Configuring VLANs

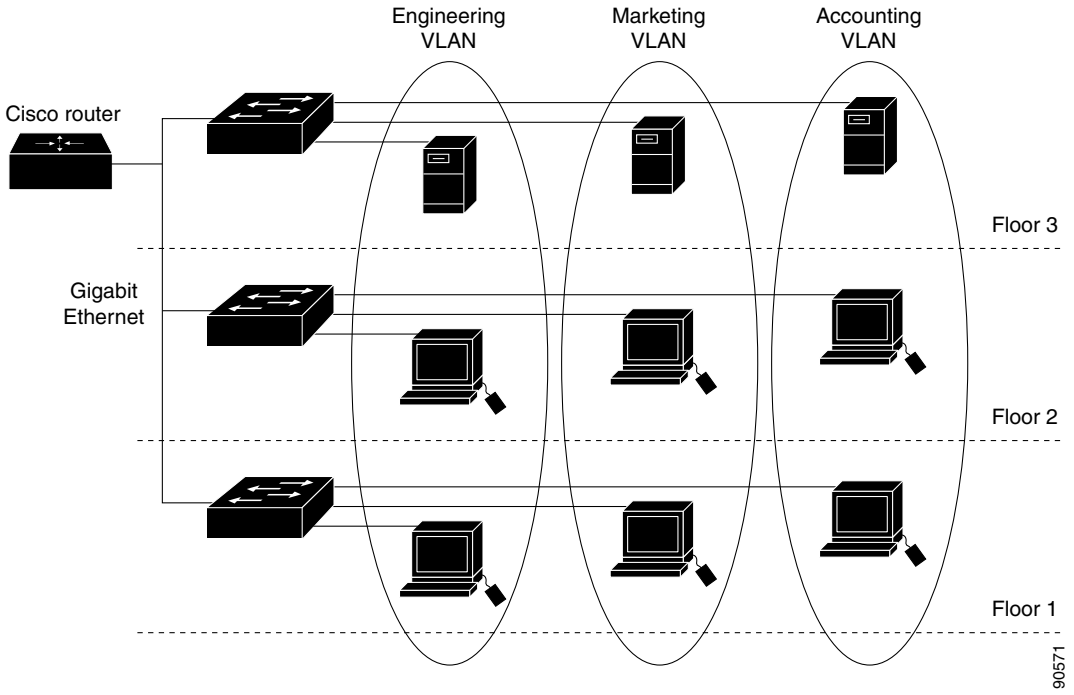
Information About Configuring VLANs

VLANs

A VLAN is a switched network that is logically segmented by function, project team, or application, without regard to the physical locations of the users. VLANs have the same attributes as physical LANs, but you can group end stations even if they are not physically located on the same LAN segment. Any switch port can belong to a VLAN, and unicast, broadcast, and multicast packets are forwarded and flooded only to end stations in the VLAN. Each VLAN is considered a logical network, and packets destined for stations that do not belong to the VLAN must be forwarded through a router or a switch supporting fallback bridging, as shown in Figure 29 on page 271. Because a VLAN is considered a separate logical network, it contains its own bridge Management Information Base (MIB) information and can support its own implementation of spanning tree. See Configuring STP, page 315

Note: Before you create VLANs, you must decide whether to use VLAN Trunking Protocol (VTP) to maintain global VLAN configuration for your network.

Figure 29 VLANs as Logically Defined Networks



VLANs are often associated with IP subnetworks. For example, all the end stations in a particular IP subnet belong to the same VLAN. Interface VLAN membership on the switch is assigned manually on an interface-by-interface basis. When you assign switch interfaces to VLANs by using this method, it is known as interface-based, or static, VLAN membership.

Traffic between VLANs must be routed or fallback bridged. The switch can route traffic between VLANs by using switch virtual interfaces (SVIs). An SVI must be explicitly configured and assigned an IP address to route traffic between VLANs.

Note: If you plan to configure many VLANs on the switch and to not enable routing, you can use the **sdm prefer vlan** global configuration command to set the Switch Database Management (sdm) feature to the VLAN template, which configures system resources to support the maximum number of unicast MAC addresses. For more information on the SDM templates, see Configuring SDM Templates, page 137

Supported VLANs

The switch supports VLANs in VTP client, server, and transparent modes. VLANs are identified by a number from 1 to 4096. VLAN IDs 1002 through 1005 are reserved for Token Ring and FDDI VLANs.

VTP version 1 and version 2 support only normal-range VLANs (VLAN IDs 1 to 1005). In these versions, the switch must be in VTP transparent mode when you create VLAN IDs from 1006 to 4096.

This release supports VTP version 3. VTP version 3 supports the entire VLAN range (VLANs 1 to 4096). Extended range VLANs (VLANs 1006 to 4096) are supported only in VTP version 3. You cannot convert from VTP version 3 to VTP version 2 if extended VLANs are configured in the domain.

Although the switch supports a total of 1005 (normal range and extended range) VLANs, the number of routed ports, SVIs, and other configured features affects the use of the switch hardware.

The switch supports per-VLAN spanning-tree plus (PVST+) or rapid PVST+ with a maximum of 128 spanning-tree instances. One spanning-tree instance is allowed per VLAN. See Normal-Range VLAN Configuration Guidelines, page 275 for more information about the number of spanning-tree instances and the number of VLANs.

VLAN Port Membership Modes

You configure a port to belong to a VLAN by assigning a membership mode that specifies the kind of traffic the port carries and the number of VLANs to which it can belong. Table 33 on page 273 lists the membership modes and membership and VTP characteristics.

Table 33 Port Membership Modes and Characteristics

Membership Mode	VLAN Membership Characteristics	VTP Characteristics
Static-access	A static-access port can belong to one VLAN and is manually assigned to that VLAN. For more information, see Assigning Static-Access Ports to a VLAN, page 285.	VTP is not required. If you do not want VTP to globally propagate information, set the VTP mode to transparent. To participate in VTP, there must be at least one trunk port on the switch connected to a trunk port of a second switch.
Trunk (ISL or IEEE 802.1Q)	A trunk port is a member of all VLANs by default, including extended-range VLANs, but membership can be limited by configuring the allowed-VLAN list. You can also modify the pruning-eligible list to block flooded traffic to VLANs on trunk ports that are included in the list. For information about configuring trunk ports, see Configuring an Ethernet Interface as a Trunk Port, page 286.	VTP is recommended but not required. VTP maintains VLAN configuration consistency by managing the addition, deletion, and renaming of VLANs on a network-wide basis. VTP exchanges VLAN configuration messages with other switches over trunk links.
Dynamic access	A dynamic-access port can belong to one VLAN and is dynamically assigned by a VMPS (VLAN Membership Policy Server). The VMPS can be a Catalyst 5000 or Catalyst 6500 series switch, for example, but never an IE 2000 switch. The IE 2000 switch is a VMPS client. You can have dynamic-access ports and trunk ports on the same switch, but you must connect the dynamic-access port to an end station or hub and not to another switch. For configuration information, see Configuring Dynamic-Access Ports on VMPS Clients, page 290.	VTP is required. Configure the VMPS and the client with the same VTP domain name. To participate in VTP, at least one trunk port on the switch must be connected to a trunk port of a second switch.
Voice VLAN	A voice VLAN port is an access port attached to a Cisco IP Phone, configured to use one VLAN for voice traffic and another VLAN for data traffic from a device attached to the phone. For more information about voice VLAN ports, see Configuring Voice VLAN, page 309	VTP is not required; it has no effect on a voice VLAN.

For more detailed definitions of access and trunk modes and their functions, see Table 35 on page 278.

When a port belongs to a VLAN, the switch learns and manages the addresses associated with the port on a per-VLAN basis. For more information, see Changing the Address Aging Time, page 115.

Normal-Range VLANs

Normal-range VLANs are VLANs with VLAN IDs 1 to 1005. If the switch is in VTP server or VTP transparent mode, you can add, modify or remove configurations for VLANs 2 to 1001 in the VLAN database. (VLAN IDs 1 and 1002 to 1005 are automatically created and cannot be removed.)

Configurations for VLAN IDs 1 to 1005 are written to the *vlan.dat* file (VLAN database), and you can display them by entering the **show vlan** privileged EXEC command. The *vlan.dat* file is stored in flash memory.

Caution: You can cause inconsistency in the VLAN database if you attempt to manually delete the *vlan.dat* file. If you want to modify the VLAN configuration, use the commands described in these sections.

You use the interface configuration mode to define the port membership mode and to add and remove ports from VLANs. The results of these commands are written to the running-configuration file, and you can display the file by entering the **show running-config** privileged EXEC command.

You can set these parameters when you create a new normal-range VLAN or modify an existing VLAN in the VLAN database:

- VLAN ID
- VLAN name
- VLAN type (Ethernet, Fiber Distributed Data Interface [FDDI], FDDI network entity title [NET], TrBRF, or TrCRF, Token Ring, Token Ring-Net)
- VLAN state (active or suspended)
- Maximum transmission unit (MTU) for the VLAN
- Security Association Identifier (SAID)
- Bridge identification number for TrBRF VLANs
- Ring number for FDDI and TrCRF VLANs
- Parent VLAN number for TrCRF VLANs
- Spanning Tree Protocol (STP) type for TrCRF VLANs
- VLAN number to use when translating from one VLAN type to another

You configure VLANs in **vlan** global configuration command by entering a VLAN ID. Enter a new VLAN ID to create a VLAN, or enter an existing VLAN ID to modify that VLAN. You can use the default VLAN configuration (Table 34 on page 276) or enter multiple commands to configure the VLAN. When you have finished the configuration, you must exit VLAN configuration mode for the configuration to take effect. To display the VLAN configuration, enter the **show vlan** privileged EXEC command.

The configurations of VLAN IDs 1 to 1005 are always saved in the VLAN database (vlan.dat file). If the VTP mode is transparent, they are also saved in the switch running configuration file. You can enter the **copy running-config startup-config** privileged EXEC command to save the configuration in the startup configuration file. To display the VLAN configuration, enter the **show vlan** privileged EXEC command.

When you save VLAN and VTP information (including extended-range VLAN configuration information) in the startup configuration file and reboot the switch, the switch configuration is selected as follows:

- If the VTP mode is transparent in the startup configuration, and the VLAN database and the VTP domain name from the VLAN database matches that in the startup configuration file, the VLAN database is ignored (cleared), and the VTP and VLAN configurations in the startup configuration file are used. The VLAN database revision number remains unchanged in the VLAN database.
- If the VTP mode or domain name in the startup configuration does not match the VLAN database, the domain name and VTP mode and configuration for the first 1005 VLANs use the VLAN database information.
- In VTP versions 1 and 2, if VTP mode is server, the domain name and VLAN configuration for only the first 1005 VLANs use the VLAN database information. VTP version 3 also supports VLANs 1006 to 4096.

Token Ring VLANs

Although the switch does not support Token Ring connections, a remote device such as a Catalyst 6500 series switch with Token Ring connections could be managed from one of the supported switches. Switches running VTP Version 2 advertise information about these Token Ring VLANs:

- Token Ring TrBRF VLANs

- Token Ring TrCRF VLANs

For more information on configuring Token Ring VLANs, see the *Catalyst 6500 Series Software Configuration Guide*.

Normal-Range VLAN Configuration Guidelines

Follow these guidelines when creating and modifying normal-range VLANs in your network:

- The switch supports 1005 VLANs in VTP client, server, and transparent modes.
- Normal-range VLANs are identified with a number between 1 and 1001. VLAN numbers 1002 through 1005 are reserved for Token Ring and FDDI VLANs.
- VLAN configuration for VLANs 1 to 1005 are always saved in the VLAN database. If the VTP mode is transparent, VTP and VLAN configuration are also saved in the switch running configuration file.
- With VTP versions 1 and 2, the switch supports VLAN IDs 1006 through 4096 only in VTP transparent mode (VTP disabled). These are extended-range VLANs and configuration options are limited. Extended-range VLANs created in VTP transparent mode are not saved in the VLAN database and are not propagated. VTP version 3 supports extended range VLAN (VLANs 1006 to 4096) database propagation. If extended VLANs are configured, you cannot convert from VTP version 3 to version 1 or 2. See Creating an Extended-Range VLAN, page 285.
- Before you can create a VLAN, the switch must be in VTP server mode or VTP transparent mode. If the switch is a VTP server, you must define a VTP domain or VTP will not function.
- The switch does not support Token Ring or FDDI media. The switch does not forward FDDI, FDDI-Net, TrCRF, or TrBRF traffic, but it does propagate the VLAN configuration through VTP.
- The switch supports 128 spanning-tree instances. If a switch has more active VLANs than supported spanning-tree instances, spanning tree can be enabled on 128 VLANs and is disabled on the remaining VLANs. If you have already used all available spanning-tree instances on a switch, adding another VLAN anywhere in the VTP domain creates a VLAN on that switch that is not running spanning-tree. If you have the default allowed list on the trunk ports of that switch (which is to allow all VLANs), the new VLAN is carried on all trunk ports. Depending on the topology of the network, this could create a loop in the new VLAN that would not be broken, particularly if there are several adjacent switches that all have run out of spanning-tree instances. You can prevent this possibility by setting allowed lists on the trunk ports of switches that have used up their allocation of spanning-tree instances.

  If the number of VLANs on the switch exceeds the number of supported spanning-tree instances, we recommend that you configure the IEEE 802.1s Multiple STP (MSTP) on your switch to map multiple VLANs to a single spanning-tree instance. For more information about MSTP, see Configuring MSTP, page 333

Default Ethernet VLAN Configuration

Note: The switch supports Ethernet interfaces exclusively. Because FDDI and Token Ring VLANs are not locally supported, you only configure FDDI and Token Ring media-specific characteristics for VTP global advertisements to other switches.

Table 34 Ethernet VLAN Defaults and Ranges

Parameter	Default	Range
VLAN ID	1	1 to 4096. **Note:** Extended-range VLANs (VLAN IDs 1006 to 4096) are only saved in the VLAN database in VTP version 3.
VLAN name	*VLANxxxx*, where *xxxx* represents four numeric digits (including leading zeros) equal to the VLAN ID number	No range
IEEE 802.10 SAID	100001 (100000 plus the VLAN ID)	1 to 4294967294
MTU size	1500	1500 to 18190
Translational bridge 1	0	0 to 1005
Translational bridge 2	0	0 to 1005
VLAN state	active	active, suspend
Remote SPAN	disabled	enabled, disabled

Ethernet VLANs

Each Ethernet VLAN in the VLAN database has a unique, 4-digit ID that can be a number from 1 to 1001. VLAN IDs 1002 to 1005 are reserved for Token Ring and FDDI VLANs. To create a normal-range VLAN to be added to the VLAN database, assign a number and name to the VLAN.

Note: With VTP version 1 and 2, if the switch is in VTP transparent mode, you can assign VLAN IDs greater than 1006, but they are not added to the VLAN database. See Creating an Extended-Range VLAN, page 285.

For the list of default parameters that are assigned when you add a VLAN, see Normal-Range VLANs, page 273.

VLAN Removal

When you delete a VLAN from a switch that is in VTP server mode, the VLAN is removed from the VLAN database for all switches in the VTP domain. When you delete a VLAN from a switch that is in VTP transparent mode, the VLAN is deleted only on that specific switch.

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

Caution: When you delete a VLAN, any ports assigned to that VLAN become inactive. They remain associated with the VLAN (and thus inactive) until you assign them to a new VLAN.

Static-Access Ports for a VLAN

You can assign a static-access port to a VLAN without having VTP globally propagate VLAN configuration information by disabling VTP (VTP transparent mode).

If you are assigning a port on a cluster member switch to a VLAN, first use the **rcommand** privileged EXEC command to log in to the cluster member switch.

Note: If you assign an interface to a VLAN that does not exist, the new VLAN is created. (See Creating or Modifying an Ethernet VLAN, page 284.)

Extended-Range VLANs

With VTP version 1 and version 2, when the switch is in VTP transparent mode (VTP disabled), you can create extended-range VLANs (in the range 1006 to 4096). VTP version supports extended-range VLANs in server or transparent move. Extended-range VLANs enable service providers to extend their infrastructure to a greater number of customers. The extended-range VLAN IDs are allowed for any switchport commands that allow VLAN IDs.

With VTP version 1 or 2, extended-range VLAN configurations are not stored in the VLAN database, but because VTP mode is transparent, they are stored in the switch running configuration file, and you can save the configuration in the startup configuration file by using the **copy running-config startup-config** privileged EXEC command. Extended-range VLANs created in VTP version 3 are stored in the VLAN database.

Default VLAN Configuration

See Table 34 on page 276 for the default configuration for Ethernet VLANs. You can change only the MTU size, private VLAN, and the remote SPAN configuration state on extended-range VLANs; all other characteristics must remain at the default state.

Extended-Range VLAN Configuration Guidelines

Follow these guidelines when creating extended-range VLANs:

- VLAN IDs in the extended range are not saved in the VLAN database and are not recognized by VTP unless the switch is running VTP version 3.
- You cannot include extended-range VLANs in the pruning eligible range.
- In VTP version 1 and 2, a switch must be in VTP transparent mode when you create extended-range VLANs. If VTP mode is server or client, an error message is generated, and the extended-range VLAN is rejected. VTP version 3 supports extended VLANs in server and transparent modes.
- For VTP version 1 or 2, you can set the VTP mode to transparent in global configuration mode. See Adding a VTP Client Switch to a VTP Domain, page 303. You should save this configuration to the startup configuration so that the switch boots up in VTP transparent mode. Otherwise, you lose the extended-range VLAN configuration if the switch resets. If you create extended-range VLANs in VTP version 3, you cannot convert to VTP version 1 or 2.
- STP is enabled by default on extended-range VLANs, but you can disable it by using the **no spanning-tree vlan** *vlan-id* global configuration command. When the maximum number of spanning-tree instances are on the switch, spanning tree is disabled on any newly created VLANs. If the number of VLANs on the switch exceeds the maximum number of spanning-tree instances, we recommend that you configure the IEEE 802.1s Multiple STP (MSTP) on your switch to map multiple VLANs to a single spanning-tree instance.
- Each routed port on the switch creates an internal VLAN for its use. These internal VLANs use extended-range VLAN numbers, and the internal VLAN ID cannot be used for an extended-range VLAN. If you try to create an extended-range VLAN with a VLAN ID that is already allocated as an internal VLAN, an error message is generated, and the command is rejected.
  - Because internal VLAN IDs are in the lower part of the extended range, we recommend that you create extended-range VLANs beginning from the highest number (4096) and moving to the lowest (1006) to reduce the possibility of using an internal VLAN ID.
  - Before configuring extended-range VLANs, enter the **show vlan internal usage** privileged EXEC command to see which VLANs have been allocated as internal VLANs.
  - If necessary, you can shut down the routed port assigned to the internal VLAN, which frees up the internal VLAN, and then create the extended-range VLAN and re-enable the port, which then uses another VLAN as its internal VLAN. See Creating an Extended-Range VLAN with an Internal VLAN ID, page 286.

- Although the switch supports a total of 1005 (normal-range and extended-range) VLANs, the number of routed ports, SVIs, and other configured features affects the use of the switch hardware. If you try to create an extended-range VLAN and there are not enough hardware resources available, an error message is generated, and the extended-range VLAN is rejected.

VLAN Trunks

Trunking Overview

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. Ethernet trunks carry the traffic of multiple VLANs over a single link, and you can extend the VLANs across an entire network.

You can configure a trunk on a single Ethernet interface or on an EtherChannel bundle.

Ethernet trunk interfaces support different trunking modes (see Table 35 on page 278). You can set an interface as trunking or nontrunking or to negotiate trunking with the neighboring interface. To autonegotiate trunking, the interfaces must be in the same VTP domain.

Trunk negotiation is managed by the Dynamic Trunking Protocol (DTP), which is a Point-to-Point Protocol. However, some internetworking devices might forward DTP frames improperly, which could cause misconfigurations.

To avoid this, you should configure interfaces connected to devices that do not support DTP to not forward DTP frames, that is, to turn off DTP.

- If you do not intend to trunk across those links, use the **switchport mode access** interface configuration command to disable trunking.
- To enable trunking to a device that does not support DTP, use the **switchport mode trunk** and **switchport nonegotiate** interface configuration commands to cause the interface to become a trunk but to not generate DTP frames.

Table 35 Layer 2 Interface Modes

Mode	Function
switchport mode access	Puts the interface (access port) into permanent nontrunking mode and negotiates to convert the link into a nontrunk link. The interface becomes a nontrunk interface regardless of whether or not the neighboring interface is a trunk interface.
switchport mode dynamic auto	Makes the interface able to convert the link to a trunk link. The interface becomes a trunk interface if the neighboring interface is set to *trunk* or *desirable* mode. The default switch port mode for all Ethernet interfaces is dynamic auto.
switchport mode dynamic desirable	Makes the interface actively attempt to convert the link to a trunk link. The interface becomes a trunk interface if the neighboring interface is set to *trunk*, *desirable*, or *auto* mode.
switchport mode trunk	Puts the interface into permanent trunking mode and negotiates to convert the neighboring link into a trunk link. The interface becomes a trunk interface even if the neighboring interface is not a trunk interface.
switchport nonegotiate	Prevents the interface from generating DTP frames. You can use this command only when the interface switchport mode is access or trunk. You must manually configure the neighboring interface as a trunk interface to establish a trunk link.

IEEE 802.1Q Configuration Guidelines

The IEEE 802.1Q trunks impose these restrictions on the trunking strategy for a network:

- In a network of Cisco switches connected through IEEE 802.1Q trunks, the switches maintain one spanning-tree instance for each VLAN allowed on the trunks. Non-Cisco devices might support one spanning-tree instance for all VLANs.

  When you connect a Cisco switch to a non-Cisco device through an IEEE 802.1Q trunk, the Cisco switch combines the spanning-tree instance of the VLAN of the trunk with the spanning-tree instance of the non-Cisco IEEE 802.1Q switch. However, spanning-tree information for each VLAN is maintained by Cisco switches separated by a cloud of non-Cisco IEEE 802.1Q switches. The non-Cisco IEEE 802.1Q cloud separating the Cisco switches is treated as a single trunk link between the switches.

- Make sure the native VLAN for an IEEE 802.1Q trunk is the same on both ends of the trunk link. If the native VLAN on one end of the trunk is different from the native VLAN on the other end, spanning-tree loops might result.

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

Default Layer 2 Ethernet Interface VLAN Settings

Feature	Default Setting
Interface mode	switchport mode dynamic auto
Allowed VLAN range	VLANs 1 to 4096
VLAN range eligible for pruning	VLANs 2 to 1001
Default VLAN (for access ports)	VLAN 1
Native VLAN (for IEEE 802.1Q trunks)	VLAN 1

Ethernet Interface as a Trunk Port

Because trunk ports send and receive VTP advertisements, to use VTP you must ensure that at least one trunk port is configured on the switch and that this trunk port is connected to the trunk port of a second switch. Otherwise, the switch cannot receive any VTP advertisements.

Note: By default, an interface is in Layer 2 mode. The default mode for Layer 2 interfaces is **switchport mode dynamic auto**. If the neighboring interface supports trunking and is configured to allow trunking, the link is a Layer 2 trunk or, if the interface is in Layer 3 mode, it becomes a Layer 2 trunk when you enter the **switchport** interface configuration command.

Trunking Interaction with Other Features

Trunking interacts with other features in these ways:

- A trunk port cannot be a secure port.
- A trunk port cannot be a tunnel port.
- Trunk ports can be grouped into EtherChannel port groups, but all trunks in the group must have the same configuration. When a group is first created, all ports follow the parameters set for the first port to be added to the group. If you change the configuration of one of these parameters, the switch propagates the setting you entered to all ports in the group:
  - Allowed-VLAN list.
  - STP port priority for each VLAN.

  - STP Port Fast setting.
  - Trunk status. If one port in a port group ceases to be a trunk, all ports cease to be trunks.
- We recommend that you configure no more than 24 trunk ports in PVST mode and no more than 40 trunk ports in MST mode.
- If you try to enable IEEE 802.1x on a trunk port, an error message appears, and IEEE 802.1x is not enabled. If you try to change the mode of an IEEE 802.1x-enabled port to trunk, the port mode is not changed.
- A port in dynamic mode can negotiate with its neighbor to become a trunk port. If you try to enable IEEE 802.1x on a dynamic port, an error message appears, and IEEE 802.1x is not enabled. If you try to change the mode of an IEEE 802.1x-enabled port to dynamic, the port mode is not changed.

Allowed VLANs on a Trunk

By default, a trunk port sends traffic to and receives traffic from all VLANs. All VLAN IDs, 1 to 4096, are allowed on each trunk. However, you can remove VLANs from the allowed list, preventing traffic from those VLANs from passing over the trunk. To restrict the traffic a trunk carries, use the **switchport trunk allowed vlan remove** *vlan-list* interface configuration command to remove specific VLANs from the allowed list.

Note: VLAN 1 is the default VLAN on all trunk ports in all Cisco switches, and it has previously been a requirement that VLAN 1 always be enabled on every trunk link. You can use the VLAN 1 minimization feature to disable VLAN 1 on any individual VLAN trunk link so that no user traffic (including spanning-tree advertisements) is sent or received on VLAN 1.

To reduce the risk of spanning-tree loops or storms, you can disable VLAN 1 on any individual VLAN trunk port by removing VLAN 1 from the allowed list. When you remove VLAN 1 from a trunk port, the interface continues to send and receive management traffic, for example, Cisco Discovery Protocol (CDP), Port Aggregation Protocol (PAgP), Link Aggregation Control Protocol (LACP), DTP, and VTP in VLAN 1.

If a trunk port with VLAN 1 disabled is converted to a nontrunk port, it is added to the access VLAN. If the access VLAN is set to 1, the port will be added to VLAN 1, regardless of the **switchport trunk allowed** setting. The same situation applies for any VLAN that has been disabled on the port.

A trunk port can become a member of a VLAN if the VLAN is enabled, if VTP knows of the VLAN, and if the VLAN is in the allowed list for the port. When VTP detects a newly enabled VLAN and the VLAN is in the allowed list for a trunk port, the trunk port automatically becomes a member of the enabled VLAN. When VTP detects a new VLAN and the VLAN is not in the allowed list for a trunk port, the trunk port does not become a member of the new VLAN.

Native VLAN for Untagged Traffic

A trunk port configured with IEEE 802.1Q tagging can receive both tagged and untagged traffic. By default, the switch forwards untagged traffic in the native VLAN configured for the port. The native VLAN is VLAN 1 by default.

Note: The native VLAN can be assigned any VLAN ID.

For information about IEEE 802.1Q configuration issues, see IEEE 802.1Q Configuration Guidelines, page 278.

Load Sharing Using Trunk Ports

Load sharing divides the bandwidth supplied by parallel trunks connecting switches. To avoid loops, STP normally blocks all but one parallel link between switches. Using load sharing, you divide the traffic between the links according to which VLAN the traffic belongs.

You configure load sharing on trunk ports by using STP port priorities or STP path costs. For load sharing using STP port priorities, both load-sharing links must be connected to the same switch. For load sharing using STP path costs, each load-sharing link can be connected to the same switch or to two different switches.

Load Sharing Using STP Port Priorities

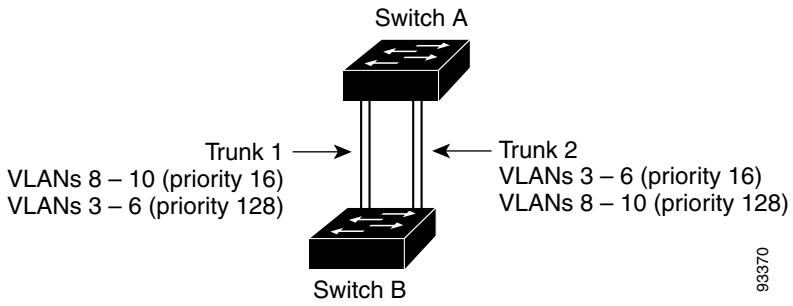
When two ports on the same switch form a loop, the switch uses the STP port priority to decide which port is enabled and which port is in a blocking state. You can set the priorities on a parallel trunk port so that the port carries all the traffic for a given VLAN. The trunk port with the higher priority (lower values) for a VLAN is forwarding traffic for that VLAN. The trunk port with the lower priority (higher values) for the same VLAN remains in a blocking state for that VLAN. One trunk port sends or receives all traffic for the VLAN.

Figure 30 on page 281 shows two trunks connecting supported switches. In this example, the switches are configured as follows:

- VLANs 8 through 10 are assigned a port priority of 16 on Trunk 1.
- VLANs 3 through 6 retain the default port priority of 128 on Trunk 1.
- VLANs 3 through 6 are assigned a port priority of 16 on Trunk 2.
- VLANs 8 through 10 retain the default port priority of 128 on Trunk 2.

In this way, Trunk 1 carries traffic for VLANs 8 through 10, and Trunk 2 carries traffic for VLANs 3 through 6. If the active trunk fails, the trunk with the lower priority takes over and carries the traffic for all of the VLANs. No duplication of traffic occurs over any trunk port.

Figure 30 Load Sharing by Using STP Port Priorities



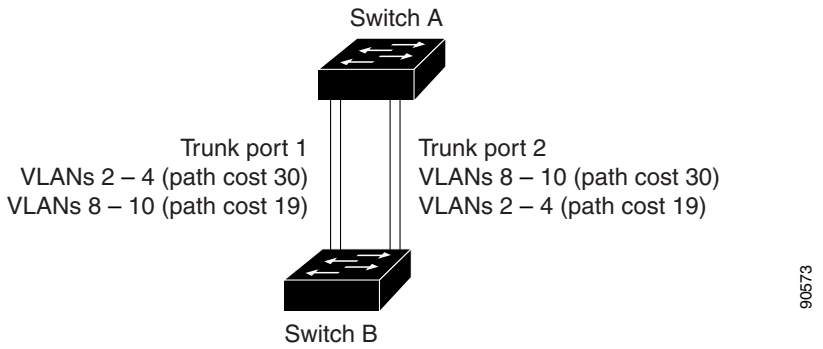
Load Sharing Using STP Path Cost

You can configure parallel trunks to share VLAN traffic by setting different path costs on a trunk and associating the path costs with different sets of VLANs, blocking different ports for different VLANs. The VLANs keep the traffic separate and maintain redundancy in the event of a lost link.

In Figure 31 on page 282, Trunk ports 1 and 2 are configured as 100BASE-T ports. These VLAN path costs are assigned:

- VLANs 2 through 4 are assigned a path cost of 30 on Trunk port 1.
- VLANs 8 through 10 retain the default 100BASE-T path cost on Trunk port 1 of 19.
- VLANs 8 through 10 are assigned a path cost of 30 on Trunk port 2.
- VLANs 2 through 4 retain the default 100BASE-T path cost on Trunk port 2 of 19.

Figure 31 Load-Sharing Trunks with Traffic Distributed by Path Cost



See Configuring Load Sharing Using STP Path Cost, page 288.

VMPS

The VLAN Query Protocol (VQP) is used to support dynamic-access ports, which are not permanently assigned to a VLAN, but give VLAN assignments based on the MAC source addresses seen on the port. Each time an unknown MAC address is seen, the switch sends a VQP query to a remote VMPS; the query includes the newly seen MAC address and the port on which it was seen. The VMPS responds with a VLAN assignment for the port. The switch cannot be a VMPS server but can act as a client to the VMPS and communicate with it through VQP.

Each time the client switch receives the MAC address of a new host, it sends a VQP query to the VMPS. When the VMPS receives this query, it searches its database for a MAC-address-to-VLAN mapping. The server response is based on this mapping and whether or not the server is in open or secure mode. In secure mode, the server shuts down the port when an illegal host is detected. In open mode, the server simply denies the host access to the port.

If the port is currently *unassigned* (that is, it does not yet have a VLAN assignment), the VMPS provides one of these responses:

- If the host is allowed on the port, the VMPS sends the client a *vlan-assignment* response containing the assigned VLAN name and allowing access to the host.
- If the host is not allowed on the port and the VMPS is in open mode, the VMPS sends an *access-denied* response.
- If the VLAN is not allowed on the port and the VMPS is in secure mode, the VMPS sends a *port-shutdown* response.

If the port already has a VLAN assignment, the VMPS provides one of these responses:

- If the VLAN in the database matches the current VLAN on the port, the VMPS sends a *success* response, allowing access to the host.
- If the VLAN in the database does not match the current VLAN on the port and active hosts exist on the port, the VMPS sends an *access-denied* or a *port-shutdown* response, depending on the secure mode of the VMPS.

If the switch receives an *access-denied* response from the VMPS, it continues to block traffic to and from the host MAC address. The switch continues to monitor the packets directed to the port and sends a query to the VMPS when it identifies a new host address. If the switch receives a *port-shutdown* response from the VMPS, it disables the port. The port must be manually reenabled by using Network Assistant, the CLI or SNMP.

Dynamic-Access Port VLAN Membership

A dynamic-access port can belong to only one VLAN with an ID from 1 to 4096. When the link comes up, the switch does not forward traffic to or from this port until the VMPS provides the VLAN assignment. The VMPS receives the source MAC address from the first packet of a new host connected to the dynamic-access port and attempts to match the MAC address to a VLAN in the VMPS database.

If there is a match, the VMPS sends the VLAN number for that port. If the client switch was not previously configured, it uses the domain name from the first VTP packet it receives on its trunk port from the VMPS. If the client switch was previously configured, it includes its domain name in the query packet to the VMPS to obtain its VLAN number. The VMPS verifies that the domain name in the packet matches its own domain name before accepting the request and responds to the client with the assigned VLAN number for the client. If there is no match, the VMPS either denies the request or shuts down the port (depending on the VMPS secure mode setting).

Multiple hosts (MAC addresses) can be active on a dynamic-access port if they are all in the same VLAN; however, the VMPS shuts down a dynamic-access port if more than 20 hosts are active on the port.

If the link goes down on a dynamic-access port, the port returns to an isolated state and does not belong to a VLAN. Any hosts that come online through the port are checked again through the VQP with the VMPS before the port is assigned to a VLAN.

Dynamic-access ports can be used for direct host connections, or they can connect to a network. A maximum of 20 MAC addresses are allowed per port on the switch. A dynamic-access port can belong to only one VLAN at a time, but the VLAN can change over time, depending on the MAC addresses seen.

Default VMPS Client Settings

Feature	Default Setting
VMPS domain server	None
VMPS reconfirm interval	60 minutes
VMPS server retry count	3
Dynamic-access ports	None configured

VMPS Configuration Guidelines

These guidelines and restrictions apply to dynamic-access port VLAN membership:

- You should configure the VMPS before you configure ports as dynamic-access ports.
- When you configure a port as a dynamic-access port, the spanning-tree Port Fast feature is automatically enabled for that port. The Port Fast mode accelerates the process of bringing the port into the forwarding state.
- IEEE 802.1x ports cannot be configured as dynamic-access ports. If you try to enable IEEE 802.1x on a dynamic-access (VQP) port, an error message appears, and IEEE 802.1x is not enabled. If you try to change an IEEE 802.1x-enabled port to dynamic VLAN assignment, an error message appears, and the VLAN configuration is not changed.
- Trunk ports cannot be dynamic-access ports, but you can enter the **switchport access vlan dynamic** interface configuration command for a trunk port. In this case, the switch retains the setting and applies it if the port is later configured as an access port.

  You must turn off trunking on the port before the dynamic-access setting takes effect.
- Dynamic-access ports cannot be monitor ports.
- Secure ports cannot be dynamic-access ports. You must disable port security on a port before it becomes dynamic.
- Private VLAN ports cannot be dynamic-access ports.
- Dynamic-access ports cannot be members of an EtherChannel group.
- Port channels cannot be configured as dynamic-access ports.

- A dynamic-access port can participate in fallback bridging.
- The VTP management domain of the VMPS client and the VMPS server must be the same.
- The VLAN configured on the VMPS server should not be a voice VLAN.

VMPS Reconfirmation Interval

VMPS clients periodically reconfirm the VLAN membership information received from the VMPS.You can set the number of minutes after which reconfirmation occurs.

If you are configuring a member switch in a cluster, this parameter must be equal to or greater than the reconfirmation setting on the command switch. You must also first use the **rcommand** privileged EXEC command to log in to the member switch.

Dynamic-Access Port VLAN Membership

The VMPS shuts down a dynamic-access port under these conditions:

- The VMPS is in secure mode, and it does not allow the host to connect to the port. The VMPS shuts down the port to prevent the host from connecting to the network.
- More than 20 active hosts reside on a dynamic-access port.

To reenable a disabled dynamic-access port, enter the **shutdown** interface configuration command followed by the **no shutdown** interface configuration command.

How to Configure VLANs

Creating or Modifying an Ethernet VLAN

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode.
2.	**vlan** *vlan-id*	Enters a VLAN ID, and enters VLAN configuration mode. **Note:** The available VLAN ID range for this command is 1 to 4096. For information about adding VLAN IDs greater than 1005 (extended-range VLANs), see Creating an Extended-Range VLAN, page 285.
3.	**name** *vlan-name*	(Optional) Enters a name for the VLAN. If no name is entered for the VLAN, the default is to append the *vlan-id* with leading zeros to the word VLAN. For example, VLAN0004 is a default VLAN name for VLAN 4.
4.	**mtu** *mtu-size*	(Optional) Changes the MTU size (or other VLAN characteristic).
5.	**remote-span**	(Optional) Configures the VLAN as the RSPAN VLAN for a remote SPAN session. **Note:** For more information on remote SPAN, see Configuring SPAN and RSPAN, page 477
6.	**end**	Returns to privileged EXEC mode.

Deleting a VLAN

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode.
2.	**no vlan** *vlan-id*	Removes the VLAN by entering the VLAN ID.
3.	**end**	Returns to privileged EXEC mode.

Assigning Static-Access Ports to a VLAN

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode
2.	**interface** *interface-id*	Enters the interface to be added to the VLAN.
3.	**switchport mode access**	Defines the VLAN membership mode for the port (Layer 2 access port).
4.	**switchport access vlan** *vlan-id*	Assigns the port to a VLAN. Valid VLAN IDs are 1 to 4096.
5.	**end**	Returns to privileged EXEC mode.

Creating an Extended-Range VLAN

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode.
2.	**vtp mode transparent**	Configures the switch for VTP transparent mode and disables VTP. **Note:** This step is not required for VTP version 3.
3.	**vlan** *vlan-id*	Enters an extended-range VLAN ID and enters VLAN configuration mode. The range is 1006 to 4096.
4.	**mtu** *mtu-size*	(Optional) Modifies the VLAN by changing the MTU size. **Note:** Although all VLAN commands appear in the CLI help, only the **mtu** *mtu-size*, **private-vlan**, and **remote-span** commands are supported for extended-range VLANs.
5.	**remote-span**	(Optional) Configures the VLAN as the RSPAN VLAN. See Configuring a VLAN as an RSPAN VLAN, page 490.
6.	**end**	Returns to privileged EXEC mode.

Creating an Extended-Range VLAN with an Internal VLAN ID

	Command	Purpose
1.	**show vlan internal usage**	Displays the VLAN IDs being used internally by the switch. If the VLAN ID that you want to use is an internal VLAN, the display shows the routed port that is using the VLAN ID. Enter that port number in Step 3.
2.	**configure terminal**	Enters global configuration mode.
3.	**interface** *interface-id*	Specifies the interface ID for the routed port that is using the VLAN ID, and enters interface configuration mode.
4.	**shutdown**	Shuts down the port to free the internal VLAN ID.
5.	**exit**	Returns to global configuration mode.
6.	**vtp mode transparent**	Sets the VTP mode to transparent for creating extended-range VLANs. **Note:** This step is not required for VTP version 3.
7.	**vlan** *vlan-id*	Enters the new extended-range VLAN ID, and enters VLAN configuration mode.
8.	**exit**	Exits from VLAN configuration mode, and returns to global configuration mode.
9.	**interface** *interface-id*	Specifies the interface ID for the routed port that you shut down in Step 4, and enters interface configuration mode.
10.	**no shutdown**	Reenables the routed port. It will be assigned a new internal VLAN ID.
11.	**end**	Returns to privileged EXEC mode.

Configuring an Ethernet Interface as a Trunk Port

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode.
2.	**interface** *interface-id*	Specifies the port to be configured for trunking, and enters interface configuration mode.
3.	**switchport mode** {**dynamic** {**auto** | **desirable**} | **trunk**}	Configures the interface as a Layer 2 trunk (required only if the interface is a Layer 2 access port or tunnel port or to specify the trunking mode). ■ **dynamic auto**—Sets the interface to a trunk link if the neighboring interface is set to trunk or desirable mode. This is the default. ■ **dynamic desirable**—Sets the interface to a trunk link if the neighboring interface is set to trunk, desirable, or auto mode. ■ **trunk**—Sets the interface in permanent trunking mode and negotiate to convert the link to a trunk link even if the neighboring interface is not a trunk interface.
4.	**switchport access vlan** *vlan-id*	(Optional) Specifies the default VLAN, which is used if the interface stops trunking.
5.	**switchport trunk native vlan** *vlan-id*	Specifies the native VLAN for IEEE 802.1Q trunks.
6.	**end**	Returns to privileged EXEC mode.

Defining the Allowed VLANs on a Trunk

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode.
2.	**interface** *interface-id*	Specifies the port to be configured, and enters interface configuration mode.
3.	**switchport mode trunk**	Configures the interface as a VLAN trunk port.
4.	**switchport trunk allowed vlan** {**add** | **all** | **except** | **remove**} *vlan-list*	(Optional) Configures the list of VLANs allowed on the trunk.
5.	**end**	Returns to privileged EXEC mode.

Changing the Pruning-Eligible List

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode.
2.	**interface** *interface-id*	Selects the trunk port for which VLANs should be pruned, and enters interface configuration mode.
3.	**switchport trunk pruning vlan** {**add** | **except** | **none** | **remove**} *vlan-list* [,*vlan*[,*vlan*[,,,]]	Configures the list of VLANs allowed to be pruned from the trunk. (See VTP Pruning, page 300.)
4.	**end**	Returns to privileged EXEC mode.

Configuring the Native VLAN for Untagged Traffic

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode.
2.	**interface** *interface-id*	Defines the interface that is configured as the IEEE 802.1Q trunk, and enters interface configuration mode.
3.	**switchport trunk native vlan** *vlan-id*	Configures the VLAN that is sending and receiving untagged traffic on the trunk port.
4.	**end**	Returns to privileged EXEC mode.

Load Sharing Using STP Port Priorities

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode on Switch A.
2.	**vtp domain** *domain-name*	Configures a VTP administrative domain. The domain name can be 1 to 32 characters.
3.	**vtp mode server**	Configures Switch A as the VTP server.
4.	**end**	Returns to privileged EXEC mode.
5.	**show vtp status**	Verifies the VTP configuration on both Switch A and Switch B.
6.	**show vlan**	Verifies that the VLANs exist in the database on Switch A.
7.	**configure terminal**	Enters global configuration mode.
8.	**interface** *interface-id_1*	Defines the interface to be configured as a trunk, and enters interface configuration mode.
9.	**switchport mode trunk**	Configures the port as a trunk port.
10.	**end**	Returns to privileged EXEC mode.
11.	**show interfaces** *interface-id_1* **switchport**	Verifes the VLAN configuration.
12.	Repeat Steps 7 through 10 on Switch A for a second port in the switch.	
13.	Repeat Steps 7 through 10 on Switch B to configure the trunk ports that connect to the trunk ports configured on Switch A.	
14.	**show vlan**	When the trunk links come up, VTP passes the VTP and VLAN information to Switch B. Verifies that Switch B has learned the VLAN configuration.
15.	**configure terminal**	Enters global configuration mode on Switch A.
16.	**interface** *interface-id_1*	Defines the interface to set the STP port priority, and enters interface configuration mode.
17.	**spanning-tree vlan 8-10 port-priority 16**	Assigns the port priority of 16 for VLANs 8 through 10.
18.	**exit**	Returns to global configuration mode.
19.	**interface** *interface-id_2*	Defines the interface to set the STP port priority, and enters interface configuration mode.
20.	**spanning-tree vlan 3-6 port-priority 16**	Assigns the port priority of 16 for VLANs 3 through 6.
21.	**end**	Returns to privileged EXEC mode.

Configuring Load Sharing Using STP Path Cost

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode on Switch A.
2.	**interface** *interface-id_1*	Defines the interface to be configured as a trunk, and enters interface configuration mode.
3.	**switchport mode trunk**	Configures the port as a trunk port.
4.	**exit**	Returns to global configuration mode.
5.		Repeat Steps 2 through 4 on a second interface in Switch A.
6.	**end**	Returns to privileged EXEC mode.

	Command	Purpose
7.	**show running-config**	Verifies your entries. In the display, make sure that the interfaces are configured as trunk ports.
8.	**show vlan**	When the trunk links come up, Switch A receives the VTP information from the other switches. Verifies that Switch A has learned the VLAN configuration.
9.	**configure terminal**	Enters global configuration mode.
10.	**interface** *interface-id_1*	Defines the interface on which to set the STP cost, and enters interface configuration mode.
11.	**spanning-tree vlan 2-4 cost 30**	Sets the spanning-tree path cost to 30 for VLANs 2 through 4.
12.	**end**	Returns to global configuration mode.
13.	Repeat Steps 9 through 12 on the other configured trunk interface on Switch A, and set the spanning-tree path cost to 30 for VLANs 8, 9, and 10.	
14.	**exit**	Returns to privileged EXEC mode.
15.	**show running-config**	Verifies your entries. In the display, verify that the path costs are set correctly for both trunk interfaces.

Configuring the VMPS Client

You configure dynamic VLANs by using the VMPS (VLAN Membership Policy Server). The switch can be a VMPS client; it cannot be a VMPS server.

Entering the IP Address of the VMPS

Before You Begin

- You must first enter the IP address of the server to configure the switch as a client.
- You must have IP connectivity to the VMPS for dynamic-access ports to work. You can test for IP connectivity by pinging the IP address of the VMPS and verifying that you get a response.
- If the VMPS is being defined for a cluster of switches, enter the address on the command switch.

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode.
2.	**vmps server** *ipaddress* **primary**	Enters the IP address of the switch acting as the primary VMPS server.
3.	**vmps server** *ipaddress*	(Optional) Enters the IP address of the switch acting as a secondary VMPS server. You can enter up to three secondary server addresses.
4.	**vmps reconfirm**	(Optional) Reconfirms dynamic-access port VLAN membership.
5.	**vmps retry** *count*	(Optional) Changes the retry count.
6.	**end**	Returns to privileged EXEC mode.

Configuring Dynamic-Access Ports on VMPS Clients

Before You Begin

If you are configuring a port on a cluster member switch as a dynamic-access port, first use the **rcommand** privileged EXEC command to log in to the cluster member switch.

Caution: Dynamic-access port VLAN membership is for end stations or hubs connected to end stations. Connecting dynamic-access ports to other switches can cause a loss of connectivity.

	Command	Purpose
1.	**configure terminal**	Enters global configuration mode.
2.	**interface** *interface-id*	Specifies the switch port that is connected to the end station, and enters interface configuration mode.
3.	**switchport mode access**	Sets the port to access mode.
4.	**switchport access vlan dynamic**	Configures the port as eligible for dynamic VLAN membership. The dynamic-access port must be connected to an end station.
5.	**end**	Returns to privileged EXEC mode.

Monitoring and Maintaining VLANs

Command	Purpose
copy running-config startup config	Saves your entries in the configuration file ■ To save an extended-range VLAN configuration, you need to save the VTP transparent mode configuration and the extended-range VLAN configuration in the switch startup configuration file. Otherwise, if the switch resets, it will default to VTP server mode, and the extended-range VLAN IDs will not be saved. ■ This step is not required for VTP version 3 because VLANs are saved in the VLAN database.
show interfaces *interface-id* **switchport**	Displays the switch port configuration of the interface.
show interfaces *interface-id* **trunk**	Displays the trunk configuration of the interface.
show running-config interface *interface-id*	Verifies the VLAN membership mode of the interface.
show vmps	Verifies your VMPS entries.
show vlan	Verifies your VLAN entries.

Configuration Examples for Configuring VLANs

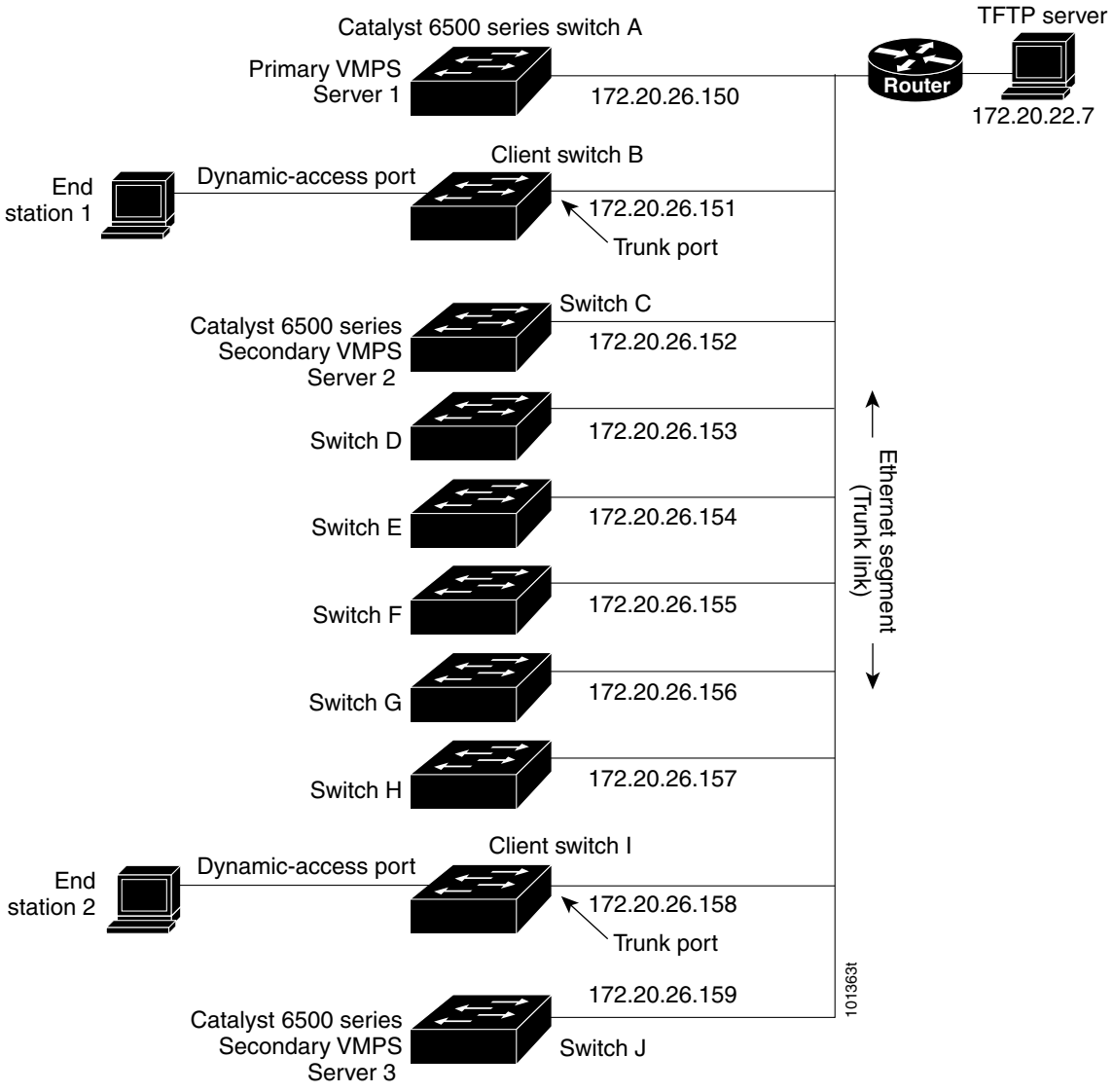
VMPS Network: Example

Figure 32 on page 291 shows a network with a VMPS server switch and VMPS client switches with dynamic-access ports. In this example, these assumptions apply:

- The VMPS server and the VMPS client are separate switches.
- The Catalyst 6500 series Switch A is the primary VMPS server.

- The Catalyst 6500 series Switch C and Switch J are secondary VMPS servers.
- End stations are connected to the clients, Switch B and Switch I.
- The database configuration file is stored on the TFTP server with the IP address 172.20.22.7.

Figure 32 Dynamic Port VLAN Membership Configuration



Configuring a VLAN: Example

This example shows how to create Ethernet VLAN 20, name it *test20,* and add it to the VLAN database:

```
Switch# configure terminal
Switch(config)# vlan 20
Switch(config-vlan)# name test20
Switch(config-vlan)# end
```

Configuring an Access Port in a VLAN: Example

This example shows how to configure a port as an access port in VLAN 2:

```
Switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)# interface GigabitEthernet1/17
Switch(config-if)# switchport mode access
Switch(config-if)# switchport access vlan 2
Switch(config-if)# end
```

Configuring an Extended-Range VLAN: Example

This example shows how to create a new extended-range VLAN with all default characteristics:

```
Switch(config)# vtp mode transparent
Switch(config)# vlan 2000
Switch(config-vlan)# end
Switch# copy running-config startup config
```

Configuring a Trunk Port: Example

This example shows how to configure a port as an IEEE 802.1Q trunk. The example assumes that the neighbor interface is configured to support IEEE 802.1Q trunking.

```
Switch(config)# interface GigabitEthernet1/18
Switch(config-if)# switchport mode dynamic desirable
Switch(config-if)# end
```

Removing a VLAN: Example

This example shows how to remove VLAN 2 from the allowed VLAN list on a port:

```
Switch(config)# interface GigabitEthernet1/17
Switch(config-if)# switchport trunk allowed vlan remove 2
Switch(config-if)# end
```

Show VMPS Output: Example

This is an example of output for the **show vmps** privileged EXEC command:

```
Switch# show vmps
VQP Client Status:
--------------------
VMPS VQP Version:   1
Reconfirm Interval: 60 min
Server Retry Count: 3
VMPS domain server: 172.20.128.86 (primary, current)
                    172.20.128.87

Reconfirmation status
---------------------
VMPS Action:         other
```

Additional References

The following sections provide references related to switch administration:

Related Documents

Related Topic	Document Title
Cisco IOS basic commands	*Cisco IOS Configuration Fundamentals Command Reference*

Standards

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

MIBs

MIBs	MIBs Link
–	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at the following URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

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

Additional References