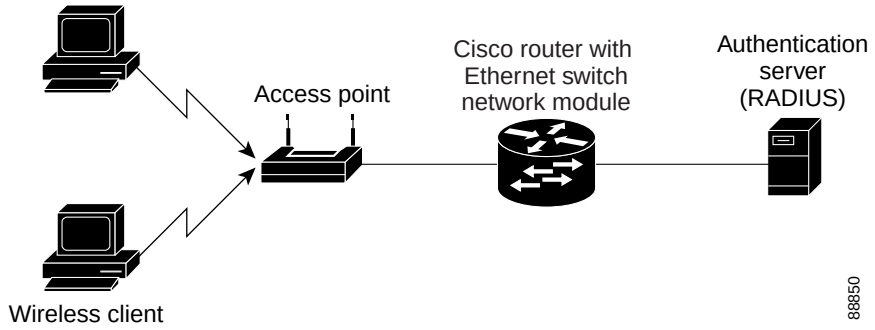
The 802.1x port-based authentication is supported in two topologies:

- Point-to-point
- Wireless LAN

In a point-to-point configuration (see Figure 10 on page 21), only one client can be connected to the 802.1x-enabled switch port. The switch detects the client when the port link state changes to the up state. If a client leaves or is replaced with another client, the switch changes the port link state to down, and the port returns to the unauthorized state.

Figure 12 shows 802.1x-port-based authentication in a wireless LAN. The 802.1x port is configured as a multiple-host port that becomes authorized as soon as one client is authenticated. When the port is authorized, all other hosts indirectly attached to the port are granted access to the network. If the port becomes unauthorized (reauthentication fails or an EAPOL-logoff message is received), the switch denies access to the network to all of the attached clients. In this topology, the wireless access point is responsible for authenticating the clients attached to it, and the wireless access point acts as a client to the switch.

Figure 12 Wireless LAN Example



Storm Control

A traffic storm occurs when packets flood the LAN, creating excessive traffic and degrading network performance. Errors in the protocol-stack implementation or in the network configuration can cause a storm. Storm control can be implemented globally or on a per-port basis. Global storm control and per-port storm control cannot be enabled at the same time.

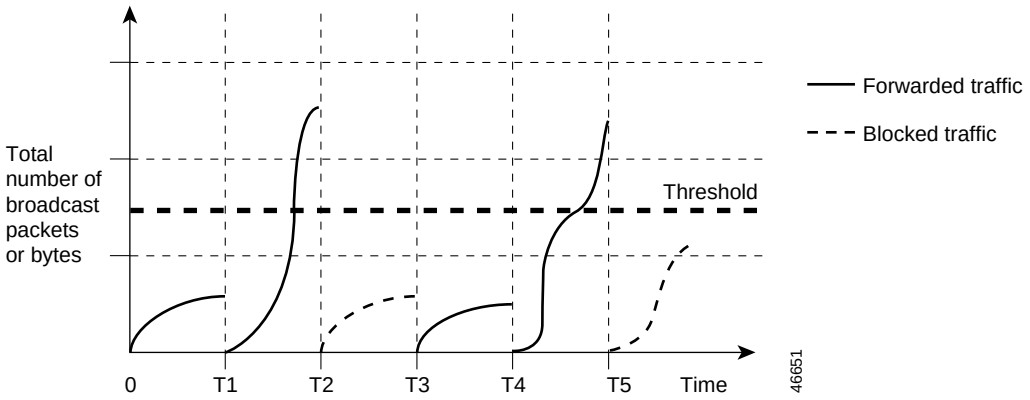
Global Storm Control

Global storm control prevents switchports on a LAN from being disrupted by a broadcast, multicast, or unicast storm on one of the interfaces. Global storm control monitors incoming traffic statistics over a time period and compares the measurement with a predefined suppression level threshold. The threshold represents the percentage of the total available bandwidth of the port. If the threshold of a traffic type is reached, further traffic of that type is suppressed until the incoming traffic falls below the threshold level. Global storm control is disabled by default.

The switch supports global storm control for broadcast, multicast, and unicast traffic. This example of broadcast suppression can also be applied to multicast and unicast traffic.

The graph in Figure 13 shows broadcast traffic patterns on an interface over a given period of time. In this example, the broadcast traffic exceeded the configured threshold between time intervals T1 and T2 and between T4 and T5. When the amount of specified traffic exceeds the threshold, all traffic of that kind is dropped. Therefore, broadcast traffic is blocked during those intervals. At the next time interval, if broadcast traffic does not exceed the threshold, it is again forwarded.

Figure 13 Broadcast Suppression Example



When global storm control is enabled, the switch monitors packets passing from an interface to the switching bus and determines if the packet is unicast, multicast, or broadcast. The switch monitors the number of broadcast, multicast, or unicast packets received within the 1-second time interval, and when a threshold for one type of traffic is reached, that type of traffic is dropped. This threshold is specified as a percentage of total available bandwidth that can be used by broadcast (multicast or unicast) traffic.

The combination of broadcast suppression threshold numbers and the 1-second time interval control the way the suppression algorithm works. A higher threshold allows more packets to pass through. A threshold value of 100 percent means that no limit is placed on the traffic.

Note Because packets do not arrive at uniform intervals, the 1-second time interval during which traffic activity is measured can affect the behavior of global storm control.

The switch continues to monitor traffic on the port, and when the utilization level is below the threshold level, the type of traffic that was dropped is forwarded again.

Per-Port Storm Control

A packet storm occurs when a large number of broadcast, unicast, or multicast packets are received on a port. Forwarding these packets can cause the network to slow down or to time out. By default, per-port storm control is disabled.

Per-port storm control uses rising and falling thresholds to block and then restore the forwarding of broadcast, unicast, or multicast packets. You can also set the switch to shut down the port when the rising threshold is reached.

Per-port storm control uses a bandwidth-based method to measure traffic activity. The thresholds are expressed as a percentage of the total available bandwidth that can be used by the broadcast, multicast, or unicast traffic.

The rising threshold is the percentage of total available bandwidth associated with multicast, broadcast, or unicast traffic before forwarding is blocked. The falling threshold is the percentage of total available bandwidth below which the switch resumes normal forwarding. In general, the higher the level, the less effective the protection against broadcast storms.

EtherChannel

EtherChannel bundles up to eight individual Ethernet links into a single logical link that provides bandwidth of up to 1600 Mbps (Fast EtherChannel full duplex) between the network module and another switch or host.

An EtherSwitch network module system supports a maximum of six EtherChannels. All interfaces in each EtherChannel must have the same speed duplex and mode.

Load Balancing

EtherChannel balances traffic load across the links in a channel by reducing part of the binary pattern formed from the addresses in the frame to a numerical value that selects one of the links in the channel.

EtherChannel load balancing can use MAC addresses or IP addresses; either source or destination or both source and destination. The selected mode applies to all EtherChannels configured on the switch.

Use the option that provides the greatest variety in your configuration. For example, if the traffic on a channel is going only to a single MAC address, using the destination MAC address always chooses the same link in the channel; using source addresses or IP addresses may result in better load balancing.

EtherChannel Configuration Guidelines and Restrictions

If improperly configured, some EtherChannel interfaces are disabled automatically to avoid network loops and other problems. Follow these guidelines and restrictions to avoid configuration problems:

- All Ethernet interfaces on all modules support EtherChannel (maximum of eight interfaces) with no requirement that interfaces be physically contiguous or on the same module.
- Configure all interfaces in an EtherChannel to operate at the same speed and duplex mode.
- Enable all interfaces in an EtherChannel. If you shut down an interface in an EtherChannel, it is treated as a link failure and its traffic is transferred to one of the remaining interfaces in the EtherChannel.
- An EtherChannel will not form if one of the interfaces is a Switched Port Analyzer (SPAN) destination port.

For Layer 2 EtherChannels:

- Assign all interfaces in the EtherChannel to the same VLAN, or configure them as trunks.

An EtherChannel supports the same allowed range of VLANs on all interfaces in a trunking Layer 2 EtherChannel. If the allowed range of VLANs is not the same, the interfaces do not form an EtherChannel.

Interfaces with different Spanning Tree Protocol (STP) port path costs can form an EtherChannel as long they are otherwise compatibly configured. Setting different STP port path costs does not, by itself, make interfaces incompatible for the formation of an EtherChannel.

After you configure an EtherChannel, configuration that you apply to the port-channel interface affects the EtherChannel.

Flow Control on Gigabit Ethernet Ports

Flow control is a feature that Gigabit Ethernet ports use to inhibit the transmission of incoming packets. If a buffer on a Gigabit Ethernet port runs out of space, the port transmits a special packet that requests remote ports to delay sending packets for a period of time. This special packet is called a *pause frame*. The **send** and **receive** keywords of the **set port flowcontrol** command are used to specify the behavior of the pause frames.

Intrachassis Stacking

Multiple switch modules may be installed simultaneously by connecting the Gigabit Ethernet (GE) ports of the EtherSwitch network module. This connection sustains a line-rate traffic similar to the switch fabric found in Cisco Catalyst switches and forms a single VLAN consisting of all ports in multiple EtherSwitch network modules. The stacking port must be configured for multiple switch modules to operate correctly in the same chassis.

- MAC address entries learned via intrachassis stacking are not displayed.
- Link status of intrachassis stacked ports are filtered.

Switched Port Analyzer

Switched Port Analyzer Session

A Switched Port Analyzer (SPAN) session is an association of a destination interface with a set of source interfaces. You configure SPAN sessions using parameters that specify the type of network traffic to monitor. SPAN sessions allow you to monitor traffic on one or more interfaces and to send either ingress traffic, egress traffic, or both to one destination interface. You can configure one SPAN session with separate or overlapping sets of SPAN source interfaces or VLANs. Only switched interfaces can be configured as SPAN sources or destinations on the same network module.

SPAN sessions do not interfere with the normal operation of the switch. You can enable or disable SPAN sessions with command-line interface (CLI) or SNMP commands. When enabled, a SPAN session might become active or inactive based on various events or actions, and this would be indicated by a syslog message. The **show monitor session** command displays the operational status of a SPAN session.

A SPAN session remains inactive after system power-up until the destination interface is operational.

Destination Interface

A destination interface (also called a monitor interface) is a switched interface to which SPAN sends packets for analysis. You can have one SPAN destination interface. Once an interface becomes an active destination interface, incoming traffic is disabled. You cannot configure a SPAN destination interface to receive ingress traffic. The interface does not forward any traffic except that required for the SPAN session.

An interface configured as a destination interface cannot be configured as a source interface. EtherChannel interfaces cannot be SPAN destination interfaces.

Specifying a trunk interface as a SPAN destination interface stops trunking on the interface.

Source Interface

A source interface is an interface monitored for network traffic analysis. One or more source interfaces can be monitored in a single SPAN session with user-specified traffic types (ingress, egress, or both) applicable for all the source interfaces.

You can configure source interfaces in any VLAN. You can configure EtherChannel as source interfaces, which means that all interfaces in the specified VLANs are source interfaces for the SPAN session.

Trunk interfaces can be configured as source interfaces and mixed with nontrunk source interfaces; however, the destination interface never encapsulates.

Traffic Types

Ingress SPAN (Rx) copies network traffic received by the source interfaces for analysis at the destination interface. Egress SPAN (Tx) copies network traffic transmitted from the source interfaces. Specifying the configuration option **both** copies network traffic received and transmitted by the source interfaces to the destination interface.

SPAN Traffic

Network traffic, including multicast, can be monitored using SPAN. Multicast packet monitoring is enabled by default. In some SPAN configurations, multiple copies of the same source packet are sent to the SPAN destination interface. For example, a bidirectional (both ingress and egress) SPAN session is configured for sources a1 and a2 to a destination interface d1. If a packet enters the switch through a1 and gets switched to a2, both incoming and outgoing packets are sent to destination interface d1; both packets would be the same (unless a Layer-3 rewrite had occurred, in which case the packets would be different).

Note Monitoring of VLANs is not supported.

SPAN Configuration Guidelines and Restrictions

Follow these guidelines and restrictions when configuring SPAN:

- Enter the **no monitor session** *session number* command with no other parameters to clear the SPAN session number.
- EtherChannel interfaces can be SPAN source interfaces; they cannot be SPAN destination interfaces.
- If you specify multiple SPAN source interfaces, the interfaces can belong to different VLANs.
- Monitoring of VLANs is not supported
- Only one SPAN session may be run at any given time.
- Outgoing CDP and BPDU packets will not be replicated.
- SPAN destinations never participate in any spanning tree instance. SPAN includes BPDUs in the monitored traffic, so any BPDUs seen on the SPAN destination are from the SPAN source.
- Use a network analyzer to monitor interfaces.
- You can have one SPAN destination interface.
- You can mix individual source interfaces within a single SPAN session.
- You cannot configure a SPAN destination interface to receive ingress traffic.
- When enabled, SPAN uses any previously entered configuration.
- When you specify source interfaces and do not specify a traffic type (**Tx**, **Rx**, or **both**), **both** is used by default.

Switched Virtual Interface

A switch virtual interface (SVI) represents a VLAN of switch ports as one interface to the routing or bridging function in the system. Only one SVI can be associated with a VLAN, but it is necessary to configure an SVI for a VLAN only when you wish to route between VLANs, fallback-bridge nonroutable protocols between VLANs, or to provide IP host connectivity to the switch. By default, an SVI is created for the default VLAN (VLAN 1) to permit remote switch administration. Additional SVIs must be explicitly configured. You can configure routing across SVIs.

SVIs are created the first time that you enter the **vlan** interface configuration command for a VLAN interface. The VLAN corresponds to the VLAN tag associated with data frames on an ISL or 802.1Q encapsulated trunk or the VLAN ID configured for an access port. Configure a VLAN interface for each VLAN for which you want to route traffic, and assign it an IP address.

SVIs support routing protocol and bridging configurations. For more information about configuring IP routing across SVIs, see the "Enabling and Verifying IP Multicast Layer 3 Switching" section on page 92.

Routed Ports

A routed port is a physical port that acts like a port on a router; it does not have to be connected to a router. A routed port is not associated with a particular VLAN, as is an access port. A routed port behaves like a regular router interface, except that it does not support subinterfaces. Routed ports can be configured with a Layer 3 routing protocol.

Configure routed ports by putting the interface into Layer 3 mode with the **no switchport** interface configuration command. Then assign an IP address to the port, enable routing, and assign routing protocol characteristics by using the **ip routing** and **router** *protocol* global configuration commands.

Caution Entering a **no switchport** interface configuration command shuts the interface down and then reenables it, which might generate messages on the device to which the interface is connected. Furthermore, when you use this command to put the interface into Layer 3 mode, you are deleting any Layer 2 characteristics configured on the interface. (Also, when you return the interface to Layer 2 mode, you are deleting any Layer 3 characteristics configured on the interface.)

The number of routed ports and SVIs that you can configure is not limited by software; however, the interrelationship between this number and the number of other features being configured might have an impact on CPU utilization because of hardware limitations.

Routed ports support only Cisco Express Forwarding (CEF) switching (IP fast switching is not supported).

IP Multicast Layer 3 Switching

The maximum number of configured VLANs must be less than or equal to 242. The maximum number of multicast groups is related to the maximum number of VLANs. The number of VLANs is determined by multiplying the number of VLANs by the number of multicast groups. For example, the maximum number for 10 VLANs and 20 groups would be 200, under the 242 limit. This feature also provides support for Protocol Independent Multicast (PIM) sparse mode/dense mode/sparse-dense mode.

IGMP Snooping

Internet Group Management Protocol (IGMP) snooping constrains the flooding of multicast traffic by dynamically configuring the interfaces so that multicast traffic is forwarded only to those interfaces associated with IP multicast devices. The LAN switch snoops on the IGMP traffic between the host and the router and keeps track of multicast groups and member ports. When the switch receives an IGMP join report from a host for a particular multicast group, the switch adds the host port number to the associated multicast forwarding table entry. When it receives an IGMP Leave Group message from a host, it removes the host port from the table entry. After it relays the IGMP queries from the multicast router, it deletes entries periodically if it does not receive any IGMP membership reports from the multicast clients.

When IGMP snooping is enabled, the multicast router sends out periodic IGMP general queries to all VLANs. The switch responds to the router queries with only one join request per MAC multicast group, and the switch creates one entry per VLAN in the Layer 2 forwarding table for each MAC group from which it receives an IGMP join request. All hosts interested in this multicast traffic send join requests and are added to the forwarding table entry.

Layer 2 multicast groups learned through IGMP snooping are dynamic. However, you can statically configure MAC multicast groups by using the **ip igmp snooping vlan static** command. If you specify group membership for a multicast group address statically, your setting supersedes any automatic manipulation by IGMP snooping. Multicast group membership lists can consist of both user-defined and IGMP snooping-learned settings.

EtherSwitch network modules support a maximum of 255 IP multicast groups and support both IGMP version 1 and IGMP version 2.

If a port spanning-tree, a port group, or a VLAN ID change occurs, the IGMP snooping-learned multicast groups from this port on the VLAN are deleted.

In the IP multicast-source-only environment, the switch learns the IP multicast group from the IP multicast data stream and only forwards traffic to the multicast router ports.

Immediate-Leave Processing

IGMP snooping Immediate-Leave processing allows the switch to remove an interface that sends a leave message from the forwarding table without first sending out MAC-based general queries to the interface. The VLAN interface is pruned from the multicast tree for the multicast group specified in the original leave message. Immediate-Leave processing ensures optimal bandwidth management for all hosts on a switched network, even when multiple multicast groups are in use simultaneously.

Note You should use the Immediate-Leave processing feature only on VLANs where only one host is connected to each port. If Immediate-Leave processing is enabled on VLANs where more than one host is connected to a port, some hosts might be inadvertently dropped. Immediate-Leave processing is supported only with IGMP version 2 hosts.

Setting the Snooping Method

Multicast-capable router ports are added to the forwarding table for every IP multicast entry. The switch learns of such ports through one of these methods:

- Snooping on PIM and DVMRP packets
- Statically connecting to a multicast router port with the **ip igmp snooping mrouter** global configuration command

You can configure the switch to snoop on PIM/Distance Vector Multicast Routing Protocol (PIM/DVMRP) packets. By default, the switch snoops on PIM/DVMRP packets on all VLANs. To learn of multicast router ports through PIM-DVMRP packets, use the **ip igmp snooping vlan** *vlan-id* **mrouter learn pim-dvmrp** interface configuration command.

Joining a Multicast Group

When a host connected to the switch wants to join an IP multicast group, it sends an IGMP join message, specifying the IP multicast group it wants to join. When the switch receives this message, it adds the port to the IP multicast group port address entry in the forwarding table.

Refer to Figure 14. Host 1 wants to join multicast group 224.1.2.3 and send a multicast message of an unsolicited IGMP membership report (IGMP join message) to the group with the equivalent MAC destination address of 0100.5E01.0203. The switch recognizes IGMP packets and forwards them to the CPU. When the CPU receives the IGMP multicast report by Host 1, the CPU uses the information to set up a multicast forwarding table entry as shown in Table 5 that includes the port numbers of Host 1 and the router.

Figure 14 Initial IGMP Join Message

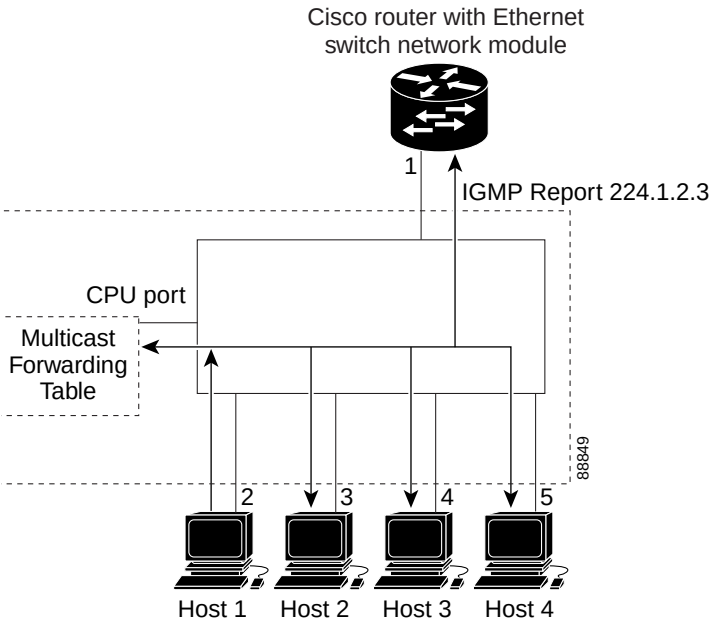


Table 5 IP Multicast Forwarding Table

Destination Address	Type of Packet	Ports
0100.5e01.0203	!IGMP	1, 2

Note that the switch architecture allows the CPU to distinguish IGMP information packets from other packets for the multicast group. The switch recognizes the IGMP packets through its filter engine. This prevents the CPU from becoming overloaded with multicast frames.

The entry in the multicast forwarding table tells the switching engine to send frames addressed to the 0100.5E01.0203 multicast MAC address that are not IGMP packets (!IGMP) to the router and to the host that has joined the group.

If another host (for example, Host 4) sends an IGMP join message for the same group (Figure 15), the CPU receives that message and adds the port number of Host 4 to the multicast forwarding table as shown in Table 6.

Figure 15 Second Host Joining a Multicast Group

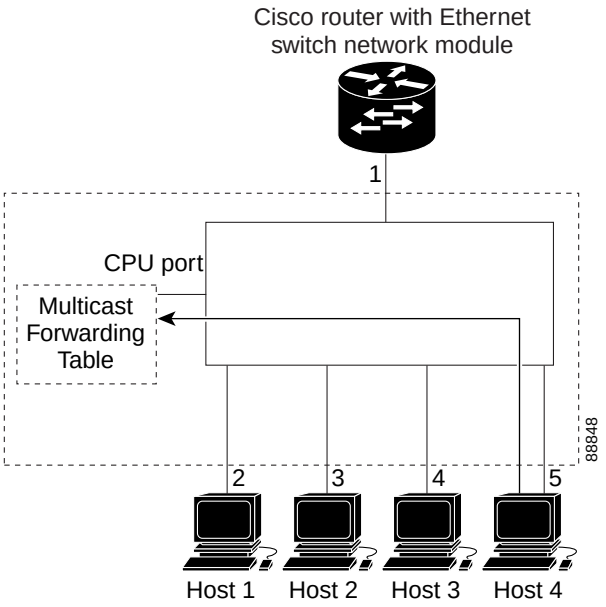


Table 6 Updated Multicast Forwarding Table

Destination Address	Type of Packet	Ports
0100.5e01.0203	!IGMP	1, 2, 5

Leaving a Multicast Group

The router sends periodic IP multicast general queries, and the switch responds to these queries with one join response per MAC multicast group. As long as at least one host in the VLAN needs multicast traffic, the switch responds to the router queries, and the router continues forwarding the multicast traffic to the VLAN. The switch only forwards IP multicast group traffic to those hosts listed in the forwarding table for that IP multicast group.

When hosts need to leave a multicast group, they can either ignore the periodic general-query requests sent by the router, or they can send a leave message. When the switch receives a leave message from a host, it sends out a group-specific query to determine if any devices behind that interface are interested in traffic for the specific multicast group. If, after a number of queries, the router processor receives no reports from a VLAN, it removes the group for the VLAN from its multicast forwarding table.

Fallback Bridging

With fallback bridging, the switch bridges together two or more VLANs or routed ports, essentially connecting multiple VLANs within one bridge domain. Fallback bridging forwards traffic that the multilayer switch does not route and forwards traffic belonging to a nonroutable protocol such as DECnet.

Fallback bridging does not allow the spanning trees from the VLANs being bridged to collapse; each VLAN has its own Spanning Tree Protocol (STP) instance and a separate spanning tree, called the VLAN-bridge spanning tree, which runs on top of the bridge group to prevent loops.

A VLAN bridge domain is represented using the switch virtual interface (SVI). A set of SVIs and routed ports (which do not have any VLANs associated with them) can be configured to form a bridge group.

Recall that an SVI represents a VLAN of switch ports as one interface to the routing or bridging function in the system. Only one SVI can be associated with a VLAN, and it is only necessary to configure an SVI for a VLAN when you want to route between VLANs, to fallback-bridge nonroutable protocols between VLANs, or to provide IP host connectivity to the switch. A routed port is a physical port that acts like a port on a router, but it is not connected to a router. A routed port is not associated with a particular VLAN, does not support subinterfaces, but behaves like a normal routed interface.

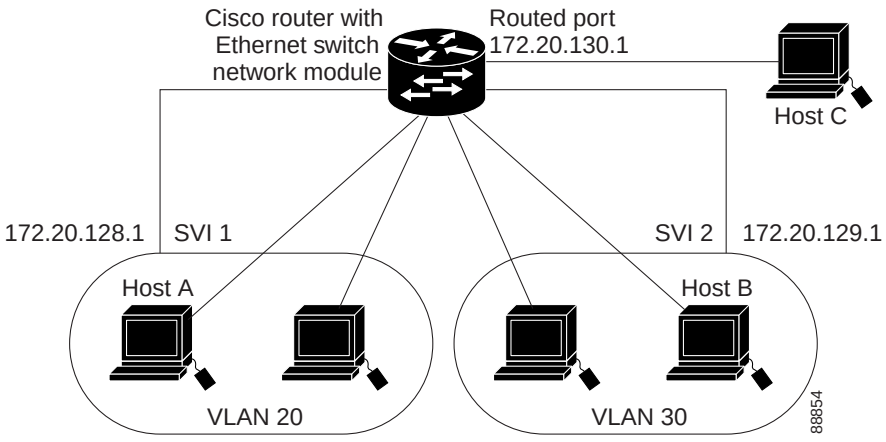
A bridge group is an internal organization of network interfaces on a switch. Bridge groups cannot be used to identify traffic switched within the bridge group outside the switch on which they are defined. Bridge groups on the same switch function as distinct bridges; that is, bridged traffic and bridge protocol data units (BPDUs) cannot be exchanged between different bridge groups on a switch. An interface can be a member of only one bridge group. Use a bridge group for each separately bridged (topologically distinct) network connected to the switch.

The purpose of placing network interfaces into a bridge group is twofold:

- To bridge all nonrouted traffic among the network interfaces making up the bridge group. If the packet destination address is in the bridge table, it is forwarded on a single interface in the bridge group. If the packet destination address is not in the bridge table, it is flooded on all forwarding interfaces in the bridge group. The bridge places source addresses in the bridge table as it learns them during the bridging process.
- To participate in the spanning-tree algorithm by receiving, and in some cases sending, BPDUs on the LANs to which they are attached. A separate spanning process runs for each configured bridge group. Each bridge group participates in a separate spanning-tree instance. A bridge group establishes a spanning-tree instance based on the BPDUs it receives on only its member interfaces.

Figure 16 shows a fallback bridging network example. The multilayer switch has two interfaces configured as SVIs with different assigned IP addresses and attached to two different VLANs. Another interface is configured as a routed port with its own IP address. If all three of these ports are assigned to the same bridge group, non-IP protocol frames can be forwarded among the end stations connected to the switch.

Figure 16 Fallback Bridging Network Example



Network Security with ACLs at Layer 2

Network security on your EtherSwitch network module can be implemented using access control lists (ACLs), which are also referred to in commands and tables as access lists.

Understanding ACLs

Packet filtering can limit network traffic and restrict network use by certain users or devices. ACLs can filter traffic as it passes through a switch and permit or deny packets from crossing specified interfaces. An ACL is a sequential collection of permit and deny conditions that apply to packets. When a packet is received on an interface, the switch compares the fields in the packet against any applied ACLs to verify that the packet has the required permissions to be forwarded, based on the criteria specified in the access lists. The switch tests the packet against the conditions in an access list one by one. The first match determines whether the switch accepts or rejects the packet. Because the switch stops testing conditions after the first match, the order of conditions in the list is critical. If no conditions match, the switch rejects the packet. If there are no restrictions, the switch forwards the packet; otherwise, the switch drops the packet.

You configure access lists on a Layer 2 switch to provide basic security for your network. If you do not configure ACLs, all packets passing through the switch could be allowed onto all parts of the network. You can use ACLs to control which hosts can access different parts of a network or to decide which types of traffic are forwarded or blocked at switch interfaces. For example, you can allow e-mail traffic to be forwarded but not Telnet traffic. ACLs can be configured to block inbound traffic.

An ACL contains an ordered list of access control entries (ACEs). Each ACE specifies *permit* or *deny* and a set of conditions the packet must satisfy in order to match the ACE. The meaning of *permit* or *deny* depends on the context in which the ACL is used.

The EtherSwitch network module supports IP ACLs to filter IP traffic, including TCP or User Datagram Protocol (UDP) traffic (but not both traffic types in the same ACL).

ACLs

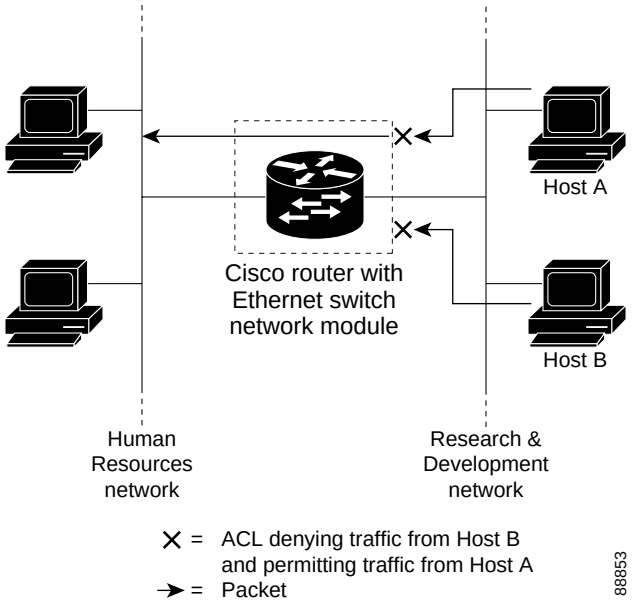
You can apply ACLs on physical Layer 2 interfaces. ACLs are applied on interfaces only on the inbound direction.

- Standard IP access lists use source addresses for matching operations.
- Extended IP access lists use source and destination addresses and optional protocol type information for matching operations.

The switch examines access lists associated with features configured on a given interface and a direction. As packets enter the switch on an interface, ACLs associated with all inbound features configured on that interface are examined.

ACLs permit or deny packet forwarding based on how the packet matches the entries in the ACL. For example, you can use ACLs to allow one host to access a part of a network, but to prevent another host from accessing the same part. In Figure 17, ACLs applied at the switch input allow Host A to access the Human Resources network, but prevent Host B from accessing the same network.

Figure 17 Using ACLs to Control Traffic to a Network



Handling Fragmented and Unfragmented Traffic

IP packets can be fragmented as they cross the network. When this happens, only the fragment containing the beginning of the packet contains the Layer 4 information, such as TCP or UDP port numbers, ICMP type and code, and so on. All other fragments are missing this information.

Some ACEs do not check Layer 4 information and therefore can be applied to all packet fragments. ACEs that do test Layer 4 information cannot be applied in the standard manner to most of the fragments in a fragmented IP packet. When the fragment contains no Layer 4 information and the ACE tests some Layer 4 information, the matching rules are modified:

- Permit ACEs that check the Layer 3 information in the fragment (including protocol type, such as TCP, UDP, and so on) are considered to match the fragment regardless of what the missing Layer 4 information might have been.
- Deny ACEs that check Layer 4 information never match a fragment unless the fragment contains Layer 4 information.

Consider access list 102, configured with these commands, applied to three fragmented packets:

```
Router(config)# access-list 102 permit tcp any host 10.1.1.1 eq smtp
Router(config)# access-list 102 deny tcp any host 10.1.1.2 eq telnet
Router(config)# access-list 102 deny tcp any any
```

Note In the first and second ACEs in the examples, the **eq** keyword after the destination address means to test for the TCP-destination-port well-known numbers equaling Simple Mail Transfer Protocol (SMTP) and Telnet, respectively.

- Packet A is a TCP packet from host 10.2.2.2, port 65000, going to host 10.1.1.1 on the SMTP port. If this packet is fragmented, the first fragment matches the first ACE (a permit), as if it were a complete packet because all Layer 4 information is present. The remaining fragments also match the

first ACE, even though they do not contain the SMTP port information because the first ACE only checks Layer 3 information when applied to fragments. (The information in this example is that the packet is TCP and that the destination is 10.1.1.1.)

- Packet B is from host 10.2.2.2, port 65001, going to host 10.1.1.2 on the Telnet port. If this packet is fragmented, the first fragment matches the second ACE (a deny) because all Layer 3 and Layer 4 information is present. The remaining fragments in the packet do not match the second ACE because they are missing Layer 4 information.
- Because the first fragment was denied, host 10.1.1.2 cannot reassemble a complete packet, so packet B is effectively denied. However, the later fragments that are permitted will consume bandwidth on the network and resources of host 10.1.1.2 as it tries to reassemble the packet.
- Fragmented packet C is from host 10.2.2.2, port 65001, going to host 10.1.1.3, port FTP. If this packet is fragmented, the first fragment matches the third ACE (a deny). All other fragments also match the third ACE because that ACE does not check any Layer 4 information and because Layer 3 information in all fragments shows that they are being sent to host 10.1.1.3, and the earlier permit ACEs were checking different hosts.

Understanding Access Control Parameters

Before configuring ACLs on the EtherSwitch network module, you must have a thorough understanding of the Access Control Parameters (ACPs). ACPs are referred to as masks in the switch CLI commands, and output.

Each ACE has a mask and a rule. The Classification Field or mask is the field of interest on which you want to perform an action. The specific values associated with a given mask are called *rules*.

Packets can be classified on these Layer 3 and Layer 4 fields.

- Layer 3 fields:
  - IP source address (Specify all 32 IP source address bits to define the flow, or specify a user-defined subnet. There are no restrictions on the IP subnet to be specified.)
  - IP destination address (Specify all 32 IP destination address bits to define the flow, or specify a user-defined subnet. There are no restrictions on the IP subnet to be specified.)

    You can use any combination or all of these fields simultaneously to define a flow.
- Layer 4 fields:
  - TCP (You can specify a TCP source, destination port number, or both at the same time.)
  - UDP (You can specify a UDP source, destination port number, or both at the same time.)

Note A mask can be a combination of multiple Layer 3 and Layer 4 fields.

There are two types of masks:

- User-defined mask—masks that are defined by the user.
- System-defined mask—these masks can be configured on any interface:

```
Router(config-ext-nacl)# permit tcp any any
Router(config-ext-nacl)# deny tcp any any
Router(config-ext-nacl)# permit udp any any
Router(config-ext-nacl)# deny udp any any
Router(config-ext-nacl)# permit ip any any
Router(config-ext-nacl)# deny ip any any
Router(config-ext-nacl)# deny any any
Router(config-ext-nacl)# permit any any
```

Note In an IP extended ACL (both named and numbered), a Layer 4 system-defined mask cannot precede a Layer 3 user-defined mask. For example, a Layer 4 system-defined mask such as **permit tcp any any** or **deny udp any any** cannot precede a Layer 3 user-defined mask such as **permit ip 10.1.1.1 any**. If you configure this combination, the ACL is not configured. All other combinations of system-defined and user-defined masks are allowed in security ACLs.

The EtherSwitch network module ACL configuration is consistent with Cisco Catalyst switches. However, there are significant restrictions as well as differences for ACL configurations on the EtherSwitch network module.

Guidelines for Configuring ACLs on the EtherSwitch network module

These configuration guidelines apply to ACL filters:

- Only one ACL can be attached to an interface.
- All ACEs in an ACL must have the same user-defined mask. However, ACEs can have different rules that use the same mask. On a given interface, only one type of user-defined mask is allowed, but you can apply any number of system-defined masks.

  The following example shows the same mask in an ACL:

  ```
  Router(config)# ip access-list extended acl2
  Router(config-ext-nacl)# permit tcp 10.1.1.1 0.0.0.0 any eq 80
  Router(config-ext-nacl)# permit tcp 20.1.1.1 0.0.0.0 any eq 23
  ```

  In this example, the first ACE permits all the TCP packets coming from the host 10.1.1.1 with a destination TCP port number of 80. The second ACE permits all TCP packets coming from the host 20.1.1.1 with a destination TCP port number of 23. Both the ACEs use the same mask; therefore, a EtherSwitch network module supports this ACL.
- Only four user-defined masks can be defined for the entire system. These can be used for either security or quality of service (QoS) but cannot be shared by QoS and security. You can configure as many ACLs as you require. However, a system error message appears if ACLs with more than four different masks are applied to interfaces.

Table 7 lists a summary of the ACL restrictions on EtherSwitch network modules.

Table 7 Summary of ACL Restrictions

Restriction	Number Permitted
Number of user-defined masks allowed in an ACL	1
Number of ACLs allowed on an interface	1
Total number of user-defined masks for security and QoS allowed on a switch	4

Quality of Service for the EtherSwitch Network Module

Quality of service (QoS) can be implemented on your EtherSwitch network module. With this feature, you can provide preferential treatment to certain types of traffic. Without QoS, the switch offers best-effort service to each packet, regardless of the packet contents or size. It transmits the packets without any assurance of reliability, delay bounds, or throughput.

Understanding Quality of Service)

Typically, networks operate on a best-effort delivery basis, which means that all traffic has equal priority and an equal chance of being delivered in a timely manner. When congestion occurs, all traffic has an equal chance of being dropped.

With the QoS feature configured on your EtherSwitch network module, you can select specific network traffic, prioritize it according to its relative importance, and use congestion-management and congestion-avoidance techniques to provide preferential treatment. Implementing QoS in your network makes network performance more predictable and bandwidth utilization more effective.

The QoS implementation for this release is based on the DiffServ architecture, an emerging standard from the Internet Engineering Task Force (IETF). This architecture specifies that each packet is classified upon entry into the network. The classification is carried in the IP packet header, using six bits from the deprecated IP type of service (ToS) field to carry the classification (*class*) information. Classification can also be carried in the Layer 2 frame. These special bits in the Layer 2 frame or a Layer 3 packet are described here and shown in Figure 18:

- Prioritization values in Layer 2 frames:

  Layer 2 802.1Q frame headers have a 2-byte Tag Control Information field that carries the CoS value in the three most-significant bits, which are called the User Priority bits. On interfaces configured as Layer 2 802.1Q trunks, all traffic is in 802.1Q frames except for traffic in the native VLAN.

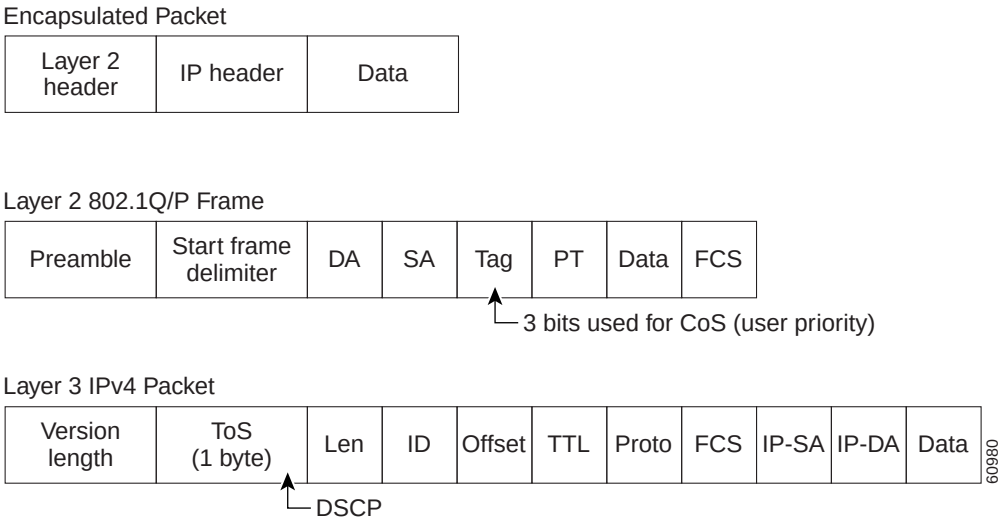
  Other frame types cannot carry Layer 2 CoS values.

  Layer 2 CoS values range from 0 for low priority to 7 for high priority.

- Prioritization bits in Layer 3 packets:

  Layer 3 IP packets can carry a Differentiated Services Code Point (DSCP) value. The supported DSCP values are 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56.

Figure 18 QoS Classification Layers in Frames and Packets



Note Layer 2 ISL Frame is not supported in this release.

Note Layer 3 IPv6 packets are dropped when received by the switch.

All switches and routers across the Internet rely on the class information to provide the same forwarding treatment to packets with the same class information and different treatment to packets with different class information. The class information in the packet can be assigned by end hosts or by switches or routers along the way, based on a configured policy, detailed examination of the packet, or both. Detailed examination of the packet is expected to happen closer to the edge of the network so that the core switches and routers are not overloaded.

Switches and routers along the path can use the class information to limit the amount of resources allocated per traffic class. The behavior of an individual device when handling traffic in the DiffServ architecture is called per-hop behavior. If all devices along a path provide a consistent per-hop behavior, you can construct an end-to-end QoS solution.

Implementing QoS in your network can be a simple or complex task and depends on the QoS features offered by your internetworking devices, the traffic types and patterns in your network, and the granularity of control you need over incoming and outgoing traffic.

The EtherSwitch network module can function as a Layer 2 switch connected to a Layer 3 router. When a packet enters the Layer 2 engine directly from a switch port, it is placed into one of four queues in the dynamic, 32-MB shared memory buffer. The queue assignment is based on the dot1p value in the packet. Any voice bearer packets that come in from the Cisco IP phones on the voice VLAN are automatically placed in the highest priority (Queue 3) based on the 802.1p value generated by the IP phone. The queues are then serviced on a weighted round robin (WRR) basis. The control traffic, which uses a CoS or ToS of 3, is placed in Queue 2.

Table 8 summarizes the queues, CoS values, and weights for Layer 2 QoS on the EtherSwitch network module.

Table 8 Queues, CoS values, and Weights for Layer 2 QoS

Queue Number	CoS Value	Weight
3	5,6,7	255
2	3,4	64
1	2	16
0	0,1	1

The weights specify the number of packets that are serviced in the queue before moving on to the next queue. Voice Realtime Transport Protocol (RTP) bearer traffic marked with a CoS or ToS of 5 and Voice Control plane traffic marked with a CoS/ToS of 3 are placed into the highest priority queues. If the queue has no packets to be serviced, it is skipped. Weighted Random Early Detection (WRED) is not supported on the Fast Ethernet ports.

You cannot configure port-based QoS on the Layer 2 switch ports.

Basic QoS Model

Figure 19 shows the basic QoS model. Actions at the ingress interface include classifying traffic, policing, and marking:

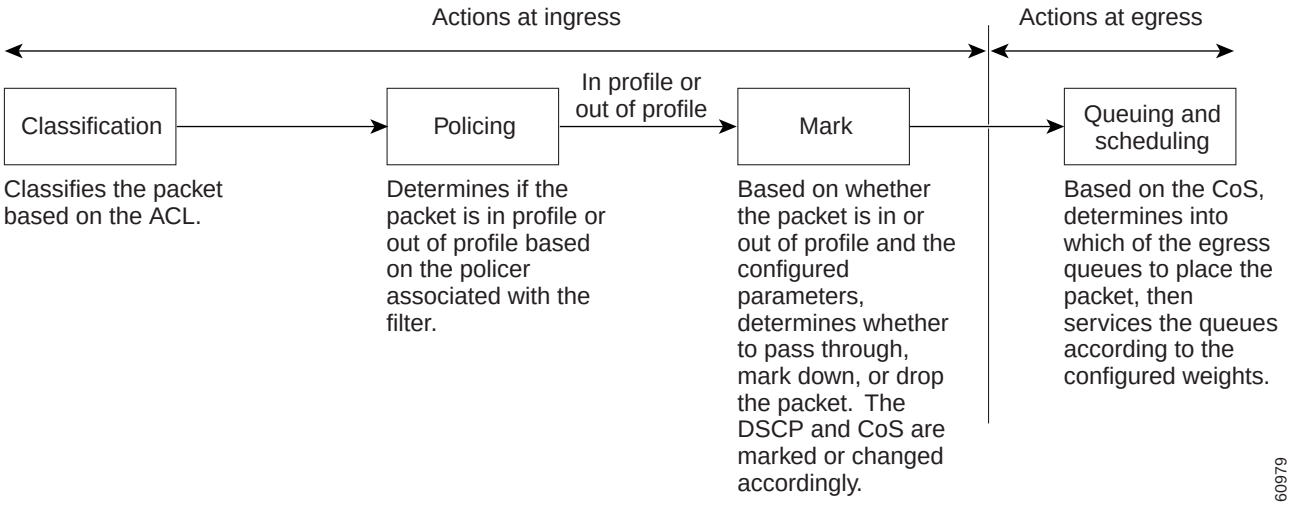
- Classifying distinguishes one kind of traffic from another. For more information, see the "Classification" section on page 40.

- Policing determines whether a packet is in or out of profile according to the configured policer, and the policer limits the bandwidth consumed by a flow of traffic. The result of this determination is passed to the marker. For more information, see the "Policing and Marking" section on page 41.
- Marking evaluates the policer and configuration information for the action to be taken when a packet is out of profile and decides what to do with the packet (pass through a packet without modification, mark down the DSCP value in the packet, or drop the packet). For more information, see the "Policing and Marking" section on page 41.

Actions at the egress interface include queueing and scheduling:

- Queuing evaluates the CoS value and determines which of the four egress queues in which to place the packet.
- Scheduling services the four egress queues based on their configured WRR weights.

Figure 19 Basic QoS Model



Classification

Classification is the process of distinguishing one kind of traffic from another by examining the fields in the packet.

Classification occurs only on a physical interface basis. No support exists for classifying packets at the VLAN or the switched virtual interface level.

You specify which fields in the frame or packet that you want to use to classify incoming traffic.

Classification Based on QoS ACLs

You can use IP standard or IP extended ACLs to define a group of packets with the same characteristics (*class*). In the QoS context, the permit and deny actions in the access control entries (ACEs) have different meanings than with security ACLs:

- If a match with a permit action is encountered (first-match principle), the specified QoS-related action is taken.
- If no match with a permit action is encountered and all the ACEs have been examined, no QoS processing occurs on the packet.
- If multiple ACLs are configured on an interface, the packet matches the first ACL with a permit action, and QoS processing begins.

- Configuration of a deny action is not supported in QoS ACLs on the 16- and 36-port EtherSwitch network modules.
- System-defined masks are allowed in class maps with these restrictions:
  - A combination of system-defined and user-defined masks cannot be used in the multiple class maps that are a part of a policy map.
  - System-defined masks that are a part of a policy map must all use the same type of system mask. For example, a policy map cannot have a class map that uses the **permit tcp any any** ACE and another that uses the **permit ip any any** ACE.
  - A policy map can contain multiple class maps that all use the same user-defined mask or the same system-defined mask.

Note For more information on the system-defined mask, see the "Understanding Access Control Parameters" section on page 36.

- For more information on ACL restrictions, see the "Guidelines for Configuring ACLs on the EtherSwitch network module" section on page 37.

After a traffic class has been defined with the ACL, you can attach a policy to it. A policy might contain multiple classes with actions specified for each one of them. A policy might include commands to rate-limit the class. This policy is then attached to a particular port on which it becomes effective.

You implement IP ACLs to classify IP traffic by using the **access-list** global configuration command.

Classification Based on Class Maps and Policy Maps

A class map is a mechanism that you use to isolate and name a specific traffic flow (or class) from all other traffic. The class map defines the criteria used to match against a specific traffic flow to further classify it; the criteria can include matching the access group defined by the ACL. If you have more than one type of traffic that you want to classify, you can create another class map and use a different name. After a packet is matched against the class-map criteria, you further classify it through the use of a policy map.

A policy map specifies which traffic class to act on. Actions can include setting a specific DSCP value in the traffic class or specifying the traffic bandwidth limitations and the action to take when the traffic is out of profile. Before a policy map can be effective, you must attach it to an interface.

The policy map can also contain commands that define the policer, the bandwidth limitations of the traffic, and the action to take if the limits are exceeded. For more information, see the "Policing and Marking" section on page 41.

A policy map also has these characteristics:

- A policy map can contain multiple class statements.
- A separate policy-map class can exist for each type of traffic received through an interface.
- A policy-map configuration state supersedes any actions due to an interface trust state.

For configuration information, see the "Configuring a QoS Policy" section on page 119.

Policing and Marking

Policing involves creating a policer that specifies the bandwidth limits for the traffic. Packets that exceed the limits are *out of profile* or *nonconforming*. Each policer specifies the action to take for packets that are in or out of profile. These actions, carried out by the marker, include dropping the packet, or marking down the packet with a new value that is user-defined.

You can create this type of policer:

Individual—QoS applies the bandwidth limits specified in the policer separately to each matched traffic class. You configure this type of policer within a policy map by using the policy-map configuration command.

For non-IP traffic, you have these marking options:

- Use the port default. If the frame does not contain a CoS value, assign the default port CoS value to the incoming frame.
- Trust the CoS value in the incoming frame (configure the port to trust CoS). Layer 2 802.1Q frame headers carry the CoS value in the three most-significant bits of the Tag Control Information field. CoS values range from 0 for low priority to 7 for high priority.

  The trust DSCP configuration is meaningless for non-IP traffic. If you configure a port with this option and non-IP traffic is received, the switch assigns the default port CoS value and classifies traffic based on the CoS value.

For IP traffic, you have these classification options:

- Trust the IP DSCP in the incoming packet (configure the port to trust DSCP), and assign the same DSCP to the packet for internal use. The IETF defines the six most-significant bits of the 1-byte type of service (ToS) field as the DSCP. The priority represented by a particular DSCP value is configurable. The supported DSCP values are 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56.
- Trust the CoS value (if present) in the incoming packet, and generate the DSCP by using the CoS-to-DSCP map.

When configuring policing and policers, keep these items in mind:

- By default, no policers are configured.
- Policers can only be configured on a physical port. There is no support for policing at a VLAN or switched virtual interface (SVI) level.
- Only one policer can be applied to a packet in the input direction.
- Only the average rate and committed burst parameters are configurable.
- Policing occurs on the ingress interfaces:
  - 60 policers are supported on ingress Gigabit-capable Ethernet ports.
  - 6 policers are supported on ingress 10/100 Ethernet ports.
  - Granularity for the average burst rate is 1 Mbps for 10/100 ports and 8 Mbps for Gigabit Ethernet ports.
- On an interface configured for QoS, all traffic received through the interface is classified, policed, and marked according to the policy map attached to the interface. On a trunk interface configured for QoS, traffic in *all* VLANs received through the interface is classified, policed, and marked according to the policy map attached to the interface.
- VLAN-based egress DSCP-to-COS mapping is supported. DSCP-to-COS mapping occurs for all packets with a specific VLAN ID egressing from the CPU to the physical port. The packets can be placed in the physical port egress queue depending on the COS value. Packets are handled according to type of service.

Note No policers can be configured on the egress interface on EtherSwitch network modules.

Mapping Tables

The EtherSwitch network modules support these types of marking to apply to the switch:

- CoS value to the DSCP value
- DSCP value to CoS value

Note An interface can be configured to trust either CoS or DSCP, but not both at the same time.

Before the traffic reaches the scheduling stage, QoS uses the configurable DSCP-to-CoS map to derive a CoS value from the internal DSCP value.

The CoS-to-DSCP and DSCP-to-CoS map have default values that might or might not be appropriate for your network.

How to Configure the EtherSwitch Network Module

This section contains the following tasks:

- Configuring Network Security with ACLs at Layer 2, page 103 (optional)
- Configuring Quality of Service (QoS) on the EtherSwitch network module, page 115 (optional)
- Configuring a QoS Policy, page 119 (optional)

Configuring VLANs

Perform this task to configure the VLANs on an EtherSwitch network module.

VLAN Removal from the Database

When you delete a VLAN from a router with an EtherSwitch network module installed that is in VTP server mode, the VLAN is removed from all EtherSwitch routers and switches in the VTP domain. When you delete a VLAN from an EtherSwitch router or switch that is in VTP transparent mode, the VLAN is deleted only on that specific device.

You cannot delete the default VLANs for the different media types: Ethernet VLAN 1 and FDDI or Token Ring VLANs 1002 to 1005.

SUMMARY STEPS

1. **enable**
2. **vlan database**
3. **vlan** *vlan-id* [**are** *hops*] [**backupcrf** *mode*] [**bridge** *type* | *number*] [**media** *type*] [**mtu** *mtu-size*] [**name** *vlan-name*] [**parent** *parent-vlan-id*] [**ring** *ring-number*] [**said** *sa-id-value*] [**state** {**suspend** | **active**}] [**stp type** *type*] [**tb-vlan1** *tb-vlan1-id*] [**tb-vlan2** *tb-vlan2-id*]
4. **no vlan** *vlan-id*
5. **exit**
6. **show vlan-switch** [**brief** | **id** *vlan* | **name** *name*]

DETAILED STEPS

	Command or Action	Purpose

Step 1	`enable`
	
	Example:
	`Router> enable`
		Enables privileged EXEC mode.
		• Enter your password if prompted.

Step 2	`vlan database`
	
	Example:
	`Router# configure terminal`
		Enters VLAN configuration mode.

	Command or Action	Purpose
Step 3	**vlan** *vlan-id* [**are** *hops*] [**backupcrf** *mode*] [**bridge** *type* | *number*] [**media** *type*] [**mtu** *mtu-size*] [**name** *vlan-name*] [**parent** *parent-vlan-id*] [**ring** *ring-number*] [**said** *sa-id-value*] [**state** {**suspend** | **active**}] [**stp type** *type*] [**tb-vlan1** *tb-vlan1-id*] [**tb-vlan2** *tb-vlan2-id*] **Example:** `Router(vlan)# vlan 2 media ethernet name vlan1502`	Configures a specific VLAN. • In this example, Ethernet VLAN 2 is added with the name of vlan1502. • The VLAN database is updated when you leave VLAN configuration mode.
Step 4	**no vlan** *vlan-id* **Example:** `Router(vlan)# no vlan 2`	(Optional) Deletes a specific VLAN. • In this example, VLAN 2 is deleted.
Step 5	**exit** **Example:** `Router(vlan)# exit`	Exits VLAN configuration mode and returns the router to privileged EXEC mode.
Step 6	**show vlan-switch** [**brief** | **id** *vlan* | **name** *name*] **Example:** `Router# show vlan-switch name vlan0003`	(Optional) Displays VLAN information. • The optional **brief** keyword displays only a single line for each VLAN, naming the VLAN, status, and ports. • The optional **id** keyword displays information about a single VLAN identified by VLAN ID number; valid values are from 1 to 1005. • The optional **name** keyword displays information about a single VLAN identified by VLAN name; valid values are an ASCII string from 1 to 32 characters.

Examples

Sample Output for the show vlan-switch Command

In the following example, output information is displayed to verify the VLAN configuration:

```
Router# show vlan-switch name vlan0003

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa1/0, Fa1/1, Fa1/2, Fa1/3
                                                Fa1/4, Fa1/5, Fa1/6, Fa1/7
                                                Fa1/8, Fa1/9, Fa1/10, Fa1/11
                                                Fa1/12, Fa1/13, Fa1/14, Fa1/15
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------
1    enet  100001     1500  -      -      -        -    -        1002   1003
1002 fddi  101002     1500  -      -      -        -    -        1      1003
1003 tr    101003     1500  1005   0      -        -    srb      1      1002
```

```
1004 fdnet 101004     1500  -      -      1        ibm  -        0      0
1005 trnet 101005     1500  -      -      1        ibm  -        0      0
```

In the following example, the **brief** keyword is used to verify that VLAN 2 has been deleted:

```
Router# show vlan-switch brief

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/2, Fa0/9, Fa0/14, Gi0/0
3    VLAN0003                         active    Fa0/4, Fa0/5, Fa0/10, Fa0/11
4    VLAN0004                         active    Fa0/6, Fa0/7, Fa0/12, Fa0/13
5    VLAN0005                         active
40   VLAN0040                         active    Fa0/15
50   VLAN0050                         active
1000 VLAN1000                         active
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active
```

Configuring VLAN Trunking Protocol

Perform this task to configure the VLAN Trunking Protocol (VTP) on an EtherSwitch network module.

VTP Mode Behavior

When a router with an EtherSwitch network module installed is in VTP server mode, you can change the VLAN configuration and have it propagate throughout the network.

When the router is in VTP client mode, you cannot change the VLAN configuration on the device. The client device receives VTP updates from a VTP server in the management domain and modifies its configuration accordingly.

When you configure the router as VTP transparent, you disable VTP on the device. A VTP transparent device does not send VTP updates and does not act on VTP updates received from other devices. However, a VTP transparent device running VTP version 2 does forward received VTP advertisements out all of its trunk links.

SUMMARY STEPS

1. **enable**
2. **vlan database**
3. **vtp server**
4. **vtp domain** *domain-name*
5. **vtp password** *password-value*
6. **vtp client**
7. **vtp transparent**
8. **vtp v2-mode**
9. **exit**
10. **show vtp** {**counters** | **status**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**vlan database** **Example:** `Router# vlan database`	Enters VLAN configuration mode.
Step 3	**vlan server** **Example:** `Router(vlan)# vlan server`	Configures the EtherSwitch network module as a VTP server.
Step 4	**vtp domain** *domain-name* **Example:** `Router(vlan)# vtp domain Lab_Network`	Defines the VTP domain name. • The *domain-name* argument consists of up to 32 characters.
Step 5	**vtp password** *password-value* **Example:** `Router(vlan)# vtp password labpassword`	(Optional) Sets a password for the VTP domain. • The *password-value* argument can consist of 8 to 64 characters.
Step 6	**vtp client** **Example:** `Router(vlan)# vtp client`	(Optional) Configures the EtherSwitch network module as a VTP client. • The VLAN database is updated when you leave VLAN configuration mode. **Note** You would configure the device as either a VTP server or a VTP client.
Step 7	**vtp transparent** **Example:** `Router(vlan)# vtp transparent`	(Optional) Disables VTP on the EtherSwitch network module.
Step 8	**vtp v2-mode** **Example:** `Router(vlan)# vtp v2-mode`	(Optional) Enables VTP version 2.

	Command or Action	Purpose
Step 9	**exit** **Example:** `Router(vlan)# exit`	Exits VLAN configuration mode and returns the router to global configuration mode.
Step 10	**show vtp** {**counters** | **status**} **Example:** `Router# show vtp status`	(Optional) Displays VTP information. • The optional **counters** keyword displays the VTP counters for the EtherSwitch network module. • The optional **status** keyword displays general information about the VTP management domain.

Examples

Sample Output for the show vtp Command

In the following example, output information about the VTP management domain is displayed:

```
Router# show vtp status

VTP Version                     : 2
Configuration Revision          : 247
Maximum VLANs supported locally : 1005
Number of existing VLANs        : 33
VTP Operating Mode              : Client
VTP Domain Name                 : Lab_Network
VTP Pruning Mode                : Enabled
VTP V2 Mode                     : Disabled
VTP Traps Generation            : Disabled
MD5 digest                      : 0x45 0x52 0xB6 0xFD 0x63 0xC8 0x49 0x80
Configuration last modified by 0.0.0.0 at 8-12-99 15:04:49
```

Configuring Spanning Tree on a VLAN

Perform this task to enable spanning tree on a per-VLAN basis and configure various spanning tree features. The EtherSwitch network module maintains a separate instance of spanning tree for each VLAN (except on VLANs on which you disable spanning tree).

VLAN Root Bridge

The EtherSwitch network module maintains a separate instance of spanning tree for each active VLAN configured on the device. A bridge ID, consisting of the bridge priority and the bridge MAC address, is associated with each instance. For each VLAN, the switch with the lowest bridge ID will become the root bridge for that VLAN.

To configure a VLAN instance to become the root bridge, the bridge priority can be modified from the default value (32768) to a significantly lower value so that the bridge becomes the root bridge for the specified VLAN. Use the **spanning-tree vlan** *vlan-id* **root** command to alter the bridge priority.

The switch checks the bridge priority of the current root bridges for each VLAN. The bridge priority for the specified VLANs is set to 8192 if this value will cause the switch to become the root for the specified VLANs.

If any root switch for the specified VLANs has a bridge priority lower than 8192, the switch sets the bridge priority for the specified VLANs to 1 less than the lowest bridge priority.

For example, if all switches in the network have the bridge priority for VLAN 100 set to the default value of 32768, entering the **spanning-tree vlan 100 root primary** command on a switch will set the bridge priority for VLAN 100 to 8192, causing the switch to become the root bridge for VLAN 100.

Note The root bridge for each instance of spanning tree should be a backbone or distribution switch device. Do not configure an access switch device as the spanning tree primary root.

Use the **diameter** keyword to specify the Layer 2 network diameter (that is, the maximum number of bridge hops between any two end stations in the Layer 2 network). When you specify the network diameter, the switch automatically picks an optimal hello time, forward delay time, and maximum age time for a network of that diameter, which can significantly reduce the spanning tree convergence time. You can use the **hello-time** keyword to override the automatically calculated hello time.

Note You should avoid configuring the hello time, forward delay time, and maximum age time manually after configuring the switch as the root bridge.

VLAN Bridge Priority

Caution Exercise care when using the **spanning-tree vlan** command with the **priority** keyword. For most situations **spanning-tree vlan** with the **root primary** keywords and the **spanning-tree vlan** with the **root secondary** keywords are the preferred commands to modify the bridge priority.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-id* [**forward-time** *seconds* | **hello-time** *seconds* | **max-age** *seconds* | **priority** *priority* | **protocol** *protocol* | [**root** {**primary** | **secondary**} [**diameter** *net-diameter*] [**hello-time** *seconds*]]]]
4. **spanning-tree vlan** *vlan-id* [**priority** *priority*]
5. **spanning-tree vlan** *vlan-id* [**root** {**primary** | **secondary**} [**diameter** *net-diameter*] [**hello-time** *seconds*]]
6. **spanning-tree vlan** *vlan-id* [**hello-time** *seconds*]
7. **spanning-tree vlan** *vlan-id* [**forward-time** *seconds*]
8. **spanning-tree vlan** *vlan-id* [**max-age** *seconds*]
9. **spanning-tree backbonefast**
10. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port*
11. **spanning-tree port-priority** *port-priority*
12. **spanning-tree cost** *cost*
13. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree vlan** *vlan-id* [**forward-time** *seconds* | **hello-time** *seconds* | **max-age** *seconds* | **priority** *priority* | **protocol** *protocol* | [**root** {**primary** | **secondary**} [**diameter** *net-diameter*] [**hello-time** *seconds*]]]] **Example:** `Router(config)# spanning-tree vlan 200`	Configures spanning tree on a per-VLAN basis. • In this example, spanning tree is enabled on VLAN 200. • Use the **no** form of this command to disable spanning tree on the specified VLAN.
Step 4	**spanning-tree vlan** *vlan-id* [**priority** *priority*] **Example:** `Router(config)# spanning-tree vlan 200 priority 33792`	(Optional) Configures the bridge priority of a VLAN. • The *priority* value can be from 1 to 65535. • Review the "VLAN Bridge Priority" section before using this command. • Use the **no** form of this command to restore the defaults.
Step 5	**spanning-tree vlan** *vlan-id* [**root** {**primary** | **secondary**} [**diameter** *net-diameter*] [**hello-time** *seconds*]] **Example:** `Router(config)# spanning-tree vlan 200 root primary diameter 4`	(Optional) Configures the EtherSwitch network module as the root bridge. • Review the "VLAN Root Bridge" concept before using this command.
Step 6	**spanning-tree vlan** *vlan-id* [**hello-time** *seconds*] **Example:** `Router(config)# spanning-tree vlan 200 hello-time 7`	(Optional) Configures the hello time of a VLAN. • The *seconds* value can be from 1 to 10 seconds. • In this example, the hello time is set to 7 seconds.
Step 7	**spanning-tree vlan** *vlan-id* [**forward-time** *seconds*] **Example:** `Router(config)# spanning-tree vlan 200 forward-time 21`	(Optional) Configures the spanning tree forward delay time of a VLAN. • The *seconds* value can be from 4 to 30 seconds. • In this example, the forward delay time is set to 21 seconds.

	Command or Action	Purpose
Step 8	**spanning-tree vlan** *vlan-id* [**max-age** *seconds*] **Example:** `Router(config)# spanning-tree vlan 200 max-age 36`	(Optional) Configures the maximum aging time of a VLAN. • The *seconds* value can be from 6 to 40 seconds. • In this example, the maximum number of seconds that the information in a BPDU is valid is set to 36 seconds.
Step 9	**spanning-tree backbonefast** **Example:** `Router(config)# spanning-tree vlan 200 max-age 36`	(Optional) Enables BackboneFast on the EtherSwitch network module. • Use this command to detect indirect link failures and to start the spanning tree reconfiguration sooner. **Note** If you use BackboneFast, you must enable it on all switch devices in the network. BackboneFast is not supported on Token Ring VLANs but it is supported for use with third-party switches.
Step 10	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port* **Example:** `Router(config)# interface fastethernet 5/8`	Selects the Ethernet interface to configure and enters interface configuration mode. • The *slot*/*port* argument identifies the slot and port numbers of the interface. The space between the interface name and number is optional.
Step 11	**spanning-tree port-priority** *port-priority* **Example:** `Router(config-if)# spanning-tree port-priority 64`	(Optional) Configures the port priority for an interface. • The *port-priority* value can be from 1 to 255 in increments of 4.
Step 12	**spanning-tree cost** *cost* **Example:** `Router(config-if)# spanning-tree cost 18`	(Optional) Configures the port cost for an interface. • The *cost* value can be from 1 to 200000000 (1 to 65535 in Cisco IOS Releases 12.1(2)E and earlier).
Step 13	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode.

Verifying Spanning Tree on a VLAN

Perform this optional task to verify the spanning tree configuration on a VLAN.

SUMMARY STEPS

1. **enable**
2. **show spanning-tree** [*bridge-group*] [**active** | **backbonefast** | **blockedports** | **bridge** | **brief** | **inconsistentports** | **interface** *interface-type interface-number* | **pathcost method** | **root** | **summary** [**totals**] | **uplinkfast** | **vlan** *vlan-id*]

DETAILED STEPS

Step 1 **enable**

Enables privileged EXEC mode. Enter your password if prompted:

```
Router> enable
```

Step 2 **show spanning-tree** [*bridge-group*] [**active** | **backbonefast** | **blockedports** | **bridge** | **brief** | **inconsistentports** | **interface** *interface-type interface-number* | **pathcost method** | **root** | **summary** [**totals**] | **uplinkfast** | **vlan** *vlan-id*]

Use this command with the **vlan** keyword to display spanning tree information about a specified VLAN:

```
Router# show spanning-tree vlan 200

VLAN200 is executing the ieee compatible Spanning Tree protocol
  Bridge Identifier has priority 32768, address 0050.3e8d.6401
  Configured hello time 2, max age 20, forward delay 15
  Current root has priority 16384, address 0060.704c.7000
  Root port is 264 (FastEthernet5/8), cost of root path is 38
  Topology change flag not set, detected flag not set
  Number of topology changes 0 last change occurred 01:53:48 ago
  Times:  hold 1, topology change 24, notification 2
          hello 2, max age 14, forward delay 10
  Timers: hello 0, topology change 0, notification 0


 Port 264 (FastEthernet5/8) of VLAN200 is forwarding
   Port path cost 19, Port priority 128, Port Identifier 129.9.
   Designated root has priority 16384, address 0060.704c.7000
   Designated bridge has priority 32768, address 00e0.4fac.b000
   Designated port id is 128.2, designated path cost 19
   Timers: message age 3, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   BPDU: sent 3, received 3417
```

Use this command with the **interface** keyword to display spanning tree information about a specified interface:

```
Router# show spanning-tree interface fastethernet 5/8

Port 264 (FastEthernet5/8) of VLAN200 is forwarding
   Port path cost 19, Port priority 100, Port Identifier 129.8.
   Designated root has priority 32768, address 0010.0d40.34c7
   Designated bridge has priority 32768, address 0010.0d40.34c7
   Designated port id is 128.1, designated path cost 0
   Timers: message age 2, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   BPDU: sent 0, received 13513
```

Use this command with the **bridge**, **brief**, and **vlan** keywords to display the bridge priority information:

```
Router# show spanning-tree bridge brief vlan 200

    Hello Max  Fwd
Vlan                 Bridge ID      Time  Age Delay  Protocol
---------------- -------------------- ---- ---- -----  --------
VLAN200          33792 0050.3e8d.64c8    2   20    15  ieee
```

Configuring Layer 2 Interfaces

Perform this task to configure a range of interfaces, define a range macro, set the interface speed, set the duplex mode, and add a description for the interface.

Interface Speed and Duplex Mode Guidelines

When configuring an interface speed and duplex mode, note these guidelines:

- If both ends of the line support autonegotiation, Cisco highly recommends the default autonegotiation settings.
- If one interface supports autonegotiation and the other end does not, configure duplex and speed on both interfaces; do not use the **auto** setting on the supported side.
- Both ends of the line need to be configured to the same setting. For example, both hard-set or both auto-negotiate. Mismatched settings are not supported.

Caution Changing the interface speed and duplex mode configuration might shut down and reenable the interface during the reconfiguration.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface range** {**vlan** *vlan-id - vlan-id*} | {{**ethernet** | **fastethernet** | **macro** *macro-name*} *slot/interface - interface*} [**,** {{**ethernet** | **fastethernet** | **macro** *macro-name*} *slot/interface - interface*}]
4. **define interface-range** *macro-name* {**vlan** *vlan-id - vlan-id*} | {{**ethernet** | **fastethernet**} *slot/interface - interface*} [**,** {{**ethernet** | **fastethernet**} *slot/interface - interface*}]
5. **interface fastethernet** *slot/interface*
6. **speed** [**10** | **100** | **auto**]
7. **duplex** [**auto** | **full** | **half**]
8. **description** *string*
9. **exit**
10. **show interfaces fastethernet** *slot/port*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface range** {**vlan** *vlan-id* **-** *vlan-id*} | {{**ethernet** | **fastethernet** | **macro** *macro-name*} *slot*/*interface* **-** *interface*}[**,** {{**ethernet** | **fastethernet** | **macro** *macro-name*} *slot*/*interface* **-** *interface*}] **Example:** `Router(config)# interface range fastethernet 5/1 - 4`	Selects the range of interfaces to be configured. • The space before and after the dash is required. For example, the command **interface range fastethernet 1 - 5** is valid; the command **interface range fastethernet 1-5** is not valid. • You can enter one macro or up to five comma-separated ranges. • Comma-separated ranges can include both VLANs and physical interfaces. • You are not required to enter spaces before or after the comma. The **interface range** command only supports VLAN interfaces that are configured with the **interface vlan** command.
Step 4	**define interface-range** *macro-name* {**vlan** *vlan-id* **-** *vlan-id*} | {{**ethernet** | **fastethernet**} *slot*/*interface* **-** *interface*} [**,** {{**ethernet** | **fastethernet**} *slot*/*interface* **-** *interface*}] **Example:** `Router(config)# define interface-range sales vlan 2 - 5`	• Defines the interface range macro and saves it in NVRAM. • In this example, the interface range macro is named sales and contains VLAN numbers from 2 to 5.
Step 5	**interface fastethernet** *slot*/*interface* **Example:** `Router(config)# interface fastethernet 1/4`	Configures a specific Fast Ethernet interface.
Step 6	**speed** [**10** | **100** | **auto**] **Example:** `Router(config-if)# speed 100`	Sets the speed for a Fast Ethernet interface. **Note** If you set the interface speed to auto on a 10/100-Mbps Ethernet interface, both speed and duplex are autonegotiated.

	Command or Action	Purpose
Step 7	**duplex** [**auto** | **full** | **half**] **Example:** `Router(config-if)# duplex full`	Sets the duplex mode for an Ethernet or Fast Ethernet interface. **Note** If you set the port speed to auto on a 10/100-Mbps Ethernet interface, both speed and duplex are autonegotiated. You cannot change the duplex mode of autonegotiation interfaces.
Step 8	**description** *string* **Example:** `Router(config-if)# description salesgroup1`	Adds a description for an interface.
Step 9	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this step one more time to exit global configuration mode.
Step 10	**show interfaces fastethernet** *slot*/*port* **Example:** `Router# show interfaces fastethernet 1/4`	(Optional) Displays information about Fast Ethernet interfaces.

Examples

Sample Output for the show interfaces fastethernet Command

In the following example, output information is displayed to verify the speed and duplex mode of a Fast Ethernet interface:

```
Router# show interfaces fastethernet 1/4

FastEthernet1/4 is up, line protocol is down
  Hardware is Fast Ethernet, address is 0000.0000.0c89 (bia 0000.0000.0c89)
  MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Auto-duplex, Auto-speed
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     3 packets output, 1074 bytes, 0 underruns(0/0/0)
     0 output errors, 0 collisions, 5 interface resets
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
```

Configuring an Ethernet Interface as a Layer 2 Trunk

Perform this task to configure an Ethernet interface as a Layer 2 trunk.

Restrictions

Note Ports do not support Dynamic Trunk Protocol (DTP). Ensure that the neighboring switch is set to a mode that will not send DTP traffic.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port*
4. **shutdown**
5. **switchport mode** {**access** | **trunk**}
6. **switchport trunk** {**encapsulation dot1q** | **native vlan** | **allowed vlan** *vlan-list*}
7. **switchport trunk allowed vlan** {**add** | **except** | **none** | **remove**} *vlan1*[**,***vlan*[**,***vlan*[**,**...]]
8. **no shutdown**
9. **exit**
10. **show interfaces fastethernet** *slot/port* {**switchport** | **trunk**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port* **Example:** `Router(config)# interface fastethernet 5/8`	Selects the Ethernet interface to configure.
Step 4	**shutdown** **Example:** `Router(config-if)# shutdown`	(Optional) Shuts down the interface to prevent traffic flow until configuration is complete. **Note** Encapsulation is always dot1q.

	Command or Action	Purpose
Step 5	**switchport mode** {**access** | **trunk**} **Example:** `Router(config-if)# switchport mode trunk`	Configures the interface type. • In this example, the interface type is set to be trunk.
Step 6	**switchport trunk** [**encapsulation dot1q** | **native vlan** | **allowed vlan** *vlan-list*] **Example:** `Router(config-if)# switchport trunk native vlan`	Specifies the trunk options when the interface is in trunking mode. • In this example, native VLAN is set for the trunk in 802.1Q trunking mode.
Step 7	**switchport trunk allowed vlan** {**add** | **except** | **none** | **remove**} *vlan1*[,*vlan*[,*vlan*[,...]] **Example:** `Router(config-if)# switchport trunk allowed vlan add 2,3,4,5`	(Optional) Configures the list of VLANs allowed on the trunk. • All VLANs are allowed by default. • You cannot remove any of the default VLANs from a trunk.
Step 8	**no shutdown** **Example:** `Router(config-if)# no shutdown`	Activates the interface. (Required only if you shut down the interface.)
Step 9	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this step one more time to exit global configuration mode.
Step 10	**show interfaces fastethernet** *slot*/*port* {**switchport** | **trunk**} **Example:** `Router# show interfaces fastethernet 5/8 switchport`	(Optional) Displays information about Fast Ethernet interfaces.

Examples

Sample Output for the show interfaces fastethernet Command

In the following two examples, output information is displayed to verify the configuration of Fast Ethernet interface as a Layer 2 trunk:

```
Router# show interfaces fastethernet 5/8 switchport

Name: Fa5/8
Switchport: Enabled
Administrative Mode: static access
Operational Mode: static access
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: native
Negotiation of Trunking: Disabled
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
Protected: false
```

```
Unknown unicast blocked: false
Unknown multicast blocked: false
Broadcast Suppression Level: 100
Multicast Suppression Level: 100
Unicast Suppression Level: 100
Voice VLAN: none
Appliance trust: none

Router# show interfaces fastethernet 5/8 trunk

Port      Mode         Encapsulation  Status        Native vlan
Fa1/15    off          802.1q         not-trunking  1
Port      Vlans allowed on trunk
Fa1/15    1
Port      Vlans allowed and active in management domain
Fa1/15    1
Port      Vlans in spanning tree forwarding state and not pruned
Fa1/15    1
```

Configuring an Ethernet Interface as a Layer 2 Access

Perform this task to configure an Ethernet interface as a Layer 2 access.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port*
4. **shutdown**
5. **switchport mode** {**access** | **trunk**}
6. **switchport access vlan** *vlan-id*
7. **no shutdown**
8. **exit**

DETAILED STEPS

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

	Command or Action	Purpose
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port* **Example:** `Router(config)# interface fastethernet 1/0`	Selects the Ethernet interface to configure.
Step 4	**shutdown** **Example:** `Router(config-if)# shutdown`	(Optional) Shuts down the interface to prevent traffic flow until configuration is complete. **Note** Encapsulation is always dot1q.
Step 5	**switchport mode** {**access** | **trunk**} **Example:** `Router(config-if)# switchport mode access`	Configures the interface type. • In this example, the interface type is set to be Layer 2 access.
Step 6	**switchport access vlan** *vlan* **Example:** `Router(config-if)# switchport access vlan 5`	For access ports, specifies the access VLAN. • In this example, the Layer 2 access VLAN 5 is set.
Step 7	**no shutdown** **Example:** `Router(config-if)# no shutdown`	Activates the interface. (Required only if you shut down the interface.)
Step 8	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this step one more time to exit global configuration mode.

Configuring Separate Voice and Data VLANs

Perform this task to configure separate voice and data VLANs on the EtherSwitch network module.

Separate Voice and Data VLANs

For ease of network administration and increased scalability, network managers can configure the EtherSwitch network module to support Cisco IP phones such that the voice and data traffic reside on separate VLANs. We recommend configuring separate VLANs when you are able to segment the existing IP address space of your branch office.

User priority bits in the 802.1p portion of the 802.1Q standard header are used to provide prioritization in Ethernet switches. This is a vital component in designing Cisco AVVID networks.

The EtherSwitch network module provides the performance and intelligent services of Cisco IOS software for branch office applications. The EtherSwitch network module can identify user applications—such as voice or multicast video—and classify traffic with the appropriate priority levels. QoS policies are enforced using Layer 2 and 3 information such as 802.1p, IP precedence, and DSCP.

Note Refer to the *Cisco AVVID QoS Design Guide* for more information on how to implement end-to-end QoS as you deploy Cisco AVVID solutions.

Voice Traffic and Voice VLAN ID (VVID) Using the EtherSwitch Network Module

The EtherSwitch network module can automatically configure voice VLAN. This capability overcomes the management complexity of overlaying a voice topology onto a data network while maintaining the quality of voice traffic. With the automatically configured voice VLAN feature, network administrators can segment phones into separate logical networks, even though the data and voice infrastructure is physically the same. The voice VLAN feature places the phones into their own VLANs without the need for end-user intervention. A user can plug the phone into the switch, and the switch provides the phone with the necessary VLAN information.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port*
4. **switchport mode** {**access** | **trunk**}
5. **switchport voice vlan** {*vlan-id* | **dot1p** | **none** | **untagged**}
6. **exit**

DETAILED STEPS

	Command or Action	Purpose

Step 1	`enable`
	
	Example:
	`Router> enable`
		Enables privileged EXEC mode.
		• Enter your password if prompted.

Step 2	`configure terminal`
	
	Example:
	`Router# configure terminal`
		Enters global configuration mode.

Step 3	`interface {ethernet | fastethernet | gigabitethernet} slot/port`
	
	Example:
	`Router(config)# interface fastethernet 5/1`
		Selects the Ethernet interface to configure and enters interface configuration mode.

Step 4	`switchport mode {access | trunk}`
	
	`Example:`
	`Router(config-if)# switchport mode trunk`
		Configures the interface type.
		• In this example, the interface type is set to trunk mode.

	Command or Action	Purpose
Step 5	**switchport voice vlan** {*vlan-id* | **dot1p** | **none** | **untagged**} **Example:** `Router(config-if)# switchport voice vlan 150`	Configures the voice port with a VVID that will be used exclusively for voice traffic. • In this example, VLAN 150 will be used for voice traffic.
Step 6	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this step one more time to exit global configuration mode.

Configuring a Single Voice and Data VLAN

Perform this task to configure a Cisco IP phone to send voice and data traffic on the same VLAN on the EtherSwitch network module.

Single Voice and Data VLAN

For network designs with incremental IP telephony deployment, network managers can configure the EtherSwitch network module so that the voice and data traffic coexist on the same subnet. This might be necessary when it is impractical either to allocate an additional IP subnet for IP phones or to divide the existing IP address space into an additional subnet at the remote branch, it might be necessary to use a single IP address space for branch offices. (This is one of the simpler ways to deploy IP telephony.) When this is the case, you must still prioritize voice above data at both Layer 2 and Layer 3.

Layer 3 classification is already handled because the phone sets the type of service (ToS) bits in all media streams to an IP Precedence value of 5. (With Cisco CallManager Release 3.0(5), this marking changed to a Differentiated Services Code Point ([DSCP]) value of EF.) However, to ensure that there is Layer 2 classification for admission to the multiple queues in the branch office switches, the phone must also use the User Priority bits in the Layer 2 802.1p header to provide class of service (CoS) marking. Setting the bits to provide marking can be done by having the switch look for 802.1p headers on the native VLAN.

This configuration approach must address two key considerations:

- Network managers should ensure that existing subnets have enough available IP addresses for the new Cisco IP phones, each of which requires a unique IP address.
- Administering a network with a mix of IP phones and workstations on the same subnet might pose a challenge.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port*
4. **switchport access vlan** *vlan-id*
5. **switchport voice vlan** {*vlan-id* | **dot1p** | **none** | **untagged**}
6. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port* Example: `Router(config)# interface fastethernet 5/2`	Selects the Ethernet interface to configure and enters interface configuration mode.
Step 4	**switchport access vlan** *vlan-id* Example: `Router(config-if)# switchport access vlan 40`	Configures the port as an access port and assigns a VLAN. • The value of *vlan-id* represents the ID of the VLAN that is sending and receiving untagged traffic on the port. Valid IDs are from 1 to 1001. Leading zeroes are not accepted.
Step 5	**switchport voice vlan** {*vlan*-id | **dot1p** | **none** | **untagged**} Example: `Router(config-if)# switchport voice vlan dot1p`	Configures the Cisco IP phone to send voice traffic with higher priority (CoS=5 on 802.1Q tag) on the access VLAN. Data traffic (from an attached PC) is sent untagged for lower priority (port default=0).
Step 6	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this step one more time to exit global configuration mode.

Managing the EtherSwitch network module

Use this task to perform basic management tasks such as adding a trap manager and assigning IP information on the EtherSwitch network module with the Cisco IOS CLI. You might find this information useful when you configure the EtherSwitch network module for the previous scenarios.

Trap Managers

A trap manager is a management station that receives and processes traps. When you configure a trap manager, community strings for each member switch must be unique. If a member switch has an IP address assigned to it, the management station accesses the switch by using its assigned IP address.

By default, no trap manager is defined, and no traps are issued.

IP Addressing

The recommended configuration for using multiple cables to connect IP phones to the Cisco AVVID network is to use a separate IP subnet and separate VLANs for IP telephony.

IP Information Assigned to the Switch

You can use a BOOTP server to automatically assign IP information to the switch; however, the BOOTP server must be set up in advance with a database of physical MAC addresses and corresponding IP addresses, subnet masks, and default gateway addresses. In addition, the switch must be able to access the BOOTP server through one of its ports. At startup, a switch without an IP address requests the information from the BOOTP server; the requested information is saved in the switch running the configuration file. To ensure that the IP information is saved when the switch is restarted, save the configuration by entering the **write memory** command in privileged EXEC mode.

You can change the information in these fields. The mask identifies the bits that denote the network number in the IP address. When you use the mask to subnet a network, the mask is then referred to as a subnet mask. The broadcast address is reserved for sending messages to all hosts. The CPU sends traffic to an unknown IP address through the default gateway.

Use of Ethernet Ports to Support Cisco IP Phones with Multiple Ports

You might want to use multiple ports to connect the Cisco IP phones if any of the following conditions apply to your Cisco IP telephony network:

- You are connecting Cisco IP phones that do not have a second Ethernet port for attaching a PC.
- You want to create a physical separation between the voice and data networks.
- You want to provide in-line power easily to the IP phones without having to upgrade the data infrastructure.

You want to limit the number of switches that need Uninterruptible Power Supply (UPS) power.

Domain Name Mapping and DNS Configuration

Each unique IP address can have a host name associated with it. IP defines a hierarchical naming scheme that allows a device to be identified by its location or domain. Domain names are pieced together with periods (.) as the delimiting characters. For example, Cisco Systems is a commercial organization that IP identifies by a *com* domain name, so its domain name is *cisco.com*. A specific device in this domain, the FTP system, for example, is identified as *ftp.cisco.com*.

To track domain names, IP has defined the concept of a domain name server (DNS), the purpose of which is to hold a cache (or database) of names mapped to IP addresses. To map domain names to IP addresses, you must first identify the host names and then specify a name server and enable the DNS, the Internet's global naming scheme that uniquely identifies network devices.

You can specify a default domain name that the software uses to complete domain name requests. You can specify either a single domain name or a list of domain names. When you specify a domain name, any IP host name without a domain name has that domain name appended to it before being added to the host table.

You can specify up to six hosts that can function as a name server to supply name information for the DNS.

If your network devices require connectivity with devices in networks for which you do not control name assignment, you can assign device names that uniquely identify your devices within the entire internetwork. The Internet's global naming scheme, the DNS, accomplishes this task. This service is enabled by default.

ARP Table Management

To communicate with a device (on Ethernet, for example), the software first must determine the 48-bit MAC or local data link address of that device. The process of determining the local data link address from an IP address is called *address resolution*.

The Address Resolution Protocol (ARP) associates a host IP address with the corresponding media or MAC addresses and VLAN ID. Taking an IP address as input, ARP determines the associated MAC address. Once a MAC address is determined, the IP-MAC address association is stored in an ARP cache for rapid retrieval. Then the IP datagram is encapsulated in a link-layer frame and sent over the network. Encapsulation of IP datagrams and ARP requests and replies on IEEE 802 networks other than Ethernet is specified by the Subnetwork Access Protocol (SNAP). By default, standard Ethernet-style ARP encapsulation (represented by the **arpa** keyword) is enabled on the IP interface.

When you manually add entries to the ARP Table by using the CLI, you must be aware that these entries do not age and must be manually removed.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server host** {*hostname* | *ip-address*} [**traps** | **informs**] [**version** {**1** | **2c** | **3** [**auth** | **noauth** | **priv**]}] *community-string* [**udp-port** *port*] [*notification-type*] [**vrf** *vrf-name*]
4. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port*
5. **ip address** *ip-address*
6. **exit**
7. **ip default-gateway** *ip-address*
8. **exit**

DETAILED STEPS

	Command or Action	Purpose

Step 1	`enable`
	
	Example:
	`Router> enable`
		Enables privileged EXEC mode.
		• Enter your password if prompted.

Step 2	`configure terminal`
	
	Example:
	`Router# configure terminal`
		Enters global configuration mode.

	Command or Action	Purpose
Step 3	**snmp-server host** {*hostname* | *ip-address*} [**traps** | **informs**] [**version** {**1** | **2c** | **3** [**auth** | **noauth** | **priv**]}] *community-string* [**udp-port** *port*] [*notification-type*] [**vrf** *vrf-name*] Example: `Router(config)# snmp-server host 10.6.1.1 traps 1 snmp vlan-membership`	Enters the trap manager IP address, community string, and the traps to generate.
Step 4	**interface vlan** *vlan-id* Example: `Router(config)# interface vlan 200`	Enters interface configuration mode, and specifies the VLAN to which the IP information is assigned. • VLAN 1 is the management VLAN, but you can configure any VLAN from IDs 1 to 1001.
Step 5	**ip address** *ip-address* Example: `Router(config-if)# ip address 10.2.1.2`	Enters the IP address and subnet mask.
Step 6	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode.
Step 7	**ip default-gateway** *ip-address* Example: `Router(config)# ip default-gateway 10.5.1.5`	Enters the IP address of the default routing device.
Step 8	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.

Configuring Voice Ports

Perform this task to instruct the Cisco 7960 IP phone to give voice traffic a higher priority and to forward all traffic through the 802.1Q native VLAN on the EtherSwitch network module. This task also disables inline power to a Cisco 7960 IP phone to allow voice traffic to be forwarded to and from the phone.

The EtherSwitch network module can connect to a Cisco 7960 IP phone and carry IP voice traffic. If necessary, the EtherSwitch network module can supply electrical power to the circuit connecting it to the Cisco 7960 IP phone.

Because the sound quality of an IP telephone call can deteriorate if the data is unevenly transmitted, the current release of the Cisco IOS software supports QoS based on IEEE 802.1p CoS. QoS uses classification and scheduling to transmit network traffic from the switch in a predictable manner.

The Cisco 7960 IP phone contains an integrated three-port 10/100 switch. The ports are dedicated to connect to the following devices:

- Port 1 connects to the EtherSwitch network module switch or other voice-over-IP device
- Port 2 is an internal 10/100 interface that carries the phone traffic
- Port 3 connects to a PC or other device

Port Connection to a Cisco 7960 IP Phone

Because a Cisco 7960 IP phone also supports connection to a PC or other device, a port connecting a EtherSwitch network module to a Cisco 7960 IP phone can carry a mix of traffic. There are three ways to configure a port connected to a Cisco 7960 IP phone:

- All traffic is transmitted according to the default COS priority (0) of the port. This is the default.
- Voice traffic is given a higher priority by the phone, and all traffic is in the same VLAN.
- Voice and data traffic are carried on separate VLANs, and voice traffic always has a CoS priority of 5.

Inline Power on an EtherSwitch Network Module

The EtherSwitch network module can supply inline power to a Cisco 7960 IP phone, if necessary. The Cisco 7960 IP phone can also be connected to an AC power source and supply its own power to the voice circuit. When the Cisco 7960 IP phone is supplying its own power, an EtherSwitch network module can forward IP voice traffic to and from the phone.

A detection mechanism on the EtherSwitch network module determines whether it is connected to a Cisco 7960 IP phone. If the switch senses that there is *no* power on the circuit, the switch supplies the power. If there is power on the circuit, the switch does not supply it.

You can configure the switch to never supply power to the Cisco 7960 IP phone and to disable the detection mechanism.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port*
4. **switchport voice vlan** {*vlan-id* | **dot1p** | **none** | **untagged**}
5. **power inline** {**auto** | **never**}
6. **exit**

DETAILED STEPS

	Command or Action	Purpose

Step 1	`enable`
	
	Example:
	`Router> enable`
		Enables privileged EXEC mode.
		• Enter your password if prompted.

Step 2	`configure terminal`
	
	Example:
	`Router# configure terminal`
		Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port* Example: Router(config)# interface fastethernet 1/0	Selects the port to configure and enters interface configuration mode.
Step 4	**switchport voice vlan** {*vlan*-id | **dot1p** | **none** | **untagged**} Example: Router(config-if)# switchport voice vlan dot1p	Instructs the EtherSwitch network module to use 802.1p priority tagging for voice traffic and to use VLAN 0 (default native VLAN) to carry all traffic.
Step 5	**power inline** {**auto** | **never**} Example: Router(config-if)# power inline never	Determine how inline power is applied to the device on the specified port. • In this example, inline power on the port is permanently disabled.
Step 6	**exit** **Example:** Router(config-if)# exit	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this step one more time to exit global configuration mode.

Verifying Cisco Discovery Protocol

Perform this optional task to verify that Cisco Discovery Protocol (CDP) is enabled globally, enabled on an interface, and to display information about neighboring equipment. CDP is enabled by default. For more details on CDP commands refer to the *Configuration Fundamentals and Network Management Command Reference*, Release 12.3 T.

SUMMARY STEPS

1. **enable**
2. **show cdp**
3. **show cdp interface** [*interface-type interface-number*]
4. **show cdp neighbors** [*interface-type interface-number*] [**detail**]

DETAILED STEPS

Step 1 **enable**

Enables privileged EXEC mode. Enter your password if prompted:

```
Router> enable
```

Step 2 **show cdp**

Use this command to verify that CDP is globally enabled:

```
Router# show cdp

Global CDP information:
        Sending CDP packets every 120 seconds
        Sending a holdtime value of 180 seconds
        Sending CDPv2 advertisements is enabled
```

Step 3 **show cdp interface** [*interface-type interface-number*]

Use this command to verify the CDP configuration on an interface:

```
Router# show cdp interface fastethernet 5/1

FastEthernet5/1 is up, line protocol is up
  Encapsulation ARPA
  Sending CDP packets every 120 seconds
  Holdtime is 180 seconds
```

Step 4 **show cdp neighbors** [*interface-type interface-number*] [**detail**]

Use this command to verify information about the neighboring equipment:

```
Router# show cdp neighbors

Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater
Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
JAB023807H1      Fas 5/3            127         T S       WS-C2948  2/46
JAB023807H1      Fas 5/2            127         T S       WS-C2948  2/45
JAB023807H1      Fas 5/1            127         T S       WS-C2948  2/44
JAB023807H1      Gig 1/2            122         T S       WS-C2948  2/50
JAB023807H1      Gig 1/1            122         T S       WS-C2948  2/49
JAB03130104      Fas 5/8            167         T S       WS-C4003  2/47
JAB03130104      Fas 5/9            152         T S       WS-C4003  2/48
```

Configuring the MAC Table to Provide Port Security

Perform this task to enable the MAC address secure option, create a static or dynamic entry in the MAC address table, and configure the aging timer.

Port security is implemented by providing the user with the option to make a port secure by allowing only well-known MAC addresses to send in data traffic.

MAC Addresses and VLANs

The EtherSwitch network module uses the MAC address tables to forward traffic between ports. All MAC addresses in the address tables are associated with one or more ports. These MAC tables include the following types of addresses:

- Dynamic address—a source MAC address that the switch learns and then drops when it is not in use.
- Secure address—a manually entered unicast address that is usually associated with a secured port. Secure addresses do not age.
- Static address—a manually entered unicast or multicast address that does not age and that is not lost when the switch resets.

The address tables list the destination MAC address and the associated VLAN ID, module, and port number associated with the address.

All addresses are associated with a VLAN. An address can exist in more than one VLAN and have different destinations in each. Multicast addresses, for example, could be forwarded to port 1 in VLAN 1 and ports 9, 10, and 11 in VLAN 5.

Each VLAN maintains its own logical address table. A known address in one VLAN is unknown in another until it is learned or statically associated with a port in the other VLAN. An address can be secure in one VLAN and dynamic in another. Addresses that are statically entered in one VLAN must be static addresses in all other VLANs.

Address Aging Time

Dynamic addresses are source MAC addresses that the switch learns and then drops when they are not in use. Use the Aging Time field to define how long the switch retains unseen addresses in the table. This parameter applies to all VLANs.

Setting too short an aging time can cause addresses to be prematurely removed from the table. Then when the switch receives a packet for an unknown destination, it floods the packet to all ports in the same VLAN as the receiving port. This unnecessary flooding can impact performance. Setting too long an aging time can cause the address table to be filled with unused addresses; it can cause delays in establishing connectivity when a workstation is moved to a new port.

Caution Cisco advises that you do not change the aging timer because the EtherSwitch network module could go out of synchronization.

Secure Addresses

The secure address table contains secure MAC addresses and their associated ports and VLANs. A secure address is a manually entered unicast address that is forwarded to only one port per VLAN. If you enter an address that is already assigned to another port, the switch reassigns the secure address to the new port.

You can enter a secure port address even when the port does not yet belong to a VLAN. When the port is later assigned to a VLAN, packets destined for that address are forwarded to the port.

Static Addresses

A static address has the following characteristics:

- It is manually entered in the address table and must be manually removed.
- It can be a unicast or multicast address.
- It does not age and is retained when the switch restarts.

Because all ports are associated with at least one VLAN, the switch acquires the VLAN ID for the address from the ports that you select on the forwarding map. A static address in one VLAN must be a static address in other VLANs. A packet with a static address that arrives on a VLAN where it has not been statically entered is flooded to all ports and not learned.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mac-address-table secure** *mac-address* {**fastethernet | gigabitethernet**} *slot/port* **vlan** *vlan-id*
4. **mac-address-table** [**dynamic** | **static**] *mac-address* {**fastethernet | gigabitethernet}** *slot/port* **vlan** *vlan-id*

5. **mac-address-table aging-time** *seconds*
6. **exit**
7. **show mac-address-table** [**aging-time** | **secure**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mac-address-table secure** *mac-address* {**fastethernet** | **gigabitethernet**} *slot*/*port* **vlan** *vlan-id* **Example:** `Router(config)# mac-address-table secure 0003.0003.0003 fastethernet 2/8 vlan 2`	Secures the MAC address traffic on the port. • Use the **no** form of this command to restore the defaults.
Step 4	**mac-address-table** [**dynamic** | **static**] *mac-address* {**fastethernet** | **gigabitethernet**} *slot*/*port* **vlan** *vlan-id* **Example:** `Router(config)# mac-address-table static 0001.6443.6440 fastethernet 2/8 vlan 1`	Creates a static or dynamic entry in the MAC address table. **Note** Only the port where the link is up will see the dynamic entry validated in the EtherSwitch network module.
Step 5	**mac-address-table aging-time** *seconds* **Example:** `Router(config)# mac-address-table aging-timer 23`	Configures the MAC address aging-timer age in seconds. • Default aging time is 300 seconds.
Step 6	**exit** **Example:** `Router(config-if)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.
Step 7	**show mac-address-table** [**aging-time** | **secure**] **Example:** `Router# show mac-address-table secure`	(Optional) Displays information about the MAC address table.

Examples

Sample Output for the show mac-address-table Command

In the following example, output information is displayed to verify the configuration of the secure port:

```
Router# show mac-address-table secure

Secure Address Table:
Destination Address  Address Type  VLAN  Destination Port
-------------------  ------------  ----  --------------------
0003.0003.0003          Secure 1  FastEthernet    2/8
```

In the following example, information about static and dynamic addresses in the MAC address table is displayed:

```
Router# show mac-address-table

Destination Address  Address Type  VLAN  Destination Port
-------------------  ------------  ----  --------------------
0001.6443.6440          Static       1      Vlan1
0004.c16d.9be1          Dynamic      1      FastEthernet2/13
0004.ddf0.0282          Dynamic      1      FastEthernet2/13
0006.0006.0006          Dynamic      1      FastEthernet2/13
001b.001b.ad45          Dynamic      1      FastEthernet2/13
```

In the following example, information about the MAC address aging timer is displayed:

```
Router# show mac-address-table aging-timer

Mac address aging time 23
```

Configuring 802.1x Authentication

Perform the following tasks to configure 802.1x port-based authentication on the EtherSwitch network module:

- Enabling 802.1x Authentication, page 73 (required)
- Configuring the Switch-to-RADIUS-Server Communication, page 75 (optional)
- Configuring 802.1x Parameters (Retransmissions and Timeouts), page 76 (optional)

802.1x Authentication Guidelines for the EtherSwitch network module

These are the 802.1x authentication configuration guidelines:

- When the 802.1x protocol is enabled, ports are authenticated before any other Layer 2 feature is enabled.
- The 802.1x protocol is supported on Layer 2 static-access ports, but it is not supported on these port types:
  - Trunk port—If you try to enable 802.1x on a trunk port, an error message appears, and 802.1x is not enabled. If you try to change the mode of an 802.1x-enabled port to trunk, the port mode is not changed.

– EtherChannel port—Before enabling 802.1x on the port, you must first remove the port from the EtherChannel before enabling 802.1x on it. If you try to enable 802.1x on an EtherChannel or on an active port in an EtherChannel, an error message appears, and 802.1x is not enabled. If you enable 802.1x on a not-yet active port of an EtherChannel, the port does not join the EtherChannel.

Switch Port Analyzer (SPAN) destination port—You can enable 802.1x on a port that is a SPAN destination port; however, 802.1x is disabled until the port is removed as a SPAN destination. You can enable 802.1x on a SPAN source port.

Table 9 shows the default 802.1x configuration.

Table 9 Default 802.1x Configuration

Feature	Default Setting
Authentication, authorization, and accounting (AAA)	Disabled.
RADIUS server • IP address • UDP authentication port • Key	 • None specified. • 1645. • None specified.
Per-interface 802.1x enable state	Disabled (force-authorized). The port transmits and receives normal traffic without 802.1x-based authentication of the client.
Periodic reauthentication	Disabled.
Number of seconds between reauthentication attempts	3600 seconds.
Quiet period	60 seconds (number of seconds that the switch remains in the quiet state following a failed authentication exchange with the client).
Retransmission time	30 seconds (number of seconds that the switch should wait for a response to an EAP request/identity frame from the client before retransmitting the request).
Maximum retransmission number	2 times (number of times that the switch will send an EAP-request/identity frame before restarting the authentication process).
Multiple host support	Disabled.
Client timeout period	30 seconds (when relaying a request from the authentication server to the client, the amount of time the switch waits for a response before retransmitting the request to the client). This setting is not configurable.
Authentication server timeout period	30 seconds (when relaying a response from the client to the authentication server, the amount of time the switch waits for a reply before retransmitting the response to the server). This setting is not configurable.

Enabling 802.1x Authentication

To enable 802.1x port-based authentication, you must enable AAA and specify the authentication method list. A method list describes the sequence and authentication methods to be queried to authenticate a user.

The software uses the first method listed to authenticate users; if that method fails to respond, the software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or until all defined methods are exhausted. If authentication fails at any point in this cycle, the authentication process stops, and no other authentication methods are attempted.

You control the port authorization state by using the **dot1x port-control** interface configuration command and these keywords:

- **force-authorized**—disables 802.1x and causes the port to change to the authorized state without any authentication exchange required. The port transmits and receives normal traffic without 802.1x-based authentication of the client. This is the default setting.
- **force-unauthorized**—causes the port to remain in the unauthorized state, ignoring all attempts by the client to authenticate. The switch cannot provide authentication services to the client through the interface.
- **auto**—enables 802.1x and causes the port to begin in the unauthorized state, allowing only EAPOL frames to be sent and received through the port. The authentication process begins when the link state of the port changes from down to up, or when an EAPOL-start frame is received. The switch requests the identity of the client and begins relaying authentication messages between the client and the authentication server. Each client attempting to access the network is uniquely identified by the switch by using the client's MAC address.

To disable AAA, use the **no aaa new-model** global configuration command. To disable 802.1x AAA authentication, use the **no** form of the **aaa authentication dot1x** global configuration command. To disable 802.1x, use the **dot1x port-control** command with the **force-authorized** keyword or the **no** form of the **dot1x port-control** interface configuration command.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa authentication dot1x default group radius**
5. **interface** *type slot/port*
6. **dot1x port-control** [**auto** | **force-authorized** | **force-unauthorized**]
7. **exit**

DETAILED STEPS

	Command	Description
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Router (config)# aaa new-model`	Enables AAA.
Step 4	**aaa authentication dot1x default group radius** **Example:** `Router (config)# aaa authentication dot1x default group radius`	Creates an 802.1x authentication method list. To create a default list that is used when a named list is *not* specified in the **authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all interfaces. Enter at least one of these keywords: • **group radius**—Use the list of all RADIUS servers for authentication. • **none**—Use no authentication. The client is automatically authenticated without the switch using the information supplied by the client.
Step 5	**interface** *type slot/port* **Example:** `Router (config)# interface fastethernet 5/1`	Enters interface configuration mode and specifies the interface to be enabled for 802.1x port-based authentication.
Step 6	**dot1x port-control** [**auto** | **force-authorized** | **force-unauthorized**] **Example:** `Router (config-if)# dot1x port-control auto`	Enables 802.1x port-based authentication on the interface. For feature interaction information with trunk, dynamic, dynamic-access, EtherChannel, secure, and SPAN ports, see the "802.1x Authentication Guidelines for the EtherSwitch network module" section on page 71.
Step 7	**exit** **Example:** `Router(config)# exit`	Exits interface configuration mode and returns the router to privileged EXEC mode. • Repeat this command to exit global configuration mode and return to privileged EXEC mode.

Configuring the Switch-to-RADIUS-Server Communication

Perform this task to configure RADIUS server parameters.

RADIUS Security Servers

RADIUS security servers are identified by their host name or IP address, host name and specific UDP port numbers, or IP address and specific UDP port numbers. The combination of the IP address and UDP port number creates a unique identifier, which enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service—for example, authentication—the second host entry configured acts as the fail-over backup to the first one. The RADIUS host entries are tried in the order that they were configured.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip radius source-interface** *interface-name*
4. **radius-server host** {*hostname* | *ip-address*} **auth-port** *port-number* **key** *string*
5. **radius-server key** *string*

DETAILED STEPS

	Command	Description
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip radius source-interface** *interface-name* **Example:** `Router (config)# ip radius source-interface ethernet1`	Forces RADIUS to use the IP address of a specified interface for all outgoing RADIUS packets.

	Command	Description
Step 4	**radius-server host** {*hostname* | *ip-address*} **auth-port** *port-number* **key** *string* **Example:** `Router (config)# radius-server host 172.16.39.46 auth-port 1612 key rad123`	Configures the RADIUS server parameters on the switch. • Use the *hostname* or *ip-address* argument to specify the host name or IP address of the remote RADIUS server. • Use the **auth-port** *port-number* keyword and argument to specify the UDP destination port for authentication requests. The default is 1645. • Use the **key** *string* keyword and argument to specify the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server. The key is a text string that must match the encryption key used on the RADIUS server. **Note** Always configure the key as the last item in the **radius-server host** command syntax because leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in the key, do not enclose the key in quotation marks unless the quotation marks are part of the key. This key must match the encryption used on the RADIUS daemon. • To use multiple RADIUS servers, repeat this command for each server.
Step 5	**radius-server key** *string* **Example:** `Router (config)# radius-server key radiuskey`	Configures the authorization and encryption key used between the router and the RADIUS daemon running on the RADIUS server. • The key is a text string that must match the encryption key used on the RADIUS server.

Configuring 802.1x Parameters (Retransmissions and Timeouts)

Perform this task to configure various 802.1x retransmission and timeout parameters. Because all of these parameters have default values, configuring them is optional.

Note You should change the default values of these commands only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port*

4. **dot1x port-control** [**auto** | **force-authorized** | **force-unauthorized**]
5. **dot1x multiple-hosts**
6. **exit**
7. **dot1x max-req** *number-of-retries*
8. **dot1x re-authentication**
9. **dot1x timeout tx-period** *value*
10. **dot1x timeout re-authperiod** *value*
11. **dot1x timeout quiet-period** *value*
12. **dot1x default**
13. **exit**
14. **show dot1x** [**statistics**] [**interface** *interface-type interface-number*]

DETAILED STEPS

	Command	Description

Step 1	`enable`
	
	Example:
	`Router> enable`
		Enables privileged EXEC mode.
		• Enter your password if prompted.

Step 2	`configure terminal`
	
	Example:
	`Router# configure terminal`
		Enters global configuration mode.

Step 3	`interface {ethernet | fastethernet | gigabitethernet} slot/port`
	
	Example:
	`Router(config)# interface fastethernet 5/6`
		Specifies the interface to which multiple hosts are indirectly attached and enters interface configuration mode.

Step 4	`dot1x port-control [auto | force-authorized | force-unauthorized]`
	
	Example:
	`Router (config-if)# dot1x port-control auto`
		Enables 802.1x port-based authentication on the interface.
		For feature interaction information with trunk, dynamic, dynamic-access, EtherChannel, secure, and SPAN ports, see the "802.1x Authentication Guidelines for the EtherSwitch network module" section on page 71.

Step 5	`dot1x multiple-hosts`
	
	Example:
	`Router (config-if)# dot1x multiple-hosts`
		Allows multiple hosts (clients) on an 802.1x-authorized port.
		Note Make sure that the **dot1x port-control** interface configuration command is set to **auto** for the specified interface.

	Command	Description
Step 6	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode.
Step 7	**dot1x max-req** *number-of-retries* **Example:** `Router (config)# dot1x max-req 3`	Sets the number of times that the switch sends an EAP-request/identity frame to the client before restarting the authentication process. • The range is from 1 to 10; the default is 2.
Step 8	**dot1x re-authentication** **Example:** `Router (config)# dot1x reauthentication`	Enables periodic reauthentication of the client, which is disabled by default. • The reauthentication period can be set using the **dot1x timeout** command.
Step 9	**dot1x timeout re-authperiod** *value* **Example:** `Router (config)# dot1x timeout re-authperiod 1800`	Sets the number of seconds between reauthentication attempts. • The range is from 1 to 4294967295; the default is 3600 seconds. **Note** This command affects the behavior of the switch only if periodic reauthentication is enabled.
Step 10	**dot1x timeout tx-period** *value* **Example:** `Router (config)# dot1x timeout tx-period 60`	Sets the number of seconds that the EtherSwitch network module waits for a response to an EAP-request/identity frame from the client before retransmitting the request. • The range is from 1 to 65535 seconds; the default is 30.
Step 11	**dot1x timeout quiet-period** *value* **Example:** `Router (config)# dot1x timeout quiet-period 600`	Sets the number of seconds that the EtherSwitch network module remains in a quiet state following a failed authentication exchange with the client. • The range is from 1 to 65535 seconds; the default is 60.
Step 12	**dot1x default** **Example:** `Router (config)# dot1x default`	Resets the configurable 802.1x parameters to the default values.
Step 13	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.
Step 14	**show dot1x** [**statistics**] [**interface** *interface-type interface-number*] **Example:** `Router# show dot1x statistics interface fastethernet 0/1`	(Optional) Displays 802.1x statistics, administrative status, and operational status for the EtherSwitch network module or a specified interface.

Examples

Sample Output for the show dot1x Command

In the following example, statistics appear for all the physical ports for the specified interface:

```
Router# show dot1x statistics fastethernet 0/1

FastEthernet0/1

    Rx: EAPOL     EAPOL     EAPOL     EAPOL     EAP       EAP       EAP
        Start     Logoff    Invalid   Total     Resp/Id   Resp/Oth  LenError
        0         0         0         21        0         0         0

        Last      Last
        EAPOLVer  EAPOLSrc
        1         0002.4b29.2a03

    Tx: EAPOL     EAP       EAP
        Total     Req/Id    Req/Oth
        622       445       0
```

In the following example, global 802.1x parameters and a summary are displayed:

```
Router# show dot1x

Global 802.1X Parameters
    reauth-enabled               no
    reauth-period              3600
    quiet-period                 60
    tx-period                    30
    supp-timeout                 30
    server-timeout               30
    reauth-max                    2
    max-req                       2

802.1X Port Summary
    Port Name                Status      Mode                Authorized
    Gi0/1                    disabled    n/a                 n/a
    Gi0/2                    enabled     Auto (negotiate)    no

802.1X Port Details
    802.1X is disabled on GigabitEthernet0/1
802.1X is enabled on GigabitEthernet0/2
      Status                Unauthorized
      Port-control          Auto
      Supplicant            0060.b0f8.fbfb
      Multiple Hosts        Disallowed
      Current Identifier    2

      Authenticator State Machine
        State               AUTHENTICATING
        Reauth Count        1

      Backend State Machine
        State               RESPONSE
        Request Count       0
        Identifier (Server) 2

      Reauthentication State Machine
        State               INITIALIZE
```

Configuring Power Management on the Interfaces

Perform this task to manage the powering of the Cisco IP phones.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port*
4. **power inline** {**auto** | **never**}
5. **exit**
6. **show power inline**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port* **Example:** `Router(config)# interface fastethernet 5/6`	Selects the Ethernet interface to configure and enters interface configuration mode.
Step 4	**power inline** {**auto** | **never**} Example: `Router(config-if)# power inline auto`	Configures the port to supply inline power automatically to a Cisco IP phone. • Use the **never** keyword to permanently disable inline power on the port.
Step 5	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this command to exit global configuration mode and return to privileged EXEC mode.
Step 6	**show power inline** **Example:** `Router# show power inline`	(Optional) Displays information about the power configuration on the ports.

Examples

Sample Output for the show power inline Command

In the following example, output information is displayed to verify the power configuration on the ports:

```
Router# show power inline

PowerSupply   SlotNum.   Maximum   Allocated       Status
-----------   --------   -------   ---------       ------
 EXT-PS          1       165.000    20.000         PS1 GOOD PS2 ABSENT

Interface           Config   Phone    Powered    PowerAllocated
---------           ------   -----    -------    --------------
FastEthernet1/0      auto    no          off      0.000 Watts
FastEthernet1/1      auto    no          off      0.000 Watts
FastEthernet1/2      auto    no          off      0.000 Watts
FastEthernet1/3      auto    no          off      0.000 Watts
FastEthernet1/4      auto    unknown     off      0.000 Watts
FastEthernet1/5      auto    unknown     off      0.000 Watts
FastEthernet1/6      auto    unknown     off      0.000 Watts
FastEthernet1/7      auto    unknown     off      0.000 Watts
FastEthernet1/8      auto    unknown     off      0.000 Watts
FastEthernet1/9      auto    unknown     off      0.000 Watts
FastEthernet1/10     auto    unknown     off      0.000 Watts
FastEthernet1/11     auto    yes         on       6.400 Watts
FastEthernet1/12     auto    yes         on       6.400 Watts
FastEthernet1/13     auto    no          off      0.000 Watts
FastEthernet1/14     auto    unknown     off      0.000 Watts
FastEthernet1/15     auto    unknown     off      0.000 Watts
```

Configuring Storm Control

This section consists of two tasks. The first task enables global storm control, and the second task configures storm control on a per-port basis.

- Enabling Global Storm Control, page 81
- Enabling Per-Port Storm Control, page 83

Enabling Global Storm Control

Perform this task to enable a specified type of global storm control.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **storm-control** {{{**broadcast** | **multicast** | **unicast**} **level** *level* [*lower-level*]} | **action shutdown**}
4. **exit**
5. **show interface** [*interface-type interface-number*] **counters** {**broadcast** | **multicast** | **unicast**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**storm-control** {{{**broadcast** | **multicast** | **unicast**} **level** *level* [*lower-level*]}| **action shutdown**} **Example:** `Router(config)# storm-control broadcast level 75`	Specifies the global broadcast, multicast, or unicast storm control suppression level as a percentage of total bandwidth. • A threshold value of 100 percent means that no limit is placed on the specified type of traffic. • Use the **level** keyword and argument to specify the threshold value. • Use the **no** form of this command to restore the defaults.
Step 4	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this command to exit global configuration mode and return to privileged EXEC mode.
Step 5	**show interface** [*interface-type interface-number*] **counters** {**broadcast** | **multicast** | **unicast**} **Example:** `Router# show interface counters broadcast`	(Optional) Displays the type of storm control suppression counter currently in use and displays the number of discarded packets. • Use the *interface-type* and *interface-number* arguments to display the type of storm control suppression counter for a specified interface.

Examples

Sample Output for the show interface counters Command

In the following example, output information is displayed to verify the number of packets discarded for the specified storm control suppression:

```
Router# show interface counters broadcast

Port      BcastSuppDiscards
Fa0/1                     0
Fa0/2                     0
```

Enabling Per-Port Storm Control

Perform this task to configure storm control on a specified interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port*
4. **storm-control** {{{**broadcast** | **multicast** | **unicast**} **level** *level* [*lower-level*]} | **action shutdown**}
5. **storm-control action shutdown**
6. **exit**
7. **show storm-control** [*interface-type interface-number*] [**broadcast** | **multicast** | **unicast** | **history**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port* **Example:** `Router(config)# interface fastethernet 5/6`	Selects the Ethernet interface to configure and enters interface configuration mode.
Step 4	**storm-control** {{{**broadcast** | **multicast** | **unicast**} **level** *level* [*lower-level*]}| **action shutdown**} **Example:** `Router(config-if)# storm-control multicast level 80`	Configures broadcast, multicast, or unicast per-port storm-control. • Use the **level** keyword and argument to specify the rising threshold level for either broadcast, multicast, or unicast traffic. The storm control action occurs when traffic utilization reaches this level. • Use the optional *lower-level* argument to specify the falling threshold level. The normal transmission restarts (if the action is filtering) when traffic drops below this level. • A threshold value of 100 percent means that no limit is placed on the specified type of traffic. • Use the **no** form of this command to restore the defaults.

	Command or Action	Purpose
Step 5	**storm-control action shutdown** **Example:** `Router(config-if)# storm-control action shutdown`	Selects the **shutdown** keyword to disable the port during a storm. • The default is to filter out the traffic • Use the **no** keyword to restore the defaults.
Step 6	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this command to exit global configuration mode and return to privileged EXEC mode.
Step 7	**show storm-control** [*interface-type interface-number*] [**broadcast** | **multicast** | **unicast** | **history**] **Example:** `Router# show storm-control broadcast`	(Optional) Displays the type of storm control suppression for all interfaces on the EtherSwitch network module. • Use the *interface-type* and *interface-number* arguments to display the type of storm control suppression for a specified interface.

Examples

Sample Output for the show storm-control Command

In the following example, output information is displayed to verify the number of packets discarded for the specified storm control suppression:

```
Router# show storm-control broadcast

Interface  Filter State   Upper    Lower    Current
---------  -------------  -------  -------  -------
Fa0/1      <inactive>     100.00%  100.00%    0.00%
Fa0/2      <inactive>     100.00%  100.00%    0.00%
Fa0/3      <inactive>     100.00%  100.00%    0.00%
Fa0/4      Forwarding      30.00%   20.00%   20.32%
```

Configuring Layer 2 EtherChannels (Port-Channel Logical Interfaces)

Perform this task to configure Layer 2 Ethernet interfaces as a Layer 2 EtherChannel, configure EtherChannel load balancing, and remove an Ethernet interface from an EtherChannel.

To configure Layer 2 EtherChannels, configure the Ethernet interfaces with the **channel-group** command, which creates the port-channel logical interface. You do not have to create a port-channel interface before assigning a physical interface to a channel group. A port-channel interface is created automatically when the channel group gets its first physical interface, if it is not already created.

Restrictions

- Cisco IOS software creates port-channel interfaces for Layer 2 EtherChannels when you configure Layer 2 Ethernet interfaces with the **channel-group** command. You cannot put Layer 2 Ethernet interfaces into a manually created port-channel interface.
- Layer 2 interfaces must be connected and functioning for Cisco IOS software to create port-channel interfaces for Layer 2 EtherChannels.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port*
4. **channel-group** *port-channel-number* **mode on**
5. Repeat Steps 3 through 4 for each Ethernet interface to be added as a Layer 2 EtherChannel.
6. **exit**
7. **port-channel load-balance** {**src-mac** | **dst-mac** | **src-dst-mac** | **src-ip** | **dst-ip** | **src-dst-ip**}
8. **no interface port-channel** *port-channel-number*
9. **exit**
10. **show interfaces fastethernet** *slot/port* {**etherchannel** | **switchport** | **trunk**}
11. **show etherchannel** [*channel-group*] {**port-channel** | **brief** | **detail** | **summary** | **port** | **load-balance**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port* **Example:** `Router(config)# interface fastethernet 5/6`	Selects the Ethernet interface to configure.
Step 4	**channel-group** *port-channel-number* **mode on** **Example:** `Router(config)# channel-group 2 mode on`	Configures the interface in a port-channel. • In this example, the Etherchannel group 2 is configured.
Step 5	Repeat Steps 3 through 4 for each Ethernet interface to be added as a Layer 2 EtherChannel.	—
Step 6	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode.

	Command or Action	Purpose
Step 7	**port-channel load-balance** {**src-mac** | **dst-mac** | **src-dst-mac** | **src-ip** | **dst-ip** | **src-dst-ip**} **Example:** `Router(config)# port-channel load-balancing src-mac`	Configures EtherChannel load balancing. • In this example, the load balancing is based on the source MAC addresses.
Step 8	**no interface port-channel** *port-channel-number* **Example:** `Router(config)# no interface port-channel 3`	Removes a port channel interface. • In this example, the interface port channel 3 is removed.
Step 9	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.
Step 10	**show interfaces fastethernet** *slot*/*port* {**etherchannel** | **switchport** | **trunk**} **Example:** `Router# show interfaces fastethernet 5/6 etherchannel`	(Optional) Displays information about Fast Ethernet interfaces. • In this example, EtherChannel information is shown for the specified interface.
Step 11	**show etherchannel** [*channel-group*] {**port-channel** | **brief** | **detail** | **summary** | **port** | **load-balance**} **Example:** `Router# show etherchannel 2 port-channel`	(Optional) Displays information about port channels for EtherChannel groups.

Examples

Sample Output for the show interfaces fastethernet Command

In the following example, output information is displayed to verify the configuration of Fast Ethernet interface as a Layer 2 EtherChannel:

```
Router# show interfaces fastethernet 5/6 etherchannel

Port state    = EC-Enbld Up In-Bndl Usr-Config

Channel group = 2           Mode = Desirable     Gcchange = 0
Port-channel  = Po2         GC   = 0x00020001
Port indx     = 1           Load = 0x55

Flags:  S - Device is sending Slow hello.  C - Device is in Consistent state.
        A - Device is in Auto mode.        P - Device learns on physical port.
Timers: H - Hello timer is running.        Q - Quit timer is running.
        S - Switching timer is running.    I - Interface timer is running.
Local information:
                               Hello    Partner  PAgP     Learning  Group
Port      Flags State   Timers  Interval Count   Priority   Method  Ifindex
Fa5/6     SC    U6/S7           30s      1        128        Any      56

Partner's information:
```

```
          Partner              Partner          Partner         Partner Group
Port      Name                 Device ID        Port       Age  Flags   Cap.
Fa5/6     JAB031301            0050.0f10.230c   2/47        18s SAC     2F

Age of the port in the current state: 00h:10m:57s
```

Sample Output for the show etherchannel Command

In the following example, output information about port channels for EtherChannel group 2 is displayed:

```
Router# show etherchannel 2 port-channel

Port-channels in the group:
               ----------------------

Port-channel: Po2
------------

Age of the Port-channel   = 00h:23m:33s
Logical slot/port   = 10/2           Number of ports in agport = 2
GC                  = 0x00020001      HotStandBy port = null
Port state          = Port-channel Ag-Inuse

Ports in the Port-channel:

Index   Load   Port
-------------------
  1     55      Fa5/6
  0     AA      Fa5/7

Time since last port bundled:    00h:23m:33s    Fa5/6
```

Configuring Flow Control on Gigabit Ethernet Ports

Perform this task to configure flow control on a Gigabit Ethernet port.

SUMMARY STEPS

1. **enable**
2. **set port flowcontrol** {**receive** | **send**} [*mod-number*/*port-number*] {**off** | **on** | **desired**}
3. **show port flowcontrol**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**set port flowcontrol** {**receive** | **send**} [*mod-number*/*port-number*] {**off** | **on** | **desired**} **Example:** `Router# set port flowcontrol 5/1 receive on`	Sets the flow control parameters on a Gigabit Ethernet port.
Step 3	**show port flowcontrol** **Example:** `Router# show port flowcontrol`	(Optional) Displays information about the flow control for Gigabit Ethernet ports.

Examples

Sample Output for the show port flowcontrol Command

In the following example, output information is displayed to verify the flow control configuration on Gigabit Ethernet ports:

```
Router# show interfaces fastethernet 5/6 etherchannel

Port   Send-Flowcontrol   Receive-Flowcntl   RxPause   TxPause
       Admin   Oper       Admin   Oper
-----  ----------------   ----------------   -------   ------
 5/1   off     off        on      disagree   0         0
 5/2   off     off        off     off        0         0
 5/3   desired on         desired off        10        10
```

Configuring Intrachassis Stacking

Perform this task to extend Layer 2 switching in the router by connecting the Gigabit Ethernet ports of the EtherSwitch network module.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot*/*port*
4. **switchport stacking-partner interface gigabit** *slot*/*port*
5. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet** *slot*/*port* **Example:** `Router(config)# interface gigabitethernet 2/0`	Selects the Gigabit Ethernet interface to configure.
Step 4	**switchport stacking-partner interface gigabitethernet** *slot*/*port* **Example:** `Router(config-if)# switchport stacking-link interface gigabitethernet 3/0`	Creates the intrachassis stacking between the current Gigabit Ethernet (GE) interface and the stacking link partner GE interface. • In this example, GE interface 2/0 is stacked on GE interface 3/0 to form an extended VLAN within one chassis on the router.
Step 5	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this command to exit global configuration mode and return to privileged EXEC mode.

Configuring Switched Port Analyzer (SPAN)

Perform this task to configure the source and destination for a SPAN session.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **monitor session** *session-number* {**source interface** *interface-type slot/port* | **vlan** *vlan-id*} [**,** | **-** | **rx** | **tx** | **both**]
4. **monitor session** *session-number* {**destination interface** *interface-type slot/port* [**,** | **-**] | **vlan** *vlan-id*}
5. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**monitor session** *session-number* {**source interface** *interface-type slot*/*port* | **vlan** *vlan-id*} [**,** | **-** | **rx** | **tx** | **both**] **Example:** `Router(config)# monitor session 1 source interface fastethernet 5/1 both`	Specifies the SPAN session number, the source interface, or VLAN, and the traffic direction to be monitored. **Note** Multiple SPAN sessions can be configured, but only one SPAN session is supported at a time.
Step 4	**monitor session** *session-number* {**destination interface** *interface-type slot*/*port* [**,** | **-**] | **vlan** *vlan-id*} **Example:** `Router(config)# monitor session 1 destination interface fastethernet 5/48`	Specifies the SPAN session number, the destination interface, or VLAN.
Step 5	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.

Configuring Layer 3 Interfaces

Perform this task to configure a Layer 3 interface on the EtherSwitch network module. A physical interface on the EtherSwitch network module is configured as a Layer 3 interface and an IP address is assigned to the interface.

Layer 3 Interface Support for the EtherSwitch network module

The EtherSwitch network module supports two types of Layer 3 interfaces for routing and bridging:

- SVIs: You should configure SVIs for any VLANs for which you want to route traffic. SVIs are created when you enter a VLAN ID following the **interface vlan** global configuration command. To delete an SVI, use the **no interface vlan** global configuration command.
- Routed ports: Routed ports are physical ports configured to be in Layer 3 mode by using the **no switchport** interface configuration command.

Note A Layer 3 switch can have an IP address assigned to each routed port and SVI. The number of routed ports and SVIs that you can configure is not limited by software; however, the interrelationship between this number and the number of other features being configured might have an impact on CPU utilization because of hardware limitations.

All Layer 3 interfaces require an IP address to route traffic (a routed port cannot obtain an IP address from a DHCP server, but the router can act as a DHCP server and serve IP addresses through a routed port).

Routed ports support only CEF switching (IP fast switching is not supported).

Note If the physical port is in Layer 2 mode (the default), you must enter the **no switchport** interface configuration command to put the interface into Layer 3 mode. Entering a **no switchport** command disables and then reenables the interface, which might generate messages on the device to which the interface is connected. When you use this command to put the interface into Layer 3 mode, you are also deleting any Layer 2 characteristics configured on the interface. (Also, when you return the interface to Layer 2 mode, you are deleting any Layer 3 characteristics configured on the interface.)

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port*
4. **no switchport**
5. **ip address** *ip-address mask*
6. **no shutdown**
7. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port* **Example:** `Router(config)# interface gigabitethernet 0/10`	Selects the Ethernet interface to configure.

	Command or Action	Purpose
Step 4	**no switchport** Example: Router(config-if)# no switchport	Disables switching on the port and enables routing (Layer 3) mode for physical ports only. • In this example, Gigabit Ethernet interface 0/10 is now a routed port instead of a switching port.
Step 5	**ip address** *ip-address mask* **Example:** Router(config)# ip address 10.1.2.3 255.255.0.0	Configures an IP address and subnet.
Step 6	**no shutdown** **Example:** Router(config-if)# no shutdown	Activates the interface. (Required only if you shut down the interface.)
Step 7	**exit** **Example:** Router(config-if)# exit	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this command to exit global configuration mode and return to privileged EXEC mode.

Enabling and Verifying IP Multicast Layer 3 Switching

Perform this task to enable IP multicast routing globally, enable IP Protocol Independent Multicast (PIM) on a Layer 3 interface, and verify the IP multicast Layer 3 switching information.

You must enable IP multicast routing globally before enabling IP multicast Layer 3 switching on Layer 3 interfaces. Enable PIM on Layer 3 interfaces before adding IP multicast Layer 3 switching functions on those interfaces.

For complete IP multicast command reference information and configuration details, refer to the following documents:

- *Cisco IOS IP Configuration Guide*
- *Cisco IOS IP Command Reference, Volume 3 of 3: Multicast*, Release 12.3 T

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip multicast-routing**
4. **interface vlan** *vlan-id*
5. **ip pim** {**dense-mode** | **sparse-mode** | **sparse-dense-mode**}
6. **exit**
7. **show ip pim** [**vrf** *vrf-name*] **interface** [*interface-type interface-number*] [**df** | **count**] [*rp-address*] [**detail**]
8. **show ip mroute** [**vrf** *vrf-name*] [*group-address* | *group-name*] [*source-address* | *source-name*] [*interface-type interface-number*] [**summary**] [**count**] [**active** *kbps*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip multicast-routing** Example: `Router(config)# ip multicast-routing`	Enables IP multicast routing globally.
Step 4	**interface vlan** *vlan-id* **Example:** `Router(config)# interface vlan 10`	Selects the interface to configure.
Step 5	**ip pim** {**dense-mode** | **sparse-mode** | **sparse-dense-mode**} Example: `Router(config-if)# ip pim sparse-mode`	Enables IP PIM on a Layer 3 interface.
Step 6	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this command to exit global configuration mode and return to privileged EXEC mode.
Step 7	**show ip pim** [**vrf** *vrf-name*] **interface** [*interface-type interface-number*] [**df** | **count**] [*rp-address*] [**detail**] **Example:** `Router# show ip pim interface count`	Verifies the IP multicast Layer 3 switching enable state on IP PIM interfaces. • Use the **count** keyword to display the number of packets received and sent on the interface.
Step 8	**show ip mroute** [**vrf** *vrf-name*] [group-address | *group-name*] [source-address | source-*name*] [*interface-type interface-number*] [**summary**] [**count**] [**active** *kbps*] **Example:** `Router# show ip mroute count`	Displays the contents of the IP multicast routing (mroute) table.

Examples

Sample Output for the show ip pim Command

In the following example, output information is displayed to verify the IP multicast Layer 3 switching information for an IP PIM Layer 3 interface:

```
Router# show ip pim interface count

State:* - Fast Switched, D - Distributed Fast Switched
      H - Hardware Switching Enabled
Address          Interface          FS  Mpackets In/Out
10.15.1.20       GigabitEthernet4/8 * H 952/4237130770
10.20.1.7        GigabitEthernet4/9 * H 1385673757/34
10.25.1.7        GigabitEthernet4/10* H 0/34
10.11.1.30       FastEthernet6/26   * H 0/0
10.37.1.1        FastEthernet6/37   * H 0/0
1.22.33.44       FastEthernet6/47   * H 514/68
```

Sample Output for the show ip mroute Command

In the following example, output information is displayed for the IP multicast routing table:

```
Router# show ip mroute count

IP Multicast Statistics
56 routes using 28552 bytes of memory
13 groups, 3.30 average sources per group
Forwarding Counts:Pkt Count/Pkts per second/Avg Pkt Size/Kilobits per second
Other counts:Total/RPF failed/Other drops(OIF-null, rate-limit etc)

Group:224.2.136.89, Source count:1, Group pkt count:29051
  Source:132.206.72.28/32, Forwarding:29051/-278/1186/0, Other:85724/8/56665
```

Note The negative counter means that the outgoing interface list of the corresponding entry is NULL, and this indicates that this flow is still active.

Configuring IGMP Snooping

Perform this task to enable IGMP snooping on a router with the Ethernet switching network module installed.

IGMP Snooping on the EtherSwitch Network Module

By default, IGMP snooping is globally enabled on the EtherSwitch network module. When globally enabled or disabled, it is also enabled or disabled in all existing VLAN interfaces. By default, IGMP snooping is enabled on all VLANs, but it can be enabled and disabled on a per-VLAN basis.

Global IGMP snooping overrides the per-VLAN IGMP snooping capability. If global snooping is disabled, you cannot enable VLAN snooping. If global snooping is enabled, you can enable or disable snooping on a VLAN basis.

IGMP Immediate-Leave Processing

When you enable IGMP Immediate-Leave processing, the EtherSwitch network module immediately removes a port from the IP multicast group when it detects an IGMP version 2 leave message on that port. Immediate-Leave processing allows the switch to remove an interface that sends a leave message from the forwarding table without first sending out group-specific queries to the interface. You should use the Immediate-Leave feature only when there is only a single receiver present on every port in the VLAN.

Static Configuration of an Interface to Join a Multicast Group

Ports normally join multicast groups through the IGMP report message, but you can also statically configure a host on an interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping**
4. **ip igmp snooping vlan** *vlan-id*
5. **ip igmp snooping vlan** *vlan-id* **immediate-leave**
6. **ip igmp snooping vlan** *vlan-id* **static** *mac-address* **interface** *interface-type slot/port*
7. **ip igmp snooping vlan** *vlan-id* **mrouter** {**interface** *interface-type slot/port* | **learn pim-dvmrp**}
8. **exit**
9. **show ip igmp snooping** [**vlan** *vlan-id*]
10. **show ip igmp snooping mrouter** [**vlan** *vlan-id*]
11. **show mac-address-table multicast** [**vlan** *vlan-id*] [**user** | **igmp-snooping**] [**count**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping** **Example:** `Router(config)# ip igmp snooping`	Globally enables IGMP snooping on all existing VLAN interfaces.
Step 4	**ip igmp snooping vlan** *vlan-id* **Example:** `Router(config)# ip igmp snooping vlan 10`	Enables IGMP snooping on the specified VLAN interface.
Step 5	**ip igmp snooping vlan** *vlan-id* **immediate-leave** **Example:** `Router(config)# ip igmp snooping vlan 10 immediate-leave`	Enables IGMP Immediate-Leave processing on the specified VLAN interface.

	Command or Action	Purpose
Step 6	**ip igmp snooping vlan** *vlan-id* **static** *mac-address* **interface** *interface-type slot/port* **Example:** `Router(config)# ip igmp snooping vlan 10 static 303.303.303.303 interface fastethernet 1/5`	Statically configures a port as a member of a multicast group: • Use the *vlan-id* argument to specify the multicast group VLAN ID. • Use the *mac-address* argument to specify the group MAC address. • Use the *interface-type* and *slot/port* arguments to configure a port as a member of a multicast group.
Step 7	**ip igmp snooping vlan** *vlan-id* **mrouter** {**interface** *interface-type slot/port* | **learn pim-dvmrp**} **Example:** `Router(config)# ip igmp snooping vlan 10 mrouter interface fastethernet 1/5`	Enables a static connection on a multicast router. • Use the *vlan-id* argument to specify the multicast group VLAN ID. • Use the *interface-type* and *slot/port* arguments to specify the interface that connects to the multicast router.
Step 8	**exit** **Example:** `Router(config-if)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.
Step 9	**show ip igmp snooping** [**vlan** *vlan-id*] **Example:** `Router# show ip igmp snooping vlan 10`	Displays the IGMP snooping configuration. • Use the *vlan-id* argument to specify the multicast group VLAN ID.
Step 10	**show ip igmp snooping mrouter** [**vlan** *vlan-id*] **Example:** `Router# show ip igmp snooping mrouter vlan 10`	Displays information on dynamically learned and manually configured multicast router interfaces.
Step 11	**show mac-address-table multicast** [**vlan** *vlan-id*] [**user** | **igmp-snooping**] [**count**] **Example:** `Router# show mac-address-table multicast vlan 10 igmp-snooping`	Displays MAC address table entries for a VLAN. • Use the *vlan-id* argument to specify the multicast group VLAN ID. • Use the **user** keyword to display only the user-configured multicast entries. • Use the **igmp-snooping** keyword to display entries learned via IGMP snooping. • Use the **count** keyword to display only the total number of entries for the selected criteria, not the actual entries.

Configuring Fallback Bridging

This section contains the following tasks to help you configure fallback bridging.

- Configuring a Bridge Group, page 97 (required)
- Adjusting Spanning-Tree Parameters, page 100 (optional)
- Disabling the Spanning Tree on an Interface, page 102 (optional)

Understanding the Default Fallback Bridging Configuration

Table 10 shows the default fallback bridging configuration.

Table 10 Default Fallback Bridging Configuration

Feature	Default Setting
Bridge groups	None are defined or assigned to an interface. No VLAN-bridge STP is defined.
Switch forwards frames for stations that it has dynamically learned	Enabled.
Bridge table aging time for dynamic entries	300 seconds.
MAC-layer frame filtering	Disabled.
Spanning tree parameters:	
• Switch priority	• 32768.
• Interface priority	• 128.
• Interface path cost	• 10 Mbps: 100. 100 Mbps: 19. 1000 Mbps: 4.
• Hello BPDU interval	• 2 seconds.
• Forward-delay interval	• 20 seconds.
• Maximum idle interval	• 30 seconds.

Configuring a Bridge Group

Perform this task to create a bridge group, filter frames using a specific MAC address, prevent the forwarding of frames for stations that the switching device has dynamically learned, and remove dynamic entries from the bridge table.

Bridge Group Creation

To configure fallback bridging for a set of SVIs or routed ports, these interfaces must be assigned to bridge groups. All interfaces in the same group belong to the same bridge domain. Each SVI or routed port can be assigned to only one bridge group. A maximum of 31 bridge groups can be configured on the switch.

Note The protected port feature is not compatible with fallback bridging. When fallback bridging is enabled, it is possible for packets to be forwarded from one protected port on a switch to another protected port on the same switch if the ports are in different VLANs.

Forwarding of Dynamically Learned Stations

By default, the switch forwards any frames for stations that it has dynamically learned. By disabling this activity, the switch only forwards frames whose addresses have been statically configured into the forwarding cache.

Bridge Table Aging Time

A switch forwards, floods, or drops packets based on the bridge table. The bridge table maintains both static and dynamic entries. Static entries are entered by you or learned by the switch. Dynamic entries are entered by the bridge learning process. A dynamic entry is automatically removed after a specified length of time, known as aging time, from the time the entry was created or last updated.

If you are likely to move hosts on a switched network, decrease the aging-time to enable the switch to quickly adapt to the change. If hosts on a switched network do not continuously send packets, increase the aging time to keep the dynamic entries for a longer time and thus reduce the possibility of flooding when the hosts send again.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **bridge** *bridge-group* **protocol vlan-bridge**
4. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port*
5. **bridge-group** *bridge-group*
6. **exit**
7. **bridge** *bridge-group* **address** *mac-address* {**forward** | **discard**} [*interface-type interface-number*]
8. **no bridge** *bridge-group* **acquire**
9. **bridge** *bridge-group* **aging-time** *seconds*
10. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**bridge** *bridge-group* **protocol vlan-bridge** **Example:** `Router(config)# bridge 10 protocol vlan-bridge`	Assigns a bridge group number, and specifies the VLAN-bridge spanning-tree protocol to run in the bridge group. • Use the *bridge-group* argument to specify the bridge group number. The range is 1 to 255. You can create up to 31 bridge groups. **Note** Frames are bridged only among interfaces in the same group.

	Command or Action	Purpose
Step 4	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port* **Example:** `Router(config)# interface gigabitethernet 0/1`	Selects the Ethernet interface on which the bridge group is assigned and enters interface configuration mode. The specified interface must be one of the following: • A routed port: a physical port that you have configured as a Layer 3 port by entering the **no switchport** interface configuration command. • An SVI: a VLAN interface that you created by using the **interface vlan** *vlan-id* global configuration command. **Note** These ports must have IP addresses assigned to them.
Step 5	**bridge-group** *bridge-group* **Example:** `Router(config-if)# bridge-group 10`	Assigns the interface to the bridge group created in Step 3. • By default, the interface is not assigned to any bridge group. • An interface can be assigned to only one bridge group.
Step 6	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode.
Step 7	**bridge** *bridge-group* **address** *mac-address* {**forward** | **discard**} [*interface-type interface-number*] **Example:** `Router(config)# bridge 1 address 0800.cb00.45e9 forward gigabitethernet 0/1`	Specifies the MAC address to discard or forward. • Use the *bridge-group* argument to specify the bridge group number. The range is from 1 to 255. • Use the **address** *mac-address* keyword and argument to specify the MAC-layer destination address to be filtered. • Use the **forward** keyword if you want the frame destined to the specified interface to be forwarded. Use the **discard** keyword if you want the frame to be discarded. • (Optional) Use the *interface-type* and *interface-number* arguments to specify the interface on which the address can be reached.
Step 8	**no bridge** *bridge-group* **acquire** **Example:** `Router(config-if)# no bridge 10 acquire`	Stops the EtherSwitch network module from forwarding any frames for stations that it has dynamically learned through the discovery process, and to limit frame forwarding to statically configured stations. • The switch filters all frames except those whose destined-to addresses have been statically configured into the forwarding cache. • To configure a static address, use the **bridge address** global configuration command, see Step 7. • Use the *bridge-group* argument to specify the bridge group number. The range is from 1 to 255.

	Command or Action	Purpose
Step 9	**bridge** *bridge-group* **aging-time** *seconds* **Example:** `Router(config-if)# bridge 10 aging-time 200`	Specifies the length of time that a dynamic entry remains in the bridge table from the time the entry was created or last updated. • Use the *bridge-group* argument to specify the bridge group number. The range is from 1 to 255. • Use the *second*s argument to enter a number from 0 to 1000000. The default is 300.
Step 10	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.

Adjusting Spanning-Tree Parameters

Perform this task to adjust spanning tree parameters such as the switch priority or interface priority. You might need to adjust certain spanning-tree parameters if the default values are not suitable for your switch configuration. Parameters affecting the entire spanning tree are configured with variations of the **bridge** global configuration command. Interface-specific parameters are configured with variations of the **bridge-group** interface configuration command.

Note Only network administrators with a good understanding of how switches and STP function should make adjustments to spanning-tree parameters. Poorly planned adjustments can have a negative impact on performance. A good source on switching is the IEEE 802.1d specification; for more information, refer to the "References and Recommended Reading" appendix in the *Cisco IOS Configuration Fundamentals and Network Management Command Reference*, Release 12.3 T.

Switch Priority

You can globally configure the priority of an individual switch when two switches tie for position as the root switch, or you can configure the likelihood that a switch will be selected as the root switch. This priority is determined by default; however, you can change it.

Interface Priority

You can change the priority for an interface. When two switches tie for position as the root switch, you configure an interface priority to break the tie. The switch with the lowest interface value is elected.

Path Cost Assignment

Each interface has a path cost associated with it. By convention, the path cost is 1000/data rate of the attached LAN, in Mbps.

BPDU Intervals Adjustment

You can adjust three different BPDU intervals. The interval between hello BPDUs can be set. The forward-delay interval is the amount of time spent listening for topology change information after an interface has been activated for switching and before forwarding actually begins. The maximum-idle

interval specifies the amount of time the switch waits to hear BPDUs from the root switch. If a switch does not hear BPDUs from the root switch within the specified interval, it recomputes the spanning-tree topology.

Note Each switch in a spanning tree adopts the interval between hello BPDUs, the forward delay interval, and the maximum idle interval parameters of the root switch, regardless of what its individual configuration might be.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **bridge** *bridge-group* **hello-time** *seconds*
4. **bridge** *bridge-group* **forward-time** *seconds*
5. **bridge** *bridge-group* **max-age** *seconds*
6. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**bridge** *bridge-group* **hello-time** *seconds* **Example:** `Router(config)# bridge 10 hello-time 5`	Specifies the interval between hello BPDUs. • Use the *bridge-group* argument to specify the bridge group number. The range is from 1 to 255. • Use the *seconds* argument to enter a number from 1 to 10. The default is 2 seconds.
Step 4	**bridge** *bridge-group* **forward-time** *seconds* **Example:** `Router(config)# bridge 10 forward-time 10`	Specifies the forward-delay interval. • Use the *bridge-group* argument to specify the bridge group number. The range is from 1 to 255. • Use the *seconds* argument to enter a number from 10 to 200. The default is 20 seconds.

	Command or Action	Purpose
Step 5	**bridge-group** *bridge-group* **max-age** *seconds* **Example:** `Router(config)# bridge-group 10 max-age 30`	Specifies the interval the switch waits to hear BPDUs from the root switch. • Use the *bridge-group* argument to specify the bridge group number. The range is from 1 to 255. • Use the *seconds* argument to enter a number from 10 to 200. The default is 30 seconds.
Step 6	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.

Disabling the Spanning Tree on an Interface

Perform this task to disable spanning tree on an interface. When a loop-free path exists between any two switched subnetworks, you can prevent BPDUs generated in one switching subnetwork from impacting devices in the other switching subnetwork, yet still permit switching throughout the network as a whole. For example, when switched LAN subnetworks are separated by a WAN, BPDUs can be prevented from traveling across the WAN link.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port*
4. **bridge** *bridge-group* **spanning-disabled**
5. **exit**

DETAILED STEPS

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

	Command or Action	Purpose
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port* **Example:** `Router(config)# interface gigabitethernet 0/1`	Selects the Ethernet interface on which the bridge group is assigned and enters interface configuration mode. The specified interface must be one of the following: • A routed port: a physical port that you have configured as a Layer 3 port by entering the **no switchport** interface configuration command. • An SVI: a VLAN interface that you created by using the **interface vlan** *vlan-id* global configuration command. • These ports must have IP addresses assigned to them.
Step 4	**bridge** *bridge-group* **spanning-disabled** **Example:** `Router(config-if)# bridge 10 spanning-disabled`	Disables spanning tree on the interface. • Use the *bridge-group* argument to specify the bridge group number. The range is from 1 to 255.
Step 5	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode. • Repeat this command to exit global configuration mode and return to privileged EXEC mode.

Configuring Network Security with ACLs at Layer 2

This section contains the following tasks:

Configuring ACLs on Layer 2 interfaces is the same as configuring ACLs on Cisco routers. The process is briefly described here. For more detailed information on configuring router ACLs, refer to the "Configuring IP Services" chapter in the *Cisco IP Configuration Guide.* For detailed information about the commands, refer to *Cisco IOS IP Command Reference* for Cisco IOS Release 12.3 T. For a list of Cisco IOS features not supported on the EtherSwitch network module, see the following section.

Restrictions

The EtherSwitch network module does not support these Cisco IOS router ACL-related features:

- Non-IP protocol ACLs (see Table 11 on page 104).
- Bridge-group ACLs.
- IP accounting.
- ACL support on the outbound direction.
- Inbound and outbound rate limiting (except with QoS ACLs).
- IP packets with a header length of less than five are not to be access-controlled.

- Reflexive ACLs.
- Dynamic ACLs.
- ICMP-based filtering.
- IGMP-based filtering.

Creating Standard and Extended IP ACLs

This section describes how to create switch IP ACLs. An ACL is a sequential collection of permit and deny conditions. The switch tests packets against the conditions in an access list one by one. The first match determines whether the switch accepts or rejects the packet. Because the switch stops testing conditions after the first match, the order of the conditions is critical. If no conditions match, the switch denies the packet.

An ACL must first be created by specifying an access list number or name and access conditions. The ACL can then be applied to interfaces or terminal lines.

The software supports these styles of ACLs or IP access lists:

- Standard IP access lists use source addresses for matching operations.
- Extended IP access lists use source and destination addresses for matching operations and optional protocol-type information for finer granularity of control.

ACL Numbers

The number you use to denote your ACL shows the type of access list that you are creating. Table 11 lists the access list number and corresponding type and shows whether or not they are supported by the switch. The EtherSwitch network module supports IP standard and IP extended access lists, numbers 1 to 199 and 1300 to 2699.

Table 11 Access List Numbers

ACL Number	Type	Supported
1–99	IP standard access list	Yes
100–199	IP extended access list	Yes
200–299	Protocol type-code access list	No
300–399	DECnet access list	No
400–499	XNS standard access list	No
500–599	XNS extended access list	No
600–699	AppleTalk access list	No
700–799	48-bit MAC address access list	No
800–899	IPX standard access list	No
900–999	IPX extended access list	No
1000–1099	IPX SAP access list	No
1100–1199	Extended 48-bit MAC address access list	No
1200–1299	IPX summary address access list	No

Table 11 Access List Numbers (continued)

ACL Number	Type	Supported
1300–1999	IP standard access list (expanded range)	Yes
2000–2699	IP extended access list (expanded range)	Yes

Note In addition to numbered standard and extended ACLs, you can also create standard and extended named IP ACLs by using the supported numbers. That is, the name of a standard IP ACL can be 1 to 99; the name of an extended IP ACL can be 100 to 199. The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

Note An attempt to apply an unsupported ACL feature to an EtherSwitch network module interface produces an error message.

Including Comments About Entries in ACLs

You can use the **remark** command to include comments (remarks) about entries in any IP standard or extended ACL. The remarks make the ACL easier for you to understand and scan. Each remark line is limited to 100 characters.

The remark can go before or after a permit or deny statement. You should be consistent about where you put the remark so that it is clear which remark describes which permit or deny statement. For example, it would be confusing to have some remarks before the associated permit or deny statements and some remarks after the associated statements.

For IP numbered standard or extended ACLs, use the **access-list** *access-list number* **remark** *remark* global configuration command to include a comment about an access list. To remove the remark, use the **no** form of this command.

For an entry in a named IP ACL, use the **remark** *access-list* global configuration command. To remove the remark, use the **no** form of this command.

Configuring a Numbered Standard ACL

Perform this task to create a numbered standard ACL.

Note When creating an ACL, remember that, by default, the end of the ACL contains an implicit deny statement for all packets that it did not find a match for before reaching the end. With standard access lists, if you omit the ask from an associated IP host address ACL specification, 0.0.0.0 is assumed to be the mask.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **access-list** *access-list-number* {**deny** | **permit** | **remark**} {*source source-wildcard* | **host** *source* | **any**}

4. **exit**
5. **show access-lists** [*number* | *name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**access-list** *access-list-number* {**deny** | **permit** | **remark**} {*source source-wildcard* | **host** *source* | **any**} **Example:** `Router(config)# access-list 2 deny host 172.17.198.102`	Defines a standard IP ACL by using a source address and wildcard. • The *access-list-number* is a decimal number from 1 to 99 or 1300 to 1999. • Enter the **deny** or **permit** keywords to specify whether to deny or permit access if conditions are matched. • The *source* is the source address of the network or host from which the packet is being sent, and is a 32-bit number in dotted-decimal format. • The *source-wildcard* applies wildcard bits to the source address. • The keyword **host** as an abbreviation for source and source-wildcard of *source* 0.0.0.0. • The keyword **any** as an abbreviation for *source* and *source-wildcard* of 0.0.0.0 255.255.255.255. You do not need to enter a source-wildcard.
Step 4	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.
Step 5	**show access-lists** [*number* | *name*] **Example:** `Router# show access-lists`	Displays access list configuration information.

Configuring a Numbered Extended ACL

Perform this task to create a numbered extended ACL.

Extended ACLs

Although standard ACLs use only source addresses for matching, you can use an extended ACL source and destination addresses for matching operations and optional protocol type information for finer granularity of control. Some protocols also have specific parameters and keywords that apply to that protocol.

These IP protocols are supported (protocol keywords are in parentheses in bold): Internet Protocol (**ip**), Transmission Control Protocol (**tcp**), or User Datagram Protocol (**udp**).

Supported parameters can be grouped into these categories:

- TCP
- UDP

Table 12 lists the possible filtering parameters for ACEs for each protocol type.

Table 12 Filtering Parameter ACEs Supported by Different IP Protocols

Filtering Parameter	TCP	UDP
Layer 3 Parameters:		
IP ToS byte[1]	No	No
Differentiated Services Code Point (DSCP)	No	No
IP source address	Yes	Yes
IP destination address	Yes	Yes
Fragments	No	No
TCP or UDP	Yes	Yes
Layer 4 Parameters		
Source port operator	Yes	Yes
Source port	Yes	Yes
Destination port operator	Yes	Yes
Destination port	Yes	Yes
TCP flag	No	No

1. No support for type of service (TOS) minimize monetary cost bit.

For more details on the specific keywords relative to each protocol, refer to the *Cisco IP Command Reference* for Cisco IOS Release 12.3 T.

Note The EtherSwitch network module does not support dynamic or reflexive access lists. It also does not support filtering based on the minimize-monetary-cost type of service (TOS) bit.

When creating ACEs in numbered extended access lists, remember that after you create the list, any additions are placed at the end of the list. You cannot reorder the list or selectively add or remove ACEs from a numbered list.

Use the **no access-list** *access-list-number* global configuration command to delete the entire access list. You cannot delete individual ACEs from numbered access lists.

After an ACL is created, any additions (possibly entered from the terminal) are placed at the end of the list. You can add ACEs to an ACL, but deleting any ACE deletes the entire ACL.

Note When creating an ACL, remember that, by default, the end of the access list contains an implicit deny statement for all packets if it did not find a match before reaching the end.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **access-list** *access-list-number* {**deny** | **permit** | **remark**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*]
4. **exit**
5. **show access-lists** [*number* | *name*]

DETAILED STEPS

	Command or Action	Purpose

Step 1	`enable`
	
	Example:
	`Router> enable`
		Enables privileged EXEC mode.
		• Enter your password if prompted.

Step 2	`configure terminal`
	
	Example:
	`Router# configure terminal`
		Enters global configuration mode.

	Command or Action	Purpose
Step 3	**access-list** *access-list-number* {**deny** | **permit** | **remark**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*] **Example:** `Router(config)# access-list 102 deny tcp 172.17.69.0 0.0.0.255 172.20.52.0 0.0.0.255 eq telnet`	Defines an extended IP access list and the access conditions. • The *access-list-number* is a decimal number from 100 to 199 or 2000 to 2699. • Enter the **deny** or **permit** keywords to specify whether to deny or permit access if conditions are matched. • For *protocol*, enter the name or number of an IP protocol: **ip**, **tcp**, or **udp**. To match any Internet protocol (including TCP and UDP), use the keyword **ip**. • The *source* is the source address of the network or host from which the packet is being sent, and is a 32-bit number in dotted-decimal format. • The *source-wildcard* applies wildcard bits to the source address. • The keyword **host** as an abbreviation for source and source-wildcard of *source* 0.0.0.0. • The keyword **any** as an abbreviation for *source* and *source-wildcard* of 0.0.0.0 255.255.255.255. You do not need to enter a source-wildcard. • The *operator* defines a destination or source port and can be only **eq** (equal). • If operator is after *source source-wildcard*, conditions match when the source port matches the defined port. • If operator is after *destination destination-wildcard*, conditions match when the destination port matches the defined port. • The *port* is a decimal number or name of a TCP or UDP port. The number can be from 0 to 65535. • Use TCP port names only for TCP traffic. • Use UDP port names only for UDP traffic. **Note** Only the **ip**, **tcp**, and **udp** protocols are supported on Ethernet switch interfaces. • The *destination* is the address of the network or host to which the packet is being sent, and is a 32-bit number in dotted-decimal format. • The *destination-wildcard* applies wildcard bits to the destination address. • The keyword **host** as an abbreviation for *destination* and *destination-wildcard* of *destination* 0.0.0.0. • The keyword **any** as an abbreviation for *destination* and *destination-wildcard* of 0.0.0.0 255.255.255.255.

	Command or Action	Purpose
Step 4	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.
Step 5	**show access-lists** [*number* | *name*] **Example:** `Router# show access-lists`	Displays access list configuration information.

What to Do Next

After creating an ACL, you must apply it to an interface, as described in the "Applying the ACL to an Interface" section on page 113.

Configuring a Named Standard ACL

Perform this task to create a named standard ACL.

Named Standard ACL Creation

You can identify IP ACLs with an alphanumeric string (a name) rather than a number. You can use named ACLs to configure more IP access lists on a switch than if you use numbered access lists. If you identify your access list with a name rather than a number, the mode and command syntax are slightly different. However, not all commands that use IP access lists accept a named ACL.

Note The name you give to a standard ACL or extended ACL can also be a number in the supported range of access list numbers. That is, the name of a standard IP ACL can be 1 to 99; the name of an extended IP ACL can be 100 to 199. The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

Consider these guidelines and limitations before configuring named ACLs:

- A standard ACL and an extended ACL cannot have the same name.
- Numbered ACLs are also available, as described in the "Creating Standard and Extended IP ACLs" section on page 104.

Note When creating an ACL, remember that, by default, the end of the ACL contains an implicit deny statement for all packets that it did not find a match for before reaching the end. With standard access lists, if you omit the ask from an associated IP host address ACL specification, 0.0.0.0 is assumed to be the mask.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip access-list standard** {*access-list-number* | *name*}

4. **deny** {*source source-wildcard* | **host** *source* | **any**}
   or
   permit {*source source-wildcard* | **host** *source* | **any**}
5. **exit**
6. **show access-lists** [*number* | *name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip access-list standard** {*access-list-number* | *name*} **Example:** `Router(config)# ip access-list standard sales`	Defines a standard IP access list using a name and enters access-list configuration mode. • The *name* argument can be a decimal number from 1 to 99.

Step 4	**deny** {*source source-wildcard* | **host** *source* | **any**}
	or
	permit {*source source-wildcard* | **host** *source* | **any**}
	
	Example:
	`Router(config-acl# deny 10.2.1.3 any`
	
	Example:
	`Router(config-acl)# permit 10.2.1.4 any`
		Specifies one or more conditions denied or permitted to determine if the packet is forwarded or dropped.
		• **host** *source* represents a source and source wildcard of *source* 0.0.0.0.
		• **any** represents a source and source wildcard of 0.0.0.0 255.255.255.255.

Step 5	**exit** **Example:** `Router(config)# exit`	Exits access-list configuration mode and returns the router to global configuration mode. • Repeat this command to exit global configuration mode and return to privileged EXEC mode.
Step 6	**show access-lists** [*number* | *name*] **Example:** `Router# show access-lists sales`	Displays access list configuration information.

Configuring a Named Extended ACL

You can identify IP ACLs with an alphanumeric string (a name) rather than a number. You can use named ACLs to configure more IP access lists on a switch than if you use numbered access lists. If you identify your access list with a name rather than a number, the mode and command syntax are slightly different. However, not all commands that use IP access lists accept a named ACL.

Note The name you give to a standard ACL or extended ACL can also be a number in the supported range of access list numbers. That is, the name of a standard IP ACL can be 1 to 99; the name of an extended IP ACL can be 100 to 199. The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

Consider these guidelines and limitations before configuring named ACLs:

- A standard ACL and an extended ACL cannot have the same name.
- Numbered ACLs are also available, as described in the "Creating Standard and Extended IP ACLs" section on page 104.

Note When creating an ACL, remember that, by default, the end of the ACL contains an implicit deny statement for all packets that it did not find a match for before reaching the end. With standard access lists, if you omit the ask from an associated IP host address ACL specification, 0.0.0.0 is assumed to be the mask.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip access-list extended** {*access-list-number* | *name*}
4. **deny** *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*]
   or
   permit {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*]
5. **exit**
6. **show access-lists** [*number* | *name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip access-list extended** {*access-list-number* | *name*} **Example:** `Router(config)# ip access-list extended marketing`	Defines an extended IP access list using a name and enters access-list configuration mode. • The *name* argument can be a decimal number from 100 to 199.

Step 4	**deny** {*source source-wildcard* | **host** *source* | **any**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*]
	or
	permit {*source source-wildcard* | **host** *source* | **any**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*]
	
	Example:
	`Router(config-acl# deny tcp any any`
	
	or
	
	`Router(config-acl)# permit tcp 10.2.1.4 0.0.0.255 eq telnet`
		Specifies one or more conditions denied or permitted to determine if the packet is forwarded or dropped.
		See the "Configuring a Numbered Extended ACL" section on page 107 for definitions of protocols and other keywords.
		• **host** *source* represents a source and source wildcard of *source* 0.0.0.0, and **host** *destination* represents a destination and destination wildcard of *destination* 0.0.0.0.
		• **any** represents a source and source wildcard or destination and destination wildcard of 0.0.0.0 255.255.255.255.

Step 5	**exit** **Example:** `Router(config-acl)# exit`	Exits access-list configuration mode and returns the router to global configuration mode. • Repeat this command to exit global configuration mode and return to privileged EXEC mode.
Step 6	**show access-lists** [*number* | *name*] **Example:** `Router# show access-lists marketing`	Displays access list configuration information.

Applying the ACL to an Interface

Perform this task to control access to a Layer 2 or Layer 3 interface. After you create an ACL, you can apply it to one or more interfaces. ACLs can be applied on inbound interfaces. This section describes how to accomplish this task for network interfaces. Note these guidelines:

- When controlling access to a line, you must use a number. Numbered ACLs can be applied to lines.
- When controlling access to an interface, you can use a name or number.

Note The **ip access-group** interface configuration command is only valid when applied to a Layer 2 interface or a Layer 3 interface. If applied to a Layer 3 interface, the interface must have been configured with an IP address. ACLs cannot be applied to interface port-channels.

For inbound ACLs, after receiving a packet, the switch checks the packet against the ACL. If the ACL permits the packet, the switch continues to process the packet. If the ACL rejects the packet, the switch discards the packet.

When you apply an undefined ACL to an interface, the switch acts as if the ACL has not been applied to the interface and permits all packets. Remember this behavior if you use undefined ACLs for network security.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port*
4. **ip access-group** {*access-list-number* | *name*} **in**
5. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port* **Example:** `Router(config)# interface gigabitethernet 0/3`	Specifies the Ethernet interface to which the ACL will be applied and enters interface configuration mode. • The interface must be a Layer 2 interface or a routed port.

	Command or Action	Purpose
Step 4	**ip access-group** {*access-list-number* | *name*} **in** **Example:** `Router(config)# ip access-group sales in`	Controls access to the specified interface.
Step 5	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this step one more time to exit global configuration mode.

Configuring Quality of Service (QoS) on the EtherSwitch network module

This section consists of the following tasks that must be performed to configure QoS on your EtherSwitch network module:

- Configuring Classification Using Port Trust States, page 117
- Configuring a QoS Policy, page 119

Prerequisites

Before configuring QoS, you must have a thorough understanding of the following items:

- The types of applications used and the traffic patterns on your network.
- Traffic characteristics and needs of your network. Is the traffic bursty? Do you need to reserve bandwidth for voice and video streams?
- Bandwidth requirements and speed of the network.
- Location of congestion points in the network.

Restrictions

- If you have EtherChannel ports configured on your switch, you must configure QoS classification, policing, mapping, and queueing on the individual physical ports that comprise the EtherChannel. You must decide whether the QoS configuration should match on all ports in the EtherChannel.
- It is not possible to match IP fragments against configured IP extended ACLs to enforce QoS. IP fragments are transmitted as best-effort. IP fragments are denoted by fields in the IP header.
- Control traffic (such as spanning-tree Bridge Protocol Data Units (BPDUs) and routing update packets) received by the switch are subject to all ingress QoS processing.
- Only one ACL per class map and only one **match** command per class map are supported. The ACL can have multiple access control entries, which are commands that match fields against the contents of the packet.
- Policy maps with ACL classification in the egress direction are not supported and cannot be attached to an interface by using the **service-policy input** *policy-map-name* interface configuration command.
- In a policy map, the class named class-default is not supported. The switch does not filter traffic based on the policy map defined by the **class class-default** policy-map configuration command.

For more information on guidelines for configuring ACLs, see the "Classification Based on QoS ACLs" section on page 40.

QoS on Switching Devices

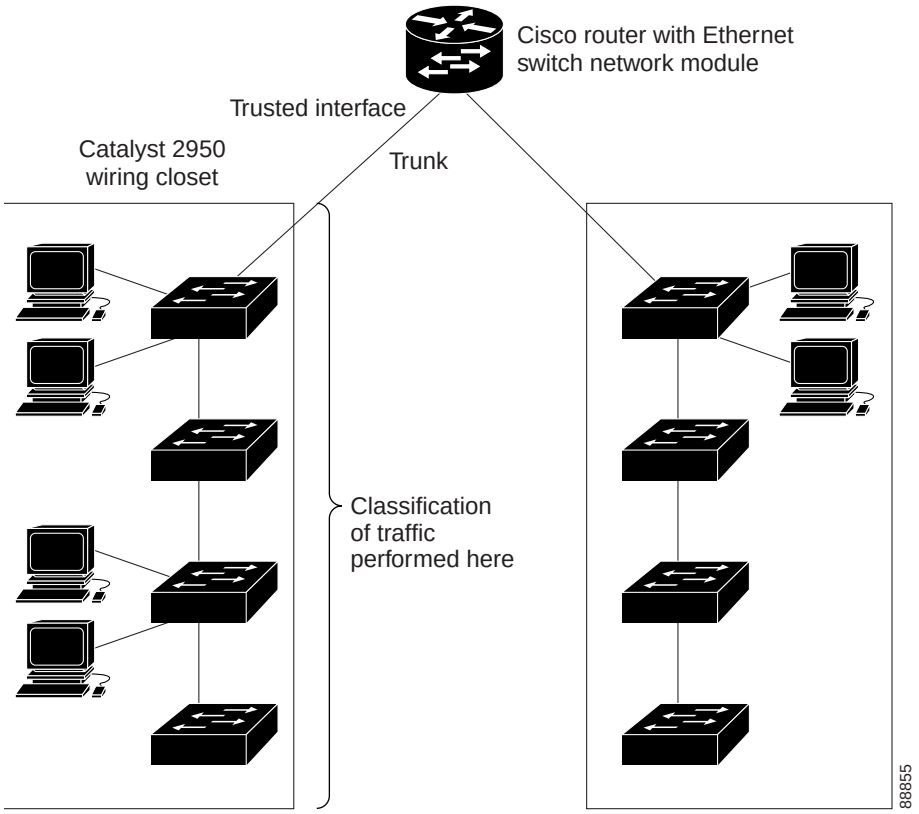
Default Settings

- The default port CoS value is 0.
- The default port trust state is untrusted.
- No policy maps are configured.
- No policers are configured.
- The default CoS-to-DSCP map is shown in Table 13 on page 124.
- The default DSCP-to-CoS map is shown in Table 14 on page 125.

Trust State on Ports and SVIs Within the QoS Domain

Packets entering a QoS domain are classified at the edge of the QoS domain. When the packets are classified at the edge, the switch port within the QoS domain can be configured to one of the trusted states because there is no need to classify the packets at every switch within the QoS domain. Figure 20 shows a sample network topology.

Figure 20 Port Trusted States within the QoS Domain



Configuring Classification Using Port Trust States

Perform this task to configure the port to trust the classification of the traffic that it receives, and then define the default CoS value of a port or to assign the default Cos to all incoming packets on the port.

Note The **mls qos cos** command replaced the **switchport priority** command in Cisco IOS Release 12.1(6)EA2.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port*
4. **mls qos trust** {**cos** | **dscp**}
5. **mls qos cos** {*default-cos* | **override**}
6. **exit**
7. **show mls qos interface** [*interface-type slot*/*port*] [**policers**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port* **Example:** `Router(config)# interface fastethernet 0/1`	Selects the Ethernet interface to be trusted and enters interface configuration mode. • Valid interfaces include physical interfaces and SVIs.

	Command or Action	Purpose
Step 4	**mls qos trust** {**cos** | **dscp**} **Example:** `Router(config-if)# mls qos trust cos`	Configures the port trust state. • By default, the port is not trusted. • Use the **cos** keyword setting if your network is composed of Ethernet LANs, Catalyst 2950 switches, and has no more than two types of traffic. • Use the **cos** keyword if you want ingress packets to be classified with the packet CoS values. For tagged IP packets, the DSCP value of the packet is modified based on the CoS-to-DSCP map. The egress queue assigned to the packet is based on the packet CoS value. • Use the **dscp** keyword if your network is not composed of only Ethernet LANs and if you are familiar with sophisticated QoS features and implementations. • Use the **dscp** keyword if you want ingress packets to be classified with packet DSCP values. For non-IP packets, the packet CoS value is used for tagged packets; the default port CoS is used for untagged packets. Internally, the switch modifies the CoS value by using the DSCP-to-CoS map. • Use the **dscp** keyword if you are using an SVI that is a VLAN interface that you created by using the **interface vlan** *vlan-id* global configuration command. The DCSP-to-CoS map will be applied to packets arriving from a router to the EtherSwitch network module through an SVI.
Step 5	**mls qos cos** {*default-cos* | **override**} **Example:** `Router(config-if)# mls qos cos 5`	Configures the default CoS value for the port. • Use the *default-cos* argument to specify a default CoS value to be assigned to a port. If the port is CoS trusted and packets are untagged, the default CoS value becomes the CoS value for the packet. The CoS range is 0 to 7. The default is 0. • Use the **override** keyword to override the previously configured trust state of the incoming packets and to apply the default port CoS value to all incoming packets. By default, CoS override is disabled. • Use the **override** keyword when all incoming packets on certain ports deserve higher priority than packets entering from other ports. Even if a port was previously set to trust DSCP, this command overrides the previously configured trust state, and all the incoming CoS values are assigned the default CoS value configured with this command. If an incoming packet is tagged, the CoS value of the packet is modified with the default CoS of the port at the ingress port.

	Command or Action	Purpose
Step 6	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode and returns the router to global configuration mode. • Repeat this step one more time to exit global configuration mode.
Step 7	**show mls qos interface** [*interface-type slot/port*] [**policers**] **Example:** `Router# show mls qos interface fastethernet 0/1`	(Optional) Displays information about Fast Ethernet interfaces.

Examples

The following is sample output from the **show mls qos interface fastethernet0/1** command:

```
Router# show mls qos interface fastethernet 0/1

FastEthernet0/1
trust state: trust cos
COS override: dis
default COS: 0
```

Configuring a QoS Policy

This section contains the following tasks:

- Classifying Traffic by Using ACLs, page 119
- Classifying Traffic Using Class Maps, page 119
- Classifying, Policing, and Marking Traffic Using Policy Maps, page 121

Configuring a QoS policy typically requires classifying traffic into classes, configuring policies applied to those traffic classes, and attaching policies to interfaces.

For background information, see the "Classification" section on page 40 and the "Policing and Marking" section on page 41.

Classifying Traffic by Using ACLs

You can classify IP traffic by using IP standard or IP extended ACLs. To create an IP standard ACL for IP traffic, refer to the "Configuring a Numbered Standard ACL" section on page 105 and to create an IP extended ACL for IP traffic refer to the "Configuring a Numbered Extended ACL" section on page 107.

Classifying Traffic Using Class Maps

Perform this task to create a class map and to define the match criteria for classifying traffic. You use the **class-map** global configuration command to isolate a specific traffic flow (or class) from all other traffic and to name it. The class map defines the criteria to use to match against a specific traffic flow to further classify it. Match statements can include criteria such as an ACL. The match criterion is defined with one match statement entered within the class-map configuration mode.

Note You can also create class maps during policy map creation by using the **class** policy-map configuration command. For more information, see the "Classifying, Policing, and Marking Traffic Using Policy Maps" section on page 121.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **access-list** *access-list-number* {**deny** | **permit** | **remark**} {*source source-wildcard* | **host** *source* | **any**}
   or
   access-list *access-list-number* {**deny** | **permit** | **remark**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator-port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator-port*]
4. **class-map** *class-map-name*
5. **match access-group** *acl-index-or-name*
6. **exit**
7. **show class-map** [*class-map-name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**access-list** *access-list-number* {**deny** | **permit** | **remark**} {*source source-wildcard* | **host** *source* | **any**} or **access-list** *access-list-number* {**deny** | **permit** | **remark**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*] **Example:** `Router(config)# access-list 103 permit any any tcp eq 80`	Creates an IP standard or extended ACL for IP traffic. • Repeat this command as many times as necessary. • For more information, see the "Configuring a Numbered Standard ACL" section on page 105 and the "Configuring a Numbered Extended ACL" section on page 107. • Deny statements are not supported for QoS ACLS. See the "Classification Based on QoS ACLs" section on page 40 for more details.

	Command or Action	Purpose
Step 4	**class-map** *class-map-name* **Example:** `Router(config)# class-map class1`	Creates a class map, and enters class-map configuration mode. • By default, no class maps are defined. • Use the *class-map-name* argument to specify the name of the class map.
Step 5	**match access-group** *acl-index-or-name* **Example:** `Router(config-cmap)# match access-group 103`	Defines the match criteria to classify traffic. • By default, no match criteria is supported. • Only one match criteria per class map is supported, and only one ACL per class map is supported. • Use the *acl-index-or-name* argument to specify the number or name of the ACL created in Step 3.
Step 6	**exit** **Example:** `Router(config-cmap)# exit`	Exits class map configuration mode and returns the router to global configuration mode. • Repeat this step one more time to exit global configuration mode.
Step 7	**show class-map** [*class-map-name*] **Example:** `Router# show class-map class1`	(Optional) Displays class maps and their matching criteria.

Classifying, Policing, and Marking Traffic Using Policy Maps

Perform this task to create a policy map. A policy map specifies which traffic class to act on. Actions can include trusting the CoS or DSCP values in the traffic class; setting a specific DSCP value in the traffic class; and specifying the traffic bandwidth limitations for each matched traffic class (policer) and the action to take when the traffic is out of profile (marking).

A separate policy-map class can exist for each type of traffic received through an interface. You can attach only one policy map per interface in the input direction.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **access-list** *access-list-number* {**deny** | **permit** | **remark**} {*source source-wildcard* | **host** *source* | **any**}
   or
   access-list *access-list-number* {**deny** | **permit** | **remark**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator-port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator-port*]
4. **policy-map** *policy-map-name*
5. **class** *class-map-name* [**access-group** *acl-index-or-name*]
6. **police** {*bps* | **cir** *bps*} [*burst-byte* | **bc** *burst-byte*] **conform-action transmit** [**exceed-action** {**drop** | **dscp** *dscp-value*}]
7. **exit**

8. **interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot/port*
9. **service-policy input** *policy-map-name*
10. **exit**
11. **show policy-map** *policy-map-name* **class** *class-name*

DETAILED STEPS

	Command or Action	Purpose

Step 1	`enable`
	
	Example:
	`Router> enable`
		Enables privileged EXEC mode.
		• Enter your password if prompted.

Step 2	`configure terminal`
	
	Example:
	`Router# configure terminal`
		Enters global configuration mode.

Step 3	**access-list** *access-list-number* {**deny** | **permit** | **remark**} {*source source-wildcard* | **host** *source* | **any**} or **access-list** *access-list-number* {**deny** | **permit** | **remark**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*] **Example:** `Router(config)# access-list 1 permit 10.1.0.0 0.0.255.255`	Creates an IP standard or extended ACL for IP traffic. • Repeat this command as many times as necessary. • For more information, see the "Configuring a Numbered Standard ACL" section on page 105 and the "Configuring a Numbered Extended ACL" section on page 107. **Note** Deny statements are not supported for QoS ACLS. See the "Classification Based on QoS ACLs" section on page 40 for more details.
Step 4	**policy-map** *policy-map-name* **Example:** `Router(config)# policy-map flow1t`	Creates a policy map by entering the policy map name, and enters policy-map configuration mode. • By default, no policy maps are defined. • The default behavior of a policy map is to set the DSCP to 0 if the packet is an IP packet and to set the CoS to 0 if the packet is tagged. No policing is performed.

	Command or Action	Purpose
Step 5	**class** {*class-map-name* | **class-default**} [**access-group** *acl-index-or-name*] **Example:** `Router(config-pmap)# class ipclass1`	Defines a traffic classification, and enters policy-map class configuration mode. • By default, no policy map class maps are defined. • If a traffic class has already been defined by using the **class-map** global configuration command, specify its name for *class-map-name* in this command. • For **access-group** *acl-index-or-name*, specify the number or name of the ACL created in Step 3. • In a policy map for the EtherSwitch network module, the class named **class-default** is not supported. The switch does not filter traffic based on the policy map defined by the **class class-default** policy-map configuration command.
Step 6	**police** {*bps* | **cir** *bps*} [*burst-byte* | **bc** *burst-byte*] **conform-action transmit** [**exceed-action** {**drop** | **dscp** *dscp-value*}] **Example:** `Router(config-pmap)# police 5000000 8192 conform-action transmit exceed-action dscp 10`	Defines a policer for the classified traffic. • You can configure up to 60 policers on ingress Gigabit-capable Ethernet ports and up to 6 policers on ingress 10/100 Ethernet ports. • For *bps*, specify average traffic rate or committed information rate in bits per second (bps). The range is 1 Mbps to 100 Mbps for 10/100 Ethernet ports and 8 Mbps to 1000 Mbps for the Gigabit-capable Ethernet ports. • For *burst-byte*, specify the normal burst size or burst count in bytes. • (Optional) Specify the action to take when the rates are exceeded. Use the **exceed-action drop** keywords to drop the packet. Use the **exceed-action dscp** *dscp-value* keywords to mark down the DSCP value and transmit the packet.
Step 7	**exit** **Example:** `Router(config-pmap)# exit`	Exits policy map configuration mode and returns the router to global configuration mode.
Step 8	**interface** {**ethernet** | **fastethernet** | **gigabitethernet**} *slot*/*port* **Example:** `Router(config)# interface fastethernet 5/6`	Enters interface configuration mode, and specifies the interface to attach to the policy map. • Valid interfaces include physical interfaces.
Step 9	**service-policy input** *policy-map-name* **Example:** `Router(config-if)# service-policy input flow1t`	Applies a policy map to the input of a particular interface. • Only one policy map per interface per direction is supported. • Use **input** *policy-map-name* to apply the specified policy map to the input of an interface.

	Command or Action	Purpose

Step 10	`exit`
	
	Example:
	`Router(config-class-map)# exit`
		Exits class map configuration mode and returns the router to global configuration mode.
		• Repeat this step one more time to exit global configuration mode.

Step 11	**show policy-map** *policy-map-name* **class** *class-map-name* **Example:** `Router# show policy-map flow1t class class1`	(Optional) Displays the configuration for the specified class of the specified policy map.

Configuring the CoS-to-DSCP Map

Perform this task to modify the CoS-to-DSCP map. You use the CoS-to-DSCP map to map CoS values in incoming packets to a DSCP value that QoS uses internally to represent the priority of the traffic.

Table 13 shows the default CoS-to-DSCP map.

Table 13 Default CoS-to-DSCP Map

CoS value	0	1	2	3	4	5	6	7
DSCP value	0	8	16	26	32	46	48	56

If these values are not appropriate for your network, you need to modify them. These CoS-to-DSCP mapping numbers follow the numbers used in deploying Cisco AVVID and may be different from the mapping numbers used by the EtherSwitch network module, Cisco Catalyst 2950, Cisco Catalyst 3550, and other switches.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mls qos map cos-dscp** *dscp1...dscp8*
4. **exit**
5. **show mls qos maps cos-dscp**

DETAILED STEPS

	Command or Action	Purpose

Step 1	`enable`
	
	Example:
	`Router> enable`
		Enables privileged EXEC mode.
		• Enter your password if prompted.

Step 2	`configure terminal`
	
	Example:
	`Router# configure terminal`
		Enters global configuration mode.

Step 3	`mls qos map cos-dscp` *dscp1...dscp8* **Example:** `Router(config)# mls qos map cos-dscp 8 8 8 8 24 32 56 56`	Modifies the CoS-to-DSCP map. • For *dscp1...dscp8*, enter eight DSCP values that correspond to CoS values 0 to 7. Separate each DSCP value with a space. • The supported DSCP values are 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56.

Step 4	`exit`
	
	Example:
	`Router(config)# exit`
		Exits global configuration mode and returns the router to privileged EXEC mode.

Step 5	`show mls qos maps cos-dscp`
	
	Example:
	`Router# show mls qos maps cos-dscp`
		(Optional) Displays the CoS-to-DSCP map.

Configuring the DSCP-to-CoS Map

Perform this task to modify the DSCP-to-CoS map. You use the DSCP-to-CoS map to map DSCP values in incoming packets to a CoS value, which is used to select one of the four egress queues. The EtherSwitch network modules support these DSCP values: 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56.

Table 14 shows the default DSCP-to-CoS map.

Table 14 Default DSCP-to-CoS Map

DSCP values	0	8, 10	16, 18	24, 26	32, 34	40, 46	48	56
CoS values	0	1	2	3	4	5	6	7

If these values are not appropriate for your network, you need to modify them. These DSCP-to-CoS mapping numbers follow the numbers used in deploying Cisco AVVID and may be different from the mapping numbers used by the EtherSwitch network module, Cisco Catalyst 2950, Cisco Catalyst 3550, and other switches.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mls qos map dscp-cos** *dscp-list* **to** *cos*
4. **exit**
5. **show mls qos maps dscp-to-cos**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mls qos map dscp-cos** *dscp-list* **to** *cos* *Example:* `Router(config)# mls qos map dscp-cos 26 48 to 7`	Modifies the DSCP-to-CoS map. • For *dscp-list*, enter up to 13 DSCP values separated by spaces. Then enter the **to** keyword. • For *cos*, enter the CoS value to which the DSCP values correspond. • The supported DSCP values are 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56. The CoS range is 0 to 7.
Step 4	**exit** **Example:** `Router(config)# exit`	Exits global configuration mode and returns the router to privileged EXEC mode.
Step 5	**show mls qos maps dscp-to-cos** **Example:** `Router# show mls qos maps dscp-to-cos`	(Optional) Displays the DSCP-to-CoS map.

Configuration Examples for the EtherSwitch Network Module

This section contains the following configuration examples:

Configuring VLANs: Example

The following example shows how to configure a VLAN:

```
Router# vlan database
Router(vlan)# vlan 2 media ethernet name vlan1502
VLAN 2 added:
Name: VLAN1502
Router(vlan)# exit
APPLY completed.
Exiting....
```

Configuring VTP: Example

The following example shows how to configure a VTP server, configure a VTP client, configure VTP version 2, and disable VTP mode on the router:

```
Router# vlan database
Router(vlan)# vtp server
Setting device to VTP SERVER mode.
Router(vlan)# vtp domain Lab_Network
Setting VTP domain name to Lab_Network
Router(vlan)# vtp password WATER
Setting device VLAN database password to WATER.
Router(vlan)# vtp client
Setting device to VTP CLIENT mode.
Router(vlan)# vtp v2-mode
V2 mode enabled.
Router(vlan)# vtp transparent
Setting device to VTP TRANSPARENT mode.
Router(vlan)# exit
APPLY completed.
Exiting....
```

Configuring Spanning Tree: Examples

The following example shows spanning tree being enabled on VLAN 200 and the bridge priority set to 33792. The hello time for VLAN 200 is set at 7 seconds, the forward delay time set at 21 seconds, and the maximum aging time at 36 seconds. BackboneFast is enable, the VLAN port priority of an interface is configured to be 64 and the spanning tree port cost of the Fast Ethernet interface 5/8 is set at 18.

```
Router# configure terminal
Router(config)# spanning-tree vlan 200
Router(config)# spanning-tree vlan 200 priority 33792
Router(config)# spanning-tree vlan 200 hello-time 7
Router(config)# spanning-tree vlan 200 forward-time 21
Router(config)# spanning-tree vlan 200 max-age 36
Router(config)# spanning-tree backbonefast
Router(config-if)# exit
Router(config)# interface fastethernet 5/8
Router(config-if)# spanning-tree vlan 200 port-priority 64
Router(config-if)# spanning-tree cost 18
Router(config-if)# exit
Router(config)# exit
```

The following example shows how to verify the configuration of VLAN 200 on the interface when it is configured as a trunk port:

```
Router# show spanning-tree vlan 200

Port 264 (FastEthernet5/8) of VLAN200 is forwarding
Port path cost 19, Port priority 64, Port Identifier 129.8.
   Designated root has priority 32768, address 0010.0d40.34c7
   Designated bridge has priority 32768, address 0010.0d40.34c7
   Designated port id is 128.1, designated path cost 0
   Timers: message age 2, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   BPDU: sent 0, received 13513
```

The following example shows how to verify the configuration of the interface when it is configured as an access port:

```
Router# show spanning-tree interface fastethernet 5/8

 Port 264 (FastEthernet5/8) of VLAN200 is forwarding
   Port path cost 18, Port priority 100, Port Identifier 129.8.
   Designated root has priority 32768, address 0010.0d40.34c7
   Designated bridge has priority 32768, address 0010.0d40.34c7
   Designated port id is 128.1, designated path cost 0
   Timers: message age 2, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   BPDU: sent 0, received 13513
```

The following example shows spanning tree being enabled on VLAN 150:

```
Router# configure terminal
Router(config)# spanning-tree vlan 150
Router(config)# end
Router#
```

Note Because spanning tree is enabled by default, issuing a **show running-config** command to view the resulting configuration will not display the command you entered to enable spanning tree.

The following example shows spanning tree being disabled on VLAN 200:

```
Router# configure terminal
Router(config)# no spanning-tree vlan 200
Router(config)# end
```

The following example shows the switch device being configured as the root bridge for VLAN 10, with a network diameter of 4:

```
Router# configure terminal
Router(config)# spanning-tree vlan 10 root primary diameter 4
Router(config)# exit
```

Configuring Layer 2 Interfaces: Examples

This section contains the following examples:

Single Range Configuration: Example

The following example shows all Fast Ethernet interfaces 5/1 to 5/5 being reenabled:

```
Router(config)# interface range fastethernet 5/1 - 5
Router(config-if)# no shutdown
Router(config-if)#
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet5/1, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet5/2, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet5/3, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet5/4, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet5/5, changed state to up
*Oct  6 08:24:36: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/5, changed
state to up
*Oct  6 08:24:36: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/3, changed
state to up
*Oct  6 08:24:36: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/4, changed
state to up
Router(config-if)#
```

Multiple Range Configuration: Example

The following example shows how to use a comma to add different interface type strings to the range to reenable all Fast Ethernet interfaces in the range 5/1 to 5/5 and both Gigabit Ethernet interfaces 1/1 and 1/2:

```
Router(config-if)# interface range fastethernet 5/1 - 5, gigabitethernet 1/1 - 2
Router(config-if)# no shutdown
Router(config-if)#
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface FastEthernet5/1, changed state to up
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface FastEthernet5/2, changed state to up
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface FastEthernet5/3, changed state to up
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface FastEthernet5/4, changed state to up
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface FastEthernet5/5, changed state to up
```

```
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface GigabitEthernet1/1, changed state to up
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface GigabitEthernet1/2, changed state to up
*Oct  6 08:29:29: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/5, changed
state to up
*Oct  6 08:29:29: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/3, changed
state to up
*Oct  6 08:29:29: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/4, changed
state to up
Router(config-if)#
```

Range Macro Definition: Example

The following example shows an interface-range macro named enet_list being defined to select Fast Ethernet interfaces 5/1 through 5/4:

```
Router(config)# define interface-range enet_list fastethernet 5/1 - 4

Router(config)#
```

The following example shows how to change to the interface-range configuration mode using the interface-range macro enet_list:

```
Router(config)# interface range macro enet_list

Router(config-if)#
```

Optional Interface Features: Example

The following example shows the interface speed being set to 100 Mbps on the Fast Ethernet interface 5/4, the interface duplex mode set to full, and a description being added for the interface:

```
Router(config)# interface fastethernet 5/4
Router(config-if)# speed 100
Router(config-if)# duplex full
Router(config-if)# description Channel-group to "Marketing"
```

Configuring an Ethernet Interface as a Layer 2 Trunk: Example

The following example shows how to configure the Fast Ethernet interface 5/8 as an 802.1Q trunk. This example assumes that the neighbor interface is configured to support 802.1Q trunking:

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# interface fastethernet 5/8
Router(config-if)# shutdown
Router(config-if)# switchport trunk encapsulation dot1q
Router(config-if)# switchport mode trunk
Router(config-if)# no shutdown
Router(config-if)# end
Router# exit
```

Configuring Voice and Data VLANs: Examples

This section contains the following examples:

Separate Voice and Data VLANs: Example

The following example shows separate VLANs being configured for voice and data on the EtherSwitch network module:

```
interface fastethernet5/1
 description DOT1Q port to IP Phone
 switchport native vlan 50
 switchport mode trunk
 switchport voice vlan 150

interface vlan 150
 description voice vlan
 ip address 10.150.1.1 255.255.255.0
 ip helper-address 172.20.73.14 (See Note below)

interface vlan 50
 description data vlan
 ip address 10.50.1.1 255.255.255.0
```

This configuration instructs the IP phone to generate a packet with an 802.1Q VLAN ID of 150 with an 802.1p value of 5 (default for voice bearer traffic).

Note In a centralized CallManager deployment model, the DHCP server might be located across the WAN link. If so, an **ip helper-address** command pointing to the DHCP server should be included on the voice VLAN interface for the IP phone. This is done to obtain its IP address as well as the address of the TFTP server required for its configuration.

Cisco IOS supports a DHCP server function. If this function is used, the EtherSwitch network module serves as a local DHCP server and a helper address would not be required.

Inter-VLAN Routing: Example

Configuring inter-VLAN routing is identical to the configuration on an EtherSwitch network module with an MSFC. Configuring an interface for WAN routing is consistent with other Cisco IOS platforms.

The following example provides a sample configuration:

```
interface vlan 160
 description voice vlan
 ip address 10.6.1.1 255.255.255.0

interface vlan 60
 description data vlan
 ip address 10.60.1.1 255.255.255.0

interface serial1/0
 ip address 172.16.1.2 255.255.255.0
```

Note Standard IGP routing protocols such as RIP, IGRP, EIGRP, and OSPF are supported on the EtherSwitch network module. Multicast routing is also supported for PIM dense mode, sparse mode, and sparse-dense mode.

Single Subnet Configuration: Example

The EtherSwitch network module supports the use of an 802.1p-only option when configuring the voice VLAN. Using this option allows the IP phone to tag VoIP packets with a CoS of 5 on the native VLAN, while all PC data traffic is sent untagged.

The following example shows a single subnet configuration for the EtherSwitch network module switch:

```
interface fastethernet 5/2
 description Port to IP Phone in single subnet
 switchport access vlan 40
 switchport voice vlan dot1p
 spanning-tree portfast
```

The EtherSwitch network module instructs the IP phone to generate an 802.1Q frame with a null VLAN ID value but with an 802.1p value (default is COS of 5 for bearer traffic). The voice and data VLANs are both 40 in this example.

Ethernet Ports on IP Phones with Multiple Ports: Example

The following example illustrates the configuration on the IP phone:

```
interface fastethernet 2/2
 switchport voice vlan 5
 switchport mode trunk
```

The following example illustrates the configuration on the PC:

```
interface fastethernet 2/3
 switchport access vlan 10
```

Note Using a separate VLAN, and possibly a separate IP address space, may not be an option for some small branch offices due to the IP routing configuration. If the IP routing can handle an additional VLAN at the remote branch, you can use Cisco Network Registrar and secondary addressing.

Configuring 802.1x Authentication: Examples

This section contains the following examples:

- Enabling 802.1x Authentication: Example, page 133
- Configuring the Switch-to-RADIUS-Server Communication: Example, page 133
- Configuring 802.1x Parameters: Example, page 133

Enabling 802.1x Authentication: Example

The following example shows how to enable AAA and 802.1x on Fast Ethernet port 0/1:

```
Router# configure terminal
Router(config)# aaa new-model
Router(config)# aaa authentication dot1x default group radius
Router(config)# interface fastethernet0/1
Router(config-if)# dot1x port-control auto
Router(config-if)# end
```

Configuring the Switch-to-RADIUS-Server Communication: Example

The following example shows how to specify the server with IP address 172.20.39.46 as the RADIUS server, to use port 1612 as the authorization port, and to set the encryption key to rad123, matching the key on the RADIUS server:

```
Router(config)# radius-server host 172.20.39.46 auth-port 1612 key rad123
```

Configuring 802.1x Parameters: Example

The following example shows how to enable periodic reauthentication, set the number of seconds between reauthentication attempts to 4000, and set the quiet time to 30 seconds on the EtherSwitch network module. The number of seconds to wait for an EAP-request/identity frame before transmitting is set to 60 seconds and the number of times the switch device will send the EAP-request/identity frames before restarting the authentication process is set to 5. 802.1x is enabled on Fast Ethernet interface 0/1 and multiple hosts are permitted.

```
Router(config)# dot1x re-authentication
Router(config)# dot1x timeout re-authperiod 4000
Router(config)# dot1x timeout quiet-period 30
Router(config)# dot1x timeout tx-period 60
Router(config)# dot1x max-req 5
Router(config)# interface fastethernet0/1
Router(config-if)# dot1x port-control auto
Router(config-if)# dot1x multiple-hosts
```

Configuring Storm-Control: Example

The following example shows global multicast suppression being enabled at 70 percent on Gigabit Ethernet interface 1 and the configuration being verified:

```
Router# configure terminal
Router(config)# interface gigabitethernet0/2
Router(config-if)# storm-control multicast level 70
Router(config-if)# end
Router# show storm-control

Name: Gi0/2
Switchport: Enabled
Administrative Mode: dynamic desirable
Operational Mode: down
Administrative Trunking Encapsulation: dot1q
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
```

```
Port Protected: Off
Unknown Unicast Traffic: Allowed
Unknown Multicast Traffic: Not Allowed

Broadcast Suppression Level: 100
Multicast Suppression Level: 70
Unicast Suppression Level: 100
```

Configuring Layer 2 EtherChannels: Example

Layer 2 EtherChannels: Example

The following example shows Fast Ethernet interfaces 5/6 and 5/7 being configured into port-channel 2 and forces the port to channel without Port Aggregation Protocol (PAgP). The EtherChannel is configured to use source and destination IP addresses.

```
Router# configure terminal
Router(config)# interface range fastethernet 5/6 - 7
Router(config-if)# channel-group 2 mode on
Router(config-if)# exit
Router(config)# port-channel load-balance src-dst-ip
```

Removing an EtherChannel: Example

The following example shows port-channel 1 being removed:

```
Router# configure terminal
Router(config)# no interface port-channel 1
Router(config)# end
```

Note Removing the port-channel also removes the channel-group command from the interfaces belonging to it.

Configuring Flow Control on Gigabit Ethernet Ports: Example

The following examples show how to turn transmit and receive flow control on and how to verify the flow-control configuration.

Port 4/0 flow control send administration status is set to on (port will send flowcontrol to far end):

```
Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# interface gigabitethernet4/0
Router(config-if)# flowcontrol send on
Router(config-if)# end
```

Port 4/0 flow control receive administration status is set to on (port will require far end to send flowcontrol):

```
Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# interface gigabitethernet4/0
Router(config-if)# flowcontrol receive on
Router(config-if)# end
```

The following example shows flow control configuration being verified:

```
Router# show interface gigabitethernet4/0
GigabitEthernet4/0 is up, line protocol is up
  Hardware is Gigabit Ethernet, address is 0087.c08b.4824 (bia
0087.c08b.4824)
  MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  output flow-control is off, input flow-control is on
  0 pause input, 0 pause output
  Full-duplex, 1000Mb/s
  ARP type:ARPA, ARP Timeout 04:00:00
  Last input 00:00:01, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue:0/75/0/0 (size/max/drops/flushes); Total output drops:0
  Queueing strategy:fifo
  Output queue:0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 1 packets/sec
     398301 packets input, 29528679 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     790904 packets output, 54653461 bytes, 0 underruns
     0 output errors, 0 collisions, 5 interface resets
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
```

The following example shows how to configure Gigabit Ethernet interface 0/10 as a routed port and to assign it an IP address:

```
Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# interface gigabitethernet0/10
Router(config-if)# no switchport
Router(config-if)# ip address 10.1.2.3 255.255.0.0
Router(config-if)# no shutdown
Router(config-if)# end
```

The following is sample output from the **show interfaces** privileged EXEC command for Gigabit Ethernet interface 0/2:

```
Router# show interfaces gigabitethernet0/2
GigabitEthernet0/2 is up, line protocol is up
  Hardware is Gigabit Ethernet, address is 0002.4b29.4400 (bia 0002.4b29.4400)
  Internet address is 192.168.135.21/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full-duplex, 100Mb/s
  input flow-control is off, output flow-control is off
```

```
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:02, output 00:00:08, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     89604 packets input, 8480109 bytes, 0 no buffer
     Received 81848 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     60665 packets output, 6029820 bytes, 0 underruns
     0 output errors, 0 collisions, 16 interface resets
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
```

The following is sample output from the **show ip interface** privileged EXEC command for Gigabit Ethernet interface 0/2:

```
Router# show ip interface gigabitethernet0/2
GigabitEthernet0/2 is up, line protocol is up
  Internet address is 192.168.135.21/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Multicast reserved groups joined: 224.0.0.5 224.0.0.6
  Outgoing access list is not set
  Inbound  access list is not set
  Proxy ARP is enabled
  Local Proxy ARP is disabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachables are always sent
  ICMP mask replies are never sent
  IP fast switching is enabled
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
  IP CEF switching is enabled
  IP CEF Fast switching turbo vector
  IP multicast fast switching is enabled
  IP multicast distributed fast switching is disabled
  IP route-cache flags are Fast, CEF
  Router Discovery is disabled
  IP output packet accounting is disabled
  IP access violation accounting is disabled
  TCP/IP header compression is disabled
RTP/IP header compression is disabled
  Probe proxy name replies are disabled
  Policy routing is disabled
  Network address translation is disabled
  WCCP Redirect outbound is disabled
  WCCP Redirect exclude is disabled
  BGP Policy Mapping is disabled
```

The following is sample output from the **show running-config** privileged EXEC command for Gigabit Ethernet interface 0/2:

```
Router# show running-config interface gigabitethernet0/2
Building configuration...

Current configuration : 122 bytes
!
interface GigabitEthernet0/2
 no switchport
 ip address 192.168.135.21 255.255.255.0
 speed 100
 mls qos trust dscp
end
```

Intrachassis Stacking: Example

The following example shows how to stack GE port 2/0 to GE port 3/0 to form an extended VLAN within one chassis:

```
Router# config terminal
Router(config)# interface Gigabit 2/0
Router(config-if)# switchport stacking-link interface Gigabit3/0
```

The following example shows interchassis stacking being verified between GE port 2/0 and GE port 3/0:

```
Router# show interface gigabit 2/0

 GigabitEthernet2/0 is up, line protocol is down
   Internal Stacking Link Active : Gi2/0 is stacked with Gi3/0
   Hardware is Gigabit Ethernet, address is 001b.3f2b.2c24 (bia 001b.3f2b.2c24)
   MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec,
      reliability 255/255, txload 1/255, rxload 1/255
   Encapsulation ARPA, loopback not set
   Keepalive set (10 sec)
   Full-duplex mode, link type is force-up, media type is unknown 0
   output flow-control is off, input flow-control is off
   Full-duplex, 1000Mb/s
   ARP type: ARPA, ARP Timeout 04:00:00
   Last input 1d22h, output never, output hang never
   Last clearing of "show interface" counters 1d22h
   Queueing strategy: fifo
   Output queue 0/40, 0 drops; input queue 0/75, 0 drops
   5 minute input rate 0 bits/sec, 0 packets/sec
   5 minute output rate 0 bits/sec, 0 packets/sec
      250707 packets input, 19562597 bytes, 0 no buffer
      Received 7 broadcasts, 0 runts, 0 giants, 0 throttles
      0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
      0 watchdog, 0 multicast, 0 pause input
      0 input packets with dribble condition detected
      7469804 packets output, 582910831 bytes, 0 underruns(0/0/0)
      0 output errors, 0 collisions, 0 interface resets
      0 babbles, 0 late collision, 0 deferred
      0 lost carrier, 0 no carrier, 0 pause output
      0 output buffer failures, 0 output buffers swapped out
```

Configuring Switched Port Analyzer (SPAN): Example

The following example shows SPAN session 1 being configured to monitor bidirectional traffic from source interface Fast Ethernet 5/1. Fast Ethernet interface 5/48 is configured as the destination for SPAN session 1 and Fast Ethernet interface 5/2 is removed as a SPAN source for SPAN session 1.

```
Router(config)# monitor session 1 source interface fastethernet 5/1
Router(config)# monitor session 1 destination interface fastethernet 5/48
Router(config)# no monitor session 1 source interface fastethernet 5/2
```

Configuring Layer 3 Interfaces: Example

The following example shows how to configure Gigabit Ethernet interface 0/10 as a routed port and to assign it an IP address:

```
Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# interface gigabitethernet0/10
Router(config-if)# no switchport
Router(config-if)# ip address 10.1.2.3 255.255.0.0
Router(config-if)# no shutdown
Router(config-if)# end
```

The following is sample output from the **show interfaces** privileged EXEC command for Gigabit Ethernet interface 0/2:

```
Router# show interfaces gigabitethernet0/2

GigabitEthernet0/2 is up, line protocol is up
  Hardware is Gigabit Ethernet, address is 0002.4b29.4400 (bia 0002.4b29.4400)
  Internet address is 192.168.135.21/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full-duplex, 100Mb/s
  input flow-control is off, output flow-control is off
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:02, output 00:00:08, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     89604 packets input, 8480109 bytes, 0 no buffer
     Received 81848 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     60665 packets output, 6029820 bytes, 0 underruns
     0 output errors, 0 collisions, 16 interface resets
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
```

The following is sample output from the **show ip interface** privileged EXEC command for Gigabit Ethernet interface 0/2:

```
Router# show ip interface gigabitethernet0/2
GigabitEthernet0/2 is up, line protocol is up
  Internet address is 192.168.135.21/24
  Broadcast address is 255.255.255.255
```

```
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Multicast reserved groups joined: 224.0.0.5 224.0.0.6
  Outgoing access list is not set
  Inbound  access list is not set
  Proxy ARP is enabled
  Local Proxy ARP is disabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachables are always sent
  ICMP mask replies are never sent
  IP fast switching is enabled
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
  IP CEF switching is enabled
  IP CEF Fast switching turbo vector
  IP multicast fast switching is enabled
  IP multicast distributed fast switching is disabled
  IP route-cache flags are Fast, CEF
  Router Discovery is disabled
  IP output packet accounting is disabled
  IP access violation accounting is disabled
  TCP/IP header compression is disabled
  RTP/IP header compression is disabled
  Probe proxy name replies are disabled
  Policy routing is disabled
  Network address translation is disabled
  WCCP Redirect outbound is disabled
  WCCP Redirect exclude is disabled
  BGP Policy Mapping is disabled
```

The following is sample output from the **show running-config** privileged EXEC command for Gigabit Ethernet interface 0/2:

```
Router# show running-config interface gigabitethernet0/2
Building configuration...

Current configuration : 122 bytes
!
interface GigabitEthernet0/2
 no switchport
 ip address 192.168.135.21 255.255.255.0
 speed 100
 mls qos trust dscp
end
```

IGMP Snooping: Example

Default IGMP Snooping Configuration

IGMP snooping is enabled by default on a VLAN or subnet basis. Multicast routing has to be enabled on the router first and then PIM (Multicast routing protocol) has to be enabled on the VLAN interface so that the EtherSwitch network module acknowledges the IGMP join and leave messages that are sent from the hosts connected to the EtherSwitch network module.

```
Router(config)# ip multicast-routing
Router(config-if)# interface VLAN1
Router(config-if)# ip-address 192.168.10.1 255.255.255.0
Router(config-if)# ip pim sparse-mode
```

The following example shows the output from configuring IGMP snooping:

```
Router# show mac-address-table multicast igmp-snooping

Slot # :3
--------------
    MACADDR     VLANID     INTERFACES

0100.5e00.0001    1
0100.5e00.0002    1
0100.5e00.000d    1
0100.5e00.0016    1
0100.5e05.0505    1        Fa3/12
0100.5e06.0606    1        Fa3/13
0100.5e7f.ffff    1        Fa3/13
0100.5e00.0001    2
0100.5e00.0002    2
0100.5e00.000d    2
0100.5e00.0016    2
0100.5e00.0128    2
0100.5e05.0505    2        Fa3/10
0100.5e06.0606    2        Fa3/11
```

The following example shows output from the **show running-config interface** privileged EXEC command for VLAN 1:

```
Router# show running-config interface vlan 1

Building configuration...

Current configuration :82 bytes
!
interface Vlan1
 ip address 192.168.4.90 255.255.255.0
 ip pim sparse-mode
end
```

The following example shows output from the **show running-config interface** privileged EXEC command for VLAN 2:

```
Router# show running-config interface vlan 2

Building configuration...

Current configuration :82 bytes
!
interface Vlan2
 ip address 192.168.5.90 255.255.255.0
 ip pim sparse-mode
end
```

The following example shows output verifying multicasting support:

```
Router# show ip igmp group

IGMP Connected Group Membership
Group Address    Interface                Uptime    Expires   Last Reporter
239.255.255.255  Vlan1                    01:06:40  00:02:20  192.168.41.101
224.0.1.40       Vlan2                    01:07:50  00:02:17  192.168.5.90
224.5.5.5        Vlan1                    01:06:37  00:02:25  192.168.41.100
224.5.5.5        Vlan2                    01:07:40  00:02:21  192.168.31.100
224.6.6.6        Vlan1                    01:06:36  00:02:22  192.168.41.101
224.6.6.6        Vlan2                    01:06:39  00:02:20  192.168.31.101
```

The following example shows output from the multicast routing table:

```
Router# show ip mroute

IP Multicast Routing Table
Flags:D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C -
Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report
Outgoing interface flags:H - Hardware switched
Timers:Uptime/Expires
Interface state:Interface, Next-Hop or VCD, State/Mode

(*, 239.255.255.255), 01:06:43/00:02:17, RP 0.0.0.0, flags:DC
  Incoming interface:Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan1, Forward/Sparse, 01:06:43/00:02:17

(*, 224.0.1.40), 01:12:42/00:00:00, RP 0.0.0.0, flags:DCL
  Incoming interface:Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan2, Forward/Sparse, 01:07:53/00:02:14

(*, 224.5.5.5), 01:07:43/00:02:22, RP 0.0.0.0, flags:DC
  Incoming interface:Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan1, Forward/Sparse, 01:06:40/00:02:22
    Vlan2, Forward/Sparse, 01:07:44/00:02:17

(*, 224.6.6.6), 01:06:43/00:02:18, RP 0.0.0.0, flags:DC
  Incoming interface:Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan1, Forward/Sparse, 01:06:40/00:02:18
    Vlan2, Forward/Sparse, 01:06:43/00:02:16
```

Configuring Fallback Bridging: Examples

This section contains the following examples:

Creating a Bridge Group: Example

The following example shows how to create bridge group 10, specify the VLAN-bridge STP to run in the bridge group, and assign an interface to the bridge group. The switch device is prevented from forwarding frames for stations that it has dynamically learned in bridge group 10, and the bridge table aging time is set to 200 seconds. Frames with a MAC address of 0800.cb00.45e9 are forwarded through an interface in bridge group 1.

```
Router(config)# bridge 10 protocol vlan-bridge
Router(config)# interface gigabitethernet0/1
Router(config-if)# no switchport
```

```
Router(config-if)# bridge-group 10
Router(config-if)# exit
Router(config)# no bridge 10 acquire
Router(config)# bridge 10 aging-time 200
Router(config)# bridge 1 address 0800.cb00.45e9 forward gigabitethernet0/1
```

Adjusting Spanning Tree Parameters: Example

The following example shows how to set the switch priority to 100 for bridge group 10, how to change the priority of an interface to 20 in bridge group 10, and how to change the path cost on an interface to 20 in bridge group 10. In bridge group 10 the hello interval is changed to 5 seconds, the forward-delay interval is changed to 10 seconds, and the maximum-idle interval to 30 seconds.

```
Router(config)# bridge 10 priority 100
Router(config)# interface gigabitethernet0/1
Router(config-if)# bridge-group 10 priority 20
Router(config-if)# bridge-group 10 path-cost 20
Router(config)# bridge 10 hello-time 5
Router(config)# bridge 10 forward-time 10
Router(config)# bridge 10 max-age 30
```

Disabling the Spanning Tree on an Interface: Example

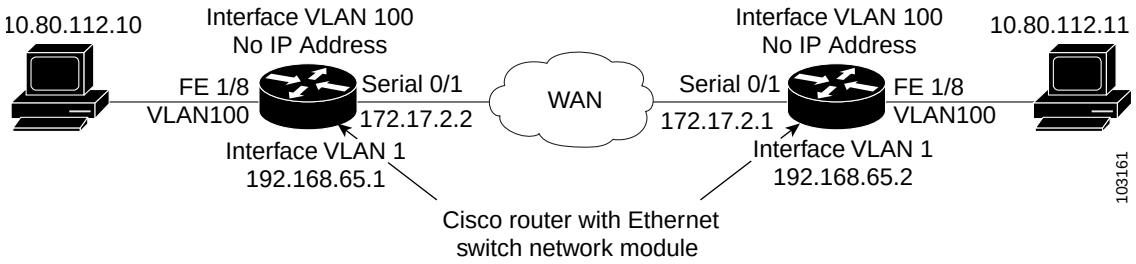
The following example shows how to disable spanning tree on an interface in bridge group 10:

```
Router(config)# interface gigabitethernet0/1
Router(config-if)# bridge group 10 spanning-disabled
```

Fallback Bridging with DLSW: Example

The following example shows how to configure fallback bridging with DLSW on the EtherSwitch network module. Using the network in Figure 21 this example shows how to bridge VLANs over routers. Normally VLANs terminate at a router. Note that both PCs are on the same subnet although they are actually separated by two routers. The fallback bridging creates a virtual bridge between the two PCs.

Figure 21 Fallback Bridging with DLSW Network Example



The following are partial configurations for Router A and Router B:

Router A

```
no spanning-tree vlan 1
no spanning-tree vlan 100
!
bridge irb
!
```

```
dlsw local-peer peer-id 192.168.65.1
dlsw remote-peer 0 tcp 192.168.66.1
dlsw bridge-group 1
!
interface FastEthernet1/8
 switchport access vlan 100
 no ip address
!
interface Vlan1
 ip address 192.168.65.1 255.255.255.0
!
interface Vlan100
 no ip address
 bridge-group 1
 bridge-group 1 spanning-disabled
!
bridge 1 protocol ieee
call rsvp-sync
```

Router B

```
no spanning-tree vlan 1
no spanning-tree vlan 100
!
bridge irb
!
dlsw local-peer peer-id 192.168.66.1
dlsw remote-peer 0 tcp 192.168.65.1
dlsw bridge-group 1
!
interface FastEthernet1/8
 switchport access vlan 100
 no ip address
interface Vlan1
 ip address 192.168.65.2 255.255.255.0
!
interface Vlan100
 no ip address
 bridge-group 1
 bridge-group 1 spanning-disabled
!
bridge 1 protocol ieee
call rsvp-sync
```

Configuring Network Security with ACLs at Layer 2: Examples

Creating Numbered Standard and Extended ACLs: Example

The following example shows how to create a standard ACL to deny access to IP host 172.16.198.102, permit access to any others, and display the results:

```
Switch (config)# access-list 2 deny host 172.16.198.102
Switch (config)# access-list 2 permit any
Router(config)# end
Router# show access-lists

Standard IP access list 2
    deny   171.69.198.102
    permit any
```

The following example shows that the switch accepts addresses on network 10.0.0.0 subnets and denies all packets coming from 10.1.0.0 subnets. The ACL is then applied to packets entering Gigabit Ethernet interface 0/1:

```
Router(config)# access-list 2 permit 10.0.0.0 0.255.255.255
Router(config)# access-list 2 deny 10.1.0.0 0.255.255.255
Router(config)# interface gigabitethernet0/1
Router(config-if)# ip access-group 2 in
```

The following example shows how to create and display an extended access list to deny Telnet access from any host in network 172.16.198.0 to any host in network 172.16.52.0 and permit any others (the **eq** keyword after the destination address means to test for the TCP destination port number equaling Telnet):

```
Router(config)# access-list 102 deny tcp 172.16.198.0 0.0.0.255 172.16.52.0 0.0.0.255 eq
telnet
Router(config)# access-list 102 permit tcp any any
Router(config)# end
Router# show access-lists

Extended IP access list 102
    deny tcp 172.16.198.0 0.0.0.255 172.16.52.0 0.0.0.255 eq telnet
    permit tcp any any
```

The following example shows an extended ACL with a network connected to the Internet and any host on the network being able to form TCP Telnet and SMTP connections to any host on the Internet:

```
Router(config)# access-list 102 permit tcp any 172.16.0.0 0.0.255.255 eq 23
Router(config)# access-list 102 permit tcp any 172.17.0.0 0.0.255.255 eq 25
Router(config)# interface gigabitethernet0/1
Router(config-if)# ip access-group 102 in
```

SMTP uses TCP port 25 on one end of the connection and a random port number on the other end. The same port numbers are used throughout the life of the connection. Mail packets coming in from the Internet have a destination port of 25. Because the secure system behind the switch always accepts mail connections on port 25, the incoming services are controlled.

Creating Named Standard and Extended ACLs: Example

The following example shows how you can delete individual ACEs from a named ACL:

```
Router(config)# ip access-list extended border-list
Router(config-ext-nacl)# no permit ip host 10.1.1.3 any
```

The following example shows the marketing_group ACL allowing any TCP Telnet traffic to the destination address and wildcard 172.16.0.0 0.0.255.255 and denying any other TCP traffic. It permits any other IP traffic:

```
Router(config)# ip access-list extended marketing_group
Router(config-ext-nacl)# permit tcp any 172.16.0.0 0.0.255.255 eq telnet
Router(config-ext-nacl)# deny tcp any any
Router(config-ext-nacl)# permit ip any any
```

The ACLs are applied to permit Gigabit Ethernet port 0/1, which is configured as a Layer 2 port, with the marketing_group ACL applied to incoming traffic.

```
Router(config)# interface gigabitethernet0/1
Router(config-if)# ip access-group marketing_group in
```

Including Comments About Entries in ACLs: Example

The following example shows an IP numbered standard ACL using the **access-list** *access-list number* **remark** *remark* global configuration command to include a comment about an access list. In this example, the workstation belonging to Jones is allowed access, and the workstation belonging to Smith is not allowed access:

```
Router(config)# access-list 1 remark Permit only Jones workstation through
Router(config)# access-list 1 permit 172.16.2.88
Router(config)# access-list 1 remark Do not allow Smith workstation through
Router(config)# access-list 1 deny 172.17.3.13
```

The following example shows an entry in a named IP ACL using the **remark** access-list global configuration command to include a comment about an access list. In this example, the Jones subnet is not allowed to use outbound Telnet:

```
Router(config)# ip access-list extended telnetting
Router(config-ext-nacl)# remark Do not allow Jones subnet to telnet out
Router(config-ext-nacl)# deny tcp host 172.16.2.88 any eq telnet
```

In this example of a numbered ACL, the workstation belonging to Jones is allowed access, and the workstation belonging to Smith is not allowed access:

```
Router(config)# access-list 1 remark Permit only Jones workstation through
Router(config)# access-list 1 permit 172.16.2.88
Router(config)# access-list 1 remark Do not allow Smith workstation through
Router(config)# access-list 1 deny 172.16.3.13
```

In this example of a numbered ACL, the Winter and Smith workstations are not allowed to browse the web:

```
Router(config)# access-list 100 remark Do not allow Winter to browse the web
Router(config)# access-list 100 deny host 172.16.3.85 any eq www
Router(config)# access-list 100 remark Do not allow Smith to browse the web
Router(config)# access-list 100 deny host 172.16.3.13 any eq www
```

Applying the ACL to an Interface: Example

The following example shows how to apply access list 2 on Gigabit Ethernet interface 0/3 to filter packets entering the interface:

```
Router(config)# interface gigabitethernet0/3
Router(config-if)# ip access-group 2 in
```

Displaying Standard and Extended ACLs: Example

The following example displays all standard and extended ACLs:

```
Router# show access-lists
Standard IP access list 1
    permit 172.20.10.10
Standard IP ACL 10
    permit 10.12.12.12
Standard IP access list 12
    deny   10.3.3.2
Standard IP access list 32
    permit 172.20.20.20
Standard IP access list 34
    permit 10.24.35.56
    permit 10.45.56.34
Extended IP access list 120
```

The following example displays only IP standard and extended ACLs:

```
Router# show ip access-lists
Standard IP access list 1
    permit 172.16.10.10
Standard IP access list 10
    permit 10.12.12.12
Standard IP access list 12
    deny   10.3.3.2
Standard IP access list 32
    permit 172.20.20.20
Standard IP access list 34
    permit 10.24.35.56
    permit 10.45.56.34
Extended IP access list 120
```

Displaying Access Groups: Example

You use the **ip access-group** interface configuration command to apply ACLs to a Layer 3 interface. When IP is enabled on an interface, you can use the **show ip interface** *interface-id* privileged EXEC command to view the input and output access lists on the interface, as well as other interface characteristics. If IP is not enabled on the interface, the access lists are not shown.

The following example shows how to view all access groups configured for VLAN 1 and for Gigabit Ethernet interface 0/2:

```
Router# show ip interface vlan 1
GigabitEthernet0/2 is up, line protocol is down
  Internet address is 10.20.30.1/16
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Outgoing access list is permit Any
  Inbound  access list is 13
.
.
.

Router# show ip interface fastethernet 0/9
FastEthernet0/9 is down, line protocol is down
  Inbound  access list is ip1
```

The only way to ensure that you can view all configured access groups under all circumstances is to use the **show running-config** privileged EXEC command. To display the ACL configuration of a single interface, use the **show running-config interface** *interface-id* command.

The following example shows how to display the ACL configuration of Gigabit Ethernet interface 0/1:

```
Router# show running-config interface gigabitethernet0/1
Building configuration...

Current configuration :112 bytes
!
interface GigabitEthernet0/1
 ip access-group 11 in
 snmp trap link-status
 no cdp enable
end
```

Compiling ACLs: Example

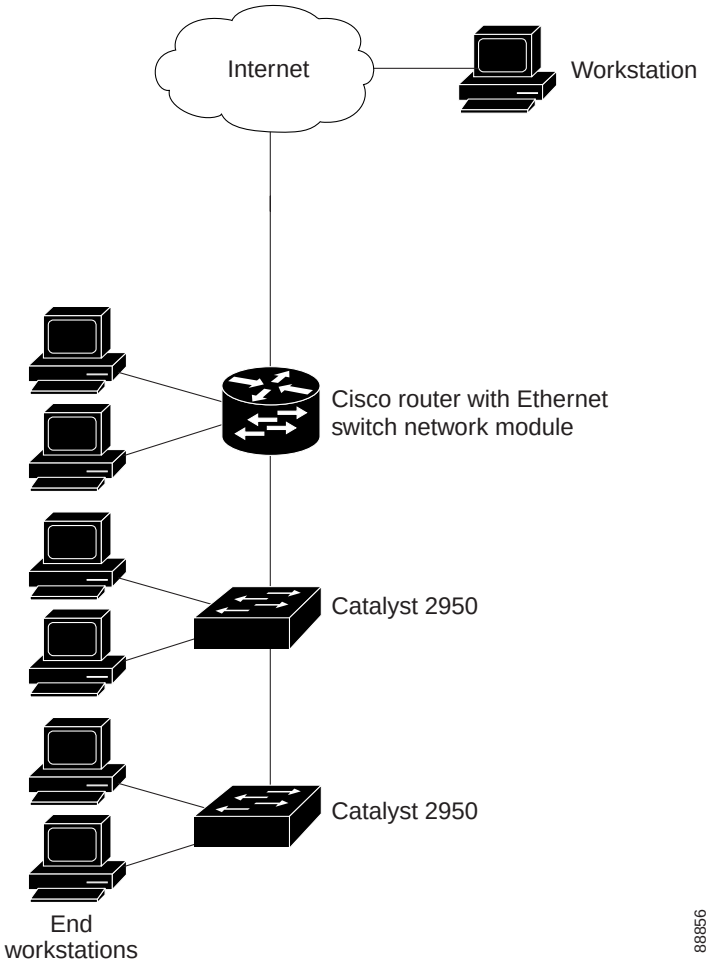
For detailed information about compiling ACLs, refer to the *Security Configuration Guide* and the "IP Services" chapter of the *Cisco IOS IP and IP Routing Configuration Guide.*

Figure 22 shows a small networked office with a stack of Catalyst 2950 switches that are connected to a Cisco router with an EtherSwitch network module installed. A host is connected to the network through the Internet using a WAN link.

Use switch ACLs to do these tasks:

- Create a standard ACL, and filter traffic from a specific Internet host with an address 172.20.128.64.
- Create an extended ACL, and filter traffic to deny HTTP access to all Internet hosts but allow all other types of access.

Figure 22 Using Switch ACLs to Control Traffic



The following example uses a standard ACL to allow access to a specific Internet host with the address 172.16.128.64:

```
Router(config)# access-list 6 permit 172.16.128.64 0.0.0.0
Router(config)# end
Router(config)# interface gigabitethernet0/1
Router(config-if)# ip access-group 6 in
```

The following example uses an extended ACL to deny traffic from port 80 (HTTP). It permits all other types of traffic:

```
Router(config)# access-list 106 deny tcp any any eq 80
Router(config)# access-list 106 permit ip any any
Router(config)# interface gigabitethernet0/2
Router(config-if)# ip access-group 106 in
```

Configuring QoS on the EtherSwitch network module: Examples

Classifying Traffic by Using ACLs: Example

The following example shows how to allow access for only those hosts on the two specified networks. The wildcard bits apply to the host portions of the network addresses. Any host with a source address that does not match the ACL statements is rejected.

```
Router(config)# access-list 1 permit 192.168.255.0 0.0.0.255
Router(config)# access-list 1 permit 10.0.0.0 0.0.0.255
```

Classifying Traffic by Using Class Maps: Example

The following example shows how to configure the class map called class1. The class1 has one match criterion, which is an ACL called 103.

```
Router(config)# access-list 103 permit any any tcp eq 80
Router(config)# class-map class1
Router(config-cmap)# match access-group 103
Router(config-cmap)# end
Router#
```

Classifying, Policing, and Marking Traffic by Using Policy Maps: Example

The following example shows how to create a policy map and attach it to an ingress interface. In the configuration, the IP standard ACL permits traffic from network 10.1.0.0. For traffic matching this classification, the DSCP value in the incoming packet is trusted. If the matched traffic exceeds an average traffic rate of 48000 bps and a normal burst size of 8000 bytes, its DSCP is marked down to a value of 10 and transmitted.

```
Router(config)# access-list 1 permit 10.1.0.0 0.0.255.255
Router(config)# class-map ipclass1
Router(config-cmap)# match access-group 1
Router(config-cmap)# exit
Router(config)# policy-map flow1t
Router(config-pmap)# class ipclass1
Router(config-pmap-c)# police 5000000 8192 exceed-action dscp 10
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface gigabitethernet0/1
Router(config-if)# switchport mode access
Router(config-if)# service-policy input flow1t
```

Configuring the CoS-to-DSCP Map: Example

The following example shows how to modify and display the CoS-to-DSCP map:

```
Router# configure terminal
Router(config)# mls qos map cos-dscp 8 8 8 8 24 32 56 56
Router(config)# end
Router# show mls qos maps cos-dscp

Cos-dscp map:
```

```
   cos:  0  1  2  3  4  5  6  7
-------------------------------
  dscp:  8  8  8  8 24 32 56 56
```

Configuring the DSCP-to-CoS Map: Example

The following example shows how the DSCP values 26 and 48 are mapped to CoS value 7. For the remaining DSCP values, the DSCP-to-CoS mapping is the default.

```
Router(config)# mls qos map dscp-cos 26 48 to 7
Router(config)# exit

Router# show mls qos maps dscp-cos

Dscp-cos map:
       dscp:  0  8 10 16 18 24 26 32 34 40 46 48 56
     ---------------------------------------------
        cos:  0  1  1  2  2  3  7  4  4  5  5  7  7
```

Displaying QoS Information: Example

The following example shows how to display the DSCP-to-CoS maps:

```
Router# show mls qos maps dscp-cos

Dscp-cos map:
       dscp:  0  8 10 16 18 24 26 32 34 40 46 48 56
     ---------------------------------------------
        cos:  0  1  1  2  2  3  3  4  4  5  5  6  7
```

Additional References

The following sections provide references related to the EtherSwitch network module.

Related Documents

Related Topic	Document Title
Quick Start Guide for the Cisco 2600 series	*Cisco 2600 Series Modular Routers Quick Start Guide*
Hardware installation for the Cisco 2600 series	*Cisco 2600 Series Hardware Installation Guide*
Quick Start Guide for the Cisco 3600 series	Quick start guides for Cisco 3600 series routers
Hardware installation for the Cisco 3600 series	*Cisco 3600 Series Hardware Installation Guide*
Quick Start Guide for the Cisco 3700 series	Quick start guides for Cisco 3700 series routers
Hardware installation for the Cisco 3700 series	Hardware installation documents for Cisco 3700 series routers
Information about configuring Voice over IP features	*Cisco IOS Voice, Video, and Fax Configuration Guide*
Voice over IP commands	*Cisco IOS Voice, Video, and Fax Command Reference,* Release 12.3 T
Information about Flow Control	*Configuring Gigabit Ethernet Switching*

Standards

Standards	Title
802.1d	*Spanning Tree Protocol*
802.1p	*Supplement to MAC Bridges: Traffic Class Expediting and Dynamic Multicast Filtering*
802.1q	*Virtual LAN (VLAN) Bridges*
802.1x	*Port Based Network Access Control*

MIBs

MIBs	MIBs Link
• IF MIB • CISCO-CDP-MIB • CISCO-CDP-MIB • CISCO-IMAGE-MIB • CISCO-FLASH-MIB • OLD-CISCO-CHASSIS-MIB • CISCO-VTP-MIB • CISCO-HSRP-MIB • OLD-CISCO-TS-MIB • CISCO-ENTITY-ASSET-MIB • CISCO-ENTITY-FRU-CONTROL-MIB • CISCO-ENTITY-ASSET-MIB • CISCO-VLAN-MEMBERSHIP-MIB • CISCO-VLAN-IFINDEX-RELATIONSHIP-MIB • RMON1-MIB • PIM-MIB • CISCO-STP-EXTENSIONS-MIB • IPMROUTE-MIB • CISCO-MEMORY-POOL-MIB • CISCO-RTTMON-MIB • CISCO-PROCESS-MIB • CISCO-COPS-CLIENT-MIB	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
RFC 1213	*Management Information Base for Network Management of TCP/IP-Based Internets, MIB-II*
RFC 1253	*OSPF Version 2 Management Information Base*
RFC 1493	*Definitions of Managed Objects for Bridges*
RFC 1643	*Definitions of Managed Objects for the Ethernet-Like Interface Types*
RFC 2037	*Entity MIB using SMIv2*
RFC 2284	*PPP Extensible Authentication Protocol (EAP)*

Technical Assistance

Description	Link
Technical Assistance Center (TAC) home page, containing 30,000 pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/public/support/tac/home.shtml

Command Reference

The following new and modified commands are pertinent to this feature. To see the command pages for these commands and other commands used with this feature, go to the *Cisco IOS Master Commands List*, Release 12.4, at http://www.cisco.com/univercd/cc/td/doc/product/software/ios124/124mindx/124index.htm.

- **aaa authentication dot1x**
- **class (EtherSwitch)**
- **debug dot1x (EtherSwitch)**
- **debug eswilp**
- **debug ip igmp snooping**
- **debug spanning-tree**
- **dot1x default**
- **dot1x max-req**
- **dot1x multiple-hosts**
- **dot1x port-control**
- **dot1x re-authenticate (EtherSwitch)**
- **dot1x re-authentication**
- **dot1x timeout (EtherSwitch)**
- **ip igmp snooping**
- **ip igmp snooping vlan**
- **ip igmp snooping vlan immediate-leave**
- **ip igmp snooping vlan mrouter**
- **ip igmp snooping vlan static**
- **mls qos cos**
- **mls qos map**
- **mls qos trust**
- **police (EtherSwitch)**
- **show dot1x (EtherSwitch)**
- **show ip igmp snooping**

- **show ip igmp snooping mrouter**
- **show mls masks**
- **show mls qos interface**
- **show mls qos maps**
- **show spanning-tree**
- **show storm-control**
- **spanning-tree backbonefast**
- **storm-control**
- **switchport**

Glossary

802.1d—IEEE standard for MAC bridges.

802.1p—IEEE standard for queuing and multicast support.

802.1q—IEEE standard for VLAN frame tagging.

802.1x—IEEE standard for port-based network access control.

ACE—access control entry. Entry in an access control list.

ACL—access control list. Used for security or as a general means to classify traffic.

AgPort—aggregate port (another name for EtherChannel).

ATM—Asynchronous Transfer Mode. The international standard for cell relay in which multiple service types (such as voice, video, or data) are conveyed in fixed-length (53-byte) cells. Fixed-length cells allow cell processing to occur in hardware, thereby reducing transit delays. ATM is designed to take advantage of high-speed transmission media such as E3, SONET, and T3.

authentication server—Entity that validates the credentials of a host trying to obtain access to the network.

authenticator—Entity that enforces authentication rules for hosts connecting to a LAN via one of its ports.

authorization state—The state of a controlled port. It can be authorized (access allowed) or unauthorized (access denied).

AVVID—Architecture for voice, video, and integrated data.

BRI—Basic Rate Interface. ISDN interface comprising two B channels and one D channel for circuit-switched communication of voice, video, and data.

CAC—connection admission control. Set of actions taken by each ATM switch during connection setup to determine whether a connection's requested QoS will violate the QoS guarantees for established connections. CAC is also used when routing a connection request through an ATM network.

candidate—Switch that is not part of a cluster, but is eligible to join a cluster because it meets the qualification criteria of the cluster.

CBWFQ—class-based weighted fair queuing. Extends the standard WFQ functionality to provide support for user-defined traffic classes.

CCN—Cisco Communications Network (Cisco IP phones and IP PBX).

classification—Process of sorting incoming packets by examining fields of interest in the packet header. Fields can be addresses, ports, DSCP value, and so on.

cluster—Group of switches that are managed as a single device. A cluster comprises one commander and multiple members.

cluster commander—Switch that provides the primary management interface to a cluster.

cluster member—Member switch that is managed through the cluster commander.

CoS—class of service. An indication of how an upper-layer protocol requires a lower-layer protocol to treat its messages. In SNA subarea routing, CoS definitions are used by subarea nodes to determine the optimal route to establish a session. A CoS definition comprises a virtual route number and a transmission priority field. Also called ToS.

DSCP—differentiated services code point. In QoS, a modification of the type of service byte. Six bits of this byte are being reallocated for use as the DSCP field, where each DSCP specifies a particular per-hop behavior that is applied to a packet.

DSL—digital subscriber line. Public network technology that delivers high bandwidth over conventional copper wiring at limited distances. There are four types of DSL: ADSL, HDSL, SDSL, and VDSL. All are provisioned via modem pairs, with one modem at a central office and the other at the customer site. Because most DSL technologies do not use the whole bandwidth of the twisted pair, there is room remaining for a voice channel.

EAP—Extensible Authentication Protocol. A mechanism (originally designed for PPP in RFC 2284) that provides authentication of hosts requesting access to a network.

EAPOL—EAP over LAN.

Frame Relay—The capability to carry normal telephony-style voice over an IP-based network with POTS-like functionality, reliability, and voice quality. VoIP lets a router carry voice traffic (such as telephone calls and faxes) over an IP network. In VoIP, the DSP segments the voice signal into frames, which then are coupled in groups of two and stored in voice packets. These voice packets are transported using IP in compliance with ITU-T specification H.323.

FXO—Foreign Exchange Office. An FXO interface connects to the Public Switched Telephone Network (PSTN) central office and is the interface offered on a standard telephone. Cisco's FX interface is an RJ-11 connector that allows an analog connection at the PSTN's central office or to a station interface on a PBX.

FXS—Foreign Exchange Station. An FXS interface connects directly to a standard telephone and supplies ring, voltage, and dial tone. Cisco's FXS interface is an RJ-11 connector that allows connections to basic telephone service equipment, keysets, and PBXs.

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

IGMP—Internet Group Management Protocol. Used by IP hosts to report their multicast group memberships to an adjacent multicast router.

ISL—InterSwitch Link, which is used to carry traffic for multiple VLANs. A method of encapsulating tagged LAN frames and transporting them over a full-duplex, point-to-point Ethernet link. The encapsulated frames can be Token Ring or Fast Ethernet and are carried unchanged from transmitter to receiver.

MIB—Management Information Base. Database of network management information that is used and maintained by a network management protocol, such as SNMP or Common Management Information Protocol (CMIP). The value of a MIB object can be changed or retrieved using SNMP or CMIP commands, usually through a graphical user interface (GUI) network management system. MIB objects are organized in a tree structure that includes public (standard) and private (proprietary) branches.

policing—Process of ensuring whether a stream of classified incoming packets conforms to a particular traffic profile. An action (drop or remark) is taken based on the rate of arrival of packets.

PRI—primary rate interface. ISDN interface to primary rate access. Primary rate access consists of one 64-kbps D channel and 23 (T1) or 30 (E1) B channels for voice or data. Compare with BRI.

PSTN—public switched telephone network. General term referring to the variety of telephone networks and services in place worldwide. Also called POTS.

PVC—permanent virtual circuit. Virtual circuit that is permanently established. PVCs save bandwidth associated with circuit establishment and tear down in situations where certain virtual circuits must exist all the time. In ATM terminology, called a permanent virtual connection.

PVST—Per-VLAN spanning tree. Support for dot1q trunks to map multiple spanning trees to a single spanning tree.

QoS—quality of service. Measure of performance for a transmission system that reflects its transmission quality and service availability.

RADIUS—Remote Access Dial-In User Service. A service used to authenticate and authorize clients.

RMON—remote monitoring. MIB agent specification described in RFC 1271 that defines functions for the remote monitoring of networked devices. The RMON specification provides numerous monitoring, problem detection, and reporting capabilities.

RSVP—Resource Reservation Protocol. Protocol that supports the reservation of resources across an IP network. Applications running on IP end systems can use RSVP to indicate to other nodes the nature (bandwidth, jitter, maximum burst, and so on) of the packet streams they want to receive. RSVP depends on IPv6. Also known as Resource Reservation Setup Protocol.

SIP—Session Initiation Protocol. Protocol developed by the IETF MMUSIC Working Group as an alternative to H.323. SIP features are compliant with IETF RFC 2543, which was published in March 1999. SIP equips platforms to signal the setup of voice and multimedia calls over IP networks.

SNMP—Simple Network Management Protocol. Network management protocol used almost exclusively in TCP/IP networks. SNMP provides a means to monitor and control network devices and to manage configurations, statistics collection, performance, and security.

stacking—Connecting two switches so they behave as one entity for management purposes. Regarding an EtherSwitch network module, stacking means connecting two EtherSwitch network modules inside a chassis so that they behave as one switch.

STP—Spanning Tree Protocol. Bridge protocol that uses the spanning-tree algorithm, which enables a learning bridge to dynamically work around loops in a network topology by creating a spanning tree. Bridges exchange Bridge Protocol Data Unit (BPDU) messages with other bridges to detect loops and then remove the loops by shutting down selected bridge interfaces. Refers to both the IEEE 802.1 Spanning-Tree Protocol standard and the earlier Digital Equipment Corporation Spanning-Tree Protocol upon which it is based. The IEEE version supports bridge domains and allows the bridge to construct a loop-free topology across an extended LAN. The IEEE version generally is preferred over the Digital version.

supplicant—Entity requesting access to the network via the authenticator.

SVI—Switch Virtual Interface. Represents a VLAN of switch ports as one interface to the routing or bridging function in a system.

VBR—variable bit rate. QoS class defined by the ATM Forum for ATM networks. VBR is subdivided into a real time (RT) class and non-real time (NRT) class. VBR (RT) is used for connections in which there is a fixed timing relationship between samples. VBR (NRT) is used for connections in which there is no fixed timing relationship between samples but that still need a guaranteed QoS.

VLAN—virtual LAN. Group of devices on one or more LANs that are configured (using management software) so that they can communicate as if they were attached to the same wire, when in fact they are on separate LAN segments. Because VLANs are based on logical instead of physical connections, they are extremely flexible.

VoIP—Voice over IP. Ability to carry normal telephony-style voice over an IP-based internet with POTS-like functionality, reliability, and voice quality. VoIP enables a router to carry voice traffic (such as telephone calls and faxes) over an IP network. In VoIP, the digital signal processor (DSP) segments the voice signal into frames, which then are coupled in groups of two and stored in voice packets. These voice packets are transported using IP in compliance with ITU-T specification H.323.

VoIPoFR—Voice-over-IP over Frame-Relay.

VPN—virtual private network. Enables IP traffic to travel securely over a public TCP/IP network by encrypting all traffic from one network to another. A VPN uses “tunneling” to encrypt all information at the IP level.

VQP—VLAN Query Protocol.

VTP—VLAN Trunking Protocol.

WAN—wide area network. A communications network that covers a wide geographic area such as state or country. A LAN (local-area network) is within a building or complex, and a MAN (metropolitan-area network) generally covers a city or suburb.

WFQ—weighted fair queuing. In QoS, a flow-based queuing algorithm that schedules low-volume traffic first while letting high-volume traffic share the remaining bandwidth. This is handled by assigning a weight to each flow, where lower weights are the first to be serviced.

WRR—Weighted Round-Robin. Type of round-robin scheduling that prevents low-priority queues from being completely neglected during periods of high-priority traffic. The WRR scheduler transmits some packets from each queue in turn. The number of packets it transmits corresponds to the relative importance of the queue.

Note Refer to *Internetworking Terms and Acronyms* for terms not included in this glossary.