Configuring Transparent Bridging

The Cisco IOS software bridging functionality combines the advantages of a spanning-tree bridge and a full multiprotocol router. This combination provides the speed and protocol transparency of an adaptive spanning-tree bridge, along with the functionality, reliability, and security of a router.

This chapter describes how to configure transparent bridging and source-route transparent (SRT) bridging. This chapter also describes the concepts of virtual networking, transparent bridging of virtual LANs (VLANs), and routing between VLANs. For a complete description of the transparent bridging commands mentioned in this chapter, refer to the "Transparent Bridging Commands" chapter in the *Cisco IOS Bridging and IBM Networking Command Reference* (Volume 1 of 2). To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

This chapter contains the following sections:

Technology Overview

The following sections provide an overview of transparent bridging in the Cisco IOS software:

Transparent and SRT Bridging

Cisco IOS software supports transparent bridging for Ethernet, Fiber Distributed Data Interface (FDDI), and serial media, and supports source-route transparent (SRT) bridging for Token Ring media. In addition, Cisco supports all the mandatory Management Information Base (MIB) variables specified for transparent bridging in RFC 1286.

Transparent Bridging Features

Cisco's transparent bridging software implementation has the following features:

- Complies with the IEEE 802.1D standard.
- Provides the ability to logically segment a transparently bridged network into virtual LANs.
- Provides two Spanning Tree Protocols—an older bridge protocol data unit (BPDU) format that is compatible with Digital Equipment Corporation (DEC) and other LAN bridges for backward compatibility and the IEEE standard BPDU format. In addition to features standard with these Spanning Tree Protocols, Cisco's proprietary software provides for multiple domains for spanning trees. The spanning-tree parameters are configurable.
- Allows frame filtering based on Media Access Control (MAC) address, protocol type, or the vendor code. Additionally, the bridging software can be configured to selectively filter local-area transport (LAT) multicast service announcements.
- Provides deterministic load distribution while maintaining a loop-free spanning tree.
- Provides the ability to bridge over Asynchronous Transfer Mode (ATM), dial-on-demand routing (DDR), FDDI, Frame Relay, multiprotocol Link Access Procedure, Balanced (LAPB), Switched Multimegabit Data Service (SMDS), and X.25 networks.
- Provides concurrent routing and bridging, which is the ability to bridge a given protocol on some interfaces in a router and concurrently route that protocol on other interfaces in the same router.
- Provides integrated routing and bridging, which is the ability to route a given protocol between routed interfaces and bridge groups, or to route a given protocol between bridge groups.
- Provides fast-switched transparent bridging for Frame Relay encapsulated serial and High-Speed Serial Interface (HSSI) interfaces, according to the format specified in RFC 1490.
- Provides fast-switched transparent bridging for the ATM interface on Cisco 7000 series routers, Cisco 4500, and Cisco 4000 series routers, according to the format specified in RFC 1483.
- Provides for compression of LAT frames to reduce LAT traffic through the network.
- Provides both bridging and routing of VLANs.

Cisco access servers and routers can be configured to serve as both multiprotocol routers and MAC-level bridges, bridging any traffic that cannot otherwise be routed. For example, a router routing the IP can also bridge DEC's LAT protocol or NetBIOS traffic.

Cisco routers also support remote bridging over synchronous serial lines. As with frames received on all other media types, dynamic learning and configurable filtering applies to frames received on serial lines.

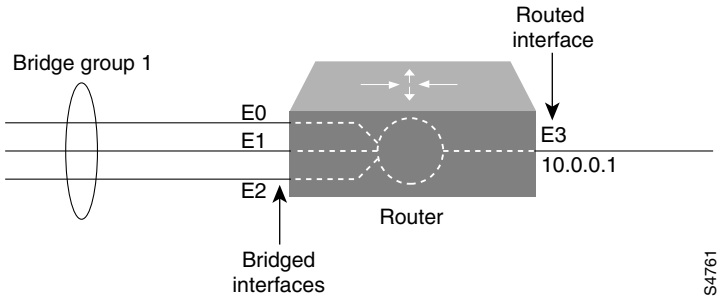
Transit bridging of Ethernet frames across FDDI media is also supported. The term *transit* refers to the fact that the source or destination of the frame cannot be on the FDDI media itself. This allows FDDI to act as a highly efficient backbone for the interconnection of many bridged networks. The configuration of FDDI transit bridging is identical to the configuration of transparent bridging on all other media types.

Integrated Routing and Bridging

While concurrent routing and bridging makes it possible to both route and bridge a specific protocol on separate interfaces within a router, the protocol is not switched between bridged and routed interfaces. Routed traffic is confined to the routed interfaces; bridged traffic is confined to bridged interfaces. A specified protocol may be either routed or bridged on a given interface, but not both.

Integrated routing and bridging makes it possible to route a specific protocol between routed interfaces and bridge groups, or route a specific protocol between bridge groups. Local or unroutable traffic can be bridged among the bridged interfaces in the same bridge group, while routable traffic can be routed to other routed interfaces or bridge groups. Figure 1 illustrates how integrated routing and bridging in a router interconnects a bridged network with a routed network.

Figure 1 Integrated Routing and Bridging Interconnecting a Bridged Network with a Routed Network



You can configure the Cisco IOS software to route a specific protocol between routed interfaces and bridge groups or to route a specific protocol between bridge groups. Specifically, local or unroutable traffic is bridged among the bridged interfaces in the same bridge group, while routable traffic is routed to other routed interfaces or bridge groups. Using integrated routing and bridging, you can do the following:

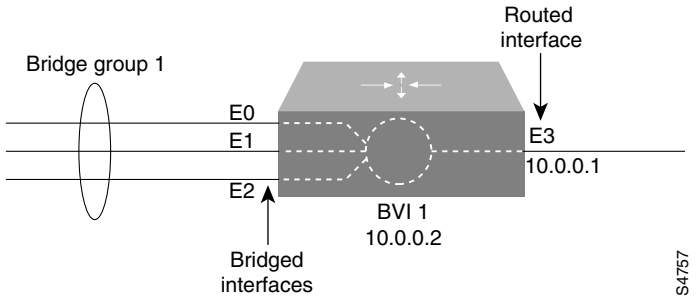
- Switch packets from a bridged interface to a routed interface
- Switch packets from a routed interface to a bridged interface
- Switch packets within the same bridge group

Bridge-Group Virtual Interface

Because bridging operates in the data link layer and routing operates in the network layer, they follow different protocol configuration models. Taking the basic IP model as an example, all bridged interfaces would belong to the same network, while each routed interface represents a distinct network.

In integrated routing and bridging, the bridge-group virtual interface is introduced to avoid confusing the protocol configuration model when a specific protocol is both bridged and routed in a bridge group. Figure 2 illustrates the bridge-group virtual interface as a user-configured virtual interface residing within a router.

Figure 2 Bridge-Group Virtual Interface in the Router



The bridge-group virtual interface is a normal routed interface that does not support bridging, but does represent its corresponding bridge group to the routed interface. It has all the network layer attributes (such as a network layer address and filters) that apply to the corresponding bridge group. The interface number assigned to this virtual interface corresponds to the bridge group that this virtual interface represents. This number is the link between the virtual interface and the bridge group.

When you enable routing for a given protocol on the bridge-group virtual interface, packets coming from a routed interface, but destined for a host in a bridged domain, are routed to the bridge-group virtual interface and are forwarded to the corresponding bridged interface. All traffic routed to the bridge-group virtual interface is forwarded to the corresponding bridge group as bridged traffic. All routable traffic received on a bridged interface is routed to other routed interfaces as if it is coming directly from the bridge-group virtual interface.

To receive routable packets arriving on a bridged interface but destined for a routed interface or to receive routed packets, the bridge-group virtual interface must also have the appropriate addresses. MAC addresses and network addresses are assigned to the bridge-group virtual interface as follows:

- The bridge-group virtual interface “borrows” the MAC address of one of the bridged interfaces in the bridge group associated with the bridge-group virtual interface.
- To route and bridge a given protocol in the same bridge group, you must configure the network layer attributes of the protocol on the bridge-group virtual interface. No protocol attributes should be configured on the bridged interfaces, and no bridging attributes can be configured on the bridge-group virtual interface.

Note When a bridged domain contains learning devices (such as switches or bridges) that can learn the MAC address of a bridge-group virtual interface, the virtual interface must be configured with its own MAC address—separate from the MAC addresses of the bridged interfaces in the bridge group that are associated with the virtual interface. The MAC address is configured by using the **mac-address** virtual interface command.

Because there can be only one bridge-group virtual interface representing a bridge group, and the bridge group can be made up of different media types configured for several different encapsulation methods, you may need to configure the bridge-group virtual interface with the particular encapsulation methods required to switch packets correctly.

For example, the bridge-group virtual interface has default data link and network layer encapsulations that are the same as those available on Ethernet interfaces, but you can configure the bridge-group virtual interface with encapsulations that are not supported on an Ethernet interface. In some cases, the default encapsulations provide appropriate results; in other cases they do not. For example, with default encapsulation, Advanced Research Projects Agency (ARPA) packets from the bridge-group virtual interface are translated to Subnetwork Access Protocol (SNAP) when bridging IP to a Token Ring- or FDDI-bridged interface. But for Internet Packet Exchange (IPX), Novell-ether encapsulation from the

bridge-group virtual interface is translated to raw-token or raw-FDDI when bridging IPX to a Token Ring- or FDDI-bridged interface. Because this behavior is usually not what you want, you must configure IPX SNAP or Service Advertisement Protocol (SAP) encapsulation on the bridge-group virtual interface.

Other Considerations

The following are additional facts regarding the support of integrated routing and bridging:

- Integrated routing and bridging is not supported on cBus platforms (AGS+ and Cisco 7000 series routers).
- Integrated routing and bridging is supported for transparent bridging, but not for source-route bridging (SRB).
- Integrated routing and bridging is supported on all media interfaces except X.25 and Integrated Services Digital Network (ISDN) bridged interfaces.
- Integrated routing and bridging supports three protocols: IP, IPX, and AppleTalk in both fast-switching and process-switching modes.
- Integrated routing and bridging and concurrent routing and bridging cannot operate at the same time.
- With integrated routing and bridging configured, associate Layer-3 attributes only on the bridge-group virtual interface and not on the bridging interfaces. Having IP addresses both on the bridge-group virtual interface and on the bridging interfaces is known to produce inconsistent behavior.
- The IEEE 802.1Q standard enables integrated routing and bridging to support connectivity for multiple VLANs using a Bridge-Group Virtual Interface (BVI) to associate a bridge group.

SRT Bridging Features

Cisco routers support transparent bridging on Token Ring interfaces that support SRT bridging. Both transparent and SRT bridging are supported on all Token Ring interface cards that can be configured for either 4- or 16-MB transmission speeds.

As with other media, all the features that use **bridge-group** commands can be used on Token Ring interfaces. As with other interface types, the bridge group can be configured to run either the IEEE or DEC Spanning Tree Protocols. When configured for the IEEE Spanning Tree Protocol, the bridge cooperates with other SRT bridges and constructs a loop-free topology across the entire extended LAN.

You can also run the DEC Spanning Tree Protocol over Token Ring. Use it when you have other non-IEEE bridges on other media and you do not have any SRT bridges on Token Ring. In this configuration, all the Token Ring transparent bridges must be Cisco routers. This is because the DEC Spanning Tree Protocol has not been standardized on Token Ring.

As specified by the SRT bridging specification, only packets without a routing information field (RIF) (RII = 0 in the SA field) are transparently bridged. Packets with a RIF (RII = 1) are passed to the SRB module for handling. An SRT-capable Token Ring interface can have both SRB and transparent bridging enabled at the same time. However, with SRT bridging, frames that did not have a RIF when they were produced by their generating host never gain a RIF, and frames that did have a RIF when they were produced never lose that RIF.

Note Because bridges running only SRT bridging never add or remove RIFs from frames, they do not integrate SRB with transparent bridging. A host connected to a source-route bridge that expects RIFs can *never* communicate with a device across a bridge that does not understand RIFs. SRT bridging cannot tie in existing source-route bridges to a transparent bridged network. To tie in existing bridges, you must use source-route translational bridging (SR/TLB) instead. SR/TLB is described in the chapter "Configuring Source-Route Bridging."

Bridging between Token Ring and other media requires certain packet transformations. In all cases, the MAC addresses are bit-swapped because the bit ordering on Token Ring is different from that on other media. In addition, Token Ring supports one packet format, logical link control (LLC), while Ethernet supports two formats (LLC and Ethernet).

The transformation of LLC frames between media is simple. A length field is either created (when the frame is sent to non-Token Ring) or removed (when the frame is sent to Token Ring). When an Ethernet format frame is sent to Token Ring, the frame is translated into an LLC-1 SNAP packet. The destination service access point (DSAP) value is AA, the source service access point (SSAP) value is AA, and the organizational unique identifier (OUI) value is 0000F8. Likewise, when a packet in LLC-1 format is bridged onto Ethernet media, the packet is translated into Ethernet format.

Caution Bridging between dissimilar media presents several problems that can prevent communication from occurring. These problems include bit order translation (or using MAC addresses as data), maximum transmission unit (MTU) differences, frame status differences, and multicast address usage. Some or all these problems might be present in a multimedia bridged LAN. Because of differences in the way end nodes implement Token Ring, these problems are most prevalent when bridging between Token Ring and Ethernet or between Ethernet and FDDI LANs.

Problems currently occur with the following protocols when bridged between Token Ring and other media: Novell IPX, DECnet Phase IV, AppleTalk, Banyan VINES, Xerox Network Systems (XNS), and IP. Further, problems can occur with the Novell IPX and XNS protocols when bridged between FDDI and other media. We recommend that these protocols be routed whenever possible.

Transparent and SRT Bridging Configuration Task List

To configure transparent bridging or SRT bridging on your router, complete one or more of the tasks in the following sections:

- Configuring Transparent and IRB Bridging on a PA-12E/2FE Ethernet Switch, page 32

See the "Transparent and SRT Bridging Configuration Examples" section on page 39 for examples.

Configuring Transparent Bridging and SRT Bridging

To configure transparent and SRT bridging, you must perform the following tasks:

- Assigning a Bridge Group Number and Defining the Spanning Tree Protocol, page 7
- Assigning Each Network Interface to a Bridge Group, page 7
- Choosing the OUI for Ethernet Type II Frames, page 8

Assigning a Bridge Group Number and Defining the Spanning Tree Protocol

The first step in setting up your transparent bridging network is to define a Spanning Tree Protocol and assign a bridge group number. You can choose either the IEEE 802.1D Spanning Tree Protocol, the earlier DEC protocol upon which this IEEE standard is based or VLAN bridge Spanning Tree Protocol. Cisco expanded the original 802.1 D Spanning Tree Protocol by providing VLAN bridge Spanning Tree Protocol support and increased port identification capability. Furthermore, the enhancement provides:

- More than one byte on a port number to distinguish interfaces
- An improved way to form the port ID

Port Number size of the Port ID support is applied only to IEEE and VLAN-bridge Spanning Tree Protocols. The DEC protocol only has 8 bits on the Port ID, so the extension of the Port ID cannot be applied.

The expansion of the Port Number field into the port priority portion of the Port ID changes the useful values the port priority can be assigned.

The way to calculate the Port Path Cost is only supported in IEEE and VLAN-bridge Spanning Tree Protocol environment.

To assign a bridge group number and define a Spanning Tree Protocol, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge` *bridge-group* `protocol {ieee | dec | vlan-bridge}`	Assigns a bridge group number and defines a Spanning Tree Protocol as IEEE 802.1D standard, DEC or VLAN bridge.

The IEEE 802.1D Spanning Tree Protocol is the preferred way of running the bridge. Use the DEC Spanning Tree Protocol only for backward compatibility. The VLAN-bridge Spanning Tree Protocol supports the following media: Ethernet, Fast Ethernet, FDDI, ATM and serial (HDLC, PPP, Frame Relay IETF, SMDS, X.25).

Assigning Each Network Interface to a Bridge Group

A bridge group is an internal organization of network interfaces on a router. Bridge groups cannot be used outside the router on which it is defined to identify traffic switched within the bridge group. Bridge groups within the same router function as distinct bridges; that is, bridged traffic and bridge protocol data units (BPDUs cannot be exchanged between different bridge groups on a router. Furthermore, bridge groups cannot be used to multiplex or de-multiplex different streams of bridged traffic on a LAN.

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 router. Typically, only one such network exists in a configuration.

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's destination address is known in the bridge table, it is forwarded on a single interface in the bridge group. If the packet's destination is unknown 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 process of bridging.
- 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. A bridge group establishes a spanning tree based on the BPDUs it receives on only its member interfaces.

For SRT bridging, if the Token Ring and serial interfaces are in the same bridge group, changing the serial encapsulation method causes the state of the corresponding Token Ring interface to be reinitialized. Its state will change from "up" to "initializing" to "up" again within a few seconds.

After you assign a bridge group number and define a Spanning Tree Protocol, assign each network interface to a bridge group by using the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group*	Assigns a network interface to a bridge group.

Choosing the OUI for Ethernet Type II Frames

For SRT bridging networks, you must choose the organizational unique identifier (OUI) code that will be used in the encapsulation of Ethernet Type II frames across Token Ring backbone networks. To choose the OUI, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# ethernet-transit-oui [90-compatible | standard | cisco]`	Selects the Ethernet Type II OUI encapsulation code.

Transparently Bridged VLANs for ISL

Traditionally, a bridge group is an independently bridged subnetwork. In this definition, bridge groups cannot exchange traffic with other bridge groups, nor can they multiplex or de-multiplex different streams of bridged traffic. The transparently bridged VLAN feature in Cisco IOS software permits a bridge group to extend outside the router to identify traffic switched within the bridge group.

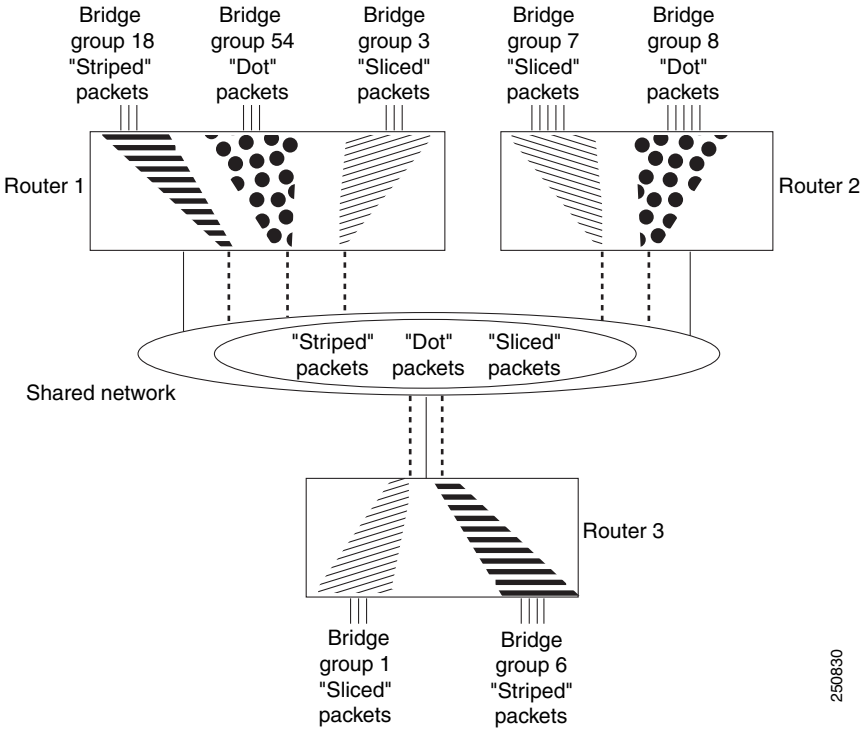
While bridge groups remain internal organizations of network interfaces functioning as distinct bridges within a router, transparent bridging on subinterfaces permits bridge groups to be used to multiplex different streams of bridged traffic on a LAN or HDLC serial interface. In this way, bridged traffic may be switched out of one bridge group on one router, multiplexed across a subinterface, and demultiplexed into a second bridge group on a second router. Together, the first bridge group and the second bridge group form a transparently bridged VLAN. This approach can be extended to impose logical topologies upon transparently bridged networks.

The primary application of transparently bridged VLANs constructed in this way is to separate traffic between bridge groups of local network interfaces, to multiplex bridged traffic from several bridge groups on a shared interface (LAN or HDLC serial), and to form VLANs composed of collections of bridge groups on several routers. These VLANs improve performance because they reduce the propagation of locally bridged traffic, and they improve security benefits because they completely separate traffic.

In Figure 3, different bridge groups on different routers are configured into three VLANs that span the bridged network. Each bridge group consists of conventionally bridged local interfaces and a subinterface on the backbone FDDI LAN. Bridged traffic on the subinterface is encapsulated and "colored" with a VLAN identifier known as a *security association identifier* common to all bridge groups participating in the VLAN. In addition, bridges only accept packets bearing security association identifiers for which they have a configured subinterface. Thus, a bridge group is configured to participate in a VLAN if it contains a subinterface configured with the VLAN's characteristic security association identifier. See the "Complex Integrated Routing and Bridging Example" section on page 42 for an example configuration of the topology shown in Figure 3.

Note The 802.10 encapsulation used to "color" transparently bridged packets on subinterfaces might increase the size of a packet so that it exceeds the MTU size of the LAN from which the packet originated. To avoid MTU violations on the shared network, the originating LANs must either have a smaller native MTU than the shared network (as is the case from Ethernet to FDDI), or the MTU on all packet sources on the originating LAN must be configured to be at least 16 bytes less than the MTU of the shared network.

Figure 3 Transparently Bridged VLANs on an FDDI Backbone



To configure a VLAN on a transparently bridged network, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface type slot/port.subinterface-number`	Specifies a subinterface.
Step 2	`Router(config-if)# encapsulation sde said`	Specifies the IEEE 802.10 Security data exchange security association identifier (in other words, specifies the "color").
Step 3	`Router(config-if)# bridge-group bridge-group`	Associates the subinterface with an existing bridge group.

Transparently bridged VLANs are supported in conjunction with only the IEEE Spanning Tree Protocol. When you logically segment a transparently bridged network into VLANs, each VLAN computes its own spanning-tree topology. Configuring each VLAN to compute its own spanning-tree topology provides much greater stability than running a single spanning tree throughout. Traffic bridged within one VLAN is unaffected by physical topology changes occurring within another VLAN.

Note The current implementation of SDE encapsulation is not recommended for serial or Ethernet media.

Routing between ISL VLANs

Our VLAN Routing implementation is designed to operate across all router platforms. However, the Inter-Switch Link (ISL) VLAN trunking protocol currently is defined on 100 BaseTX/FX Fast Ethernet interfaces only and therefore is appropriate to the Cisco 7000 and higher-end platforms only. The IEEE 802.10 protocol can run over any LAN or HDLC serial interface. VLAN traffic is fast switched. The actual format of these VLAN encapsulations are detailed in the *IEEE Standard 802.10-1992 Secure Data Exchange* and in the *Inter-Switch Link (ISL) Protocol Specification*.

Our VLAN Routing implementation treats the ISL and 802.10 protocols as encapsulation types. On a physical router interface that receives and sends VLAN packets, you can select an arbitrary subinterface and map it to the particular VLAN "color" embedded within the VLAN header. This mapping allows you to selectively control how LAN traffic is routed or switched outside of its own VLAN domain. In the VLAN routing paradigm, a switched VLAN corresponds to a single routed subnet, and the network address is assigned to the subinterface.

To route a received VLAN packet the Cisco IOS software VLAN switching code first extracts the VLAN ID from the packet header (this is a 10-bit field in the case of ISL and a 4-byte entity known as the security association identifier in the case of IEEE 802.10), then demultiplexes the VLAN ID value into a subinterface of the receiving port. If the VLAN color does not resolve to a subinterface, the Cisco IOS software can transparently bridge the foreign packet natively (without modifying the VLAN header) on the condition that the Cisco IOS software is configured to bridge on the subinterface itself. For VLAN packets that bear an ID corresponding to a configured subinterface, received packets are then classified by protocol type before running the appropriate protocol specific fast switching engine. If the subinterface is assigned to a bridge group then non-routed packets are de-encapsulated before they are bridged. This is termed "fall-back bridging" and is most appropriate for nonroutable traffic types.

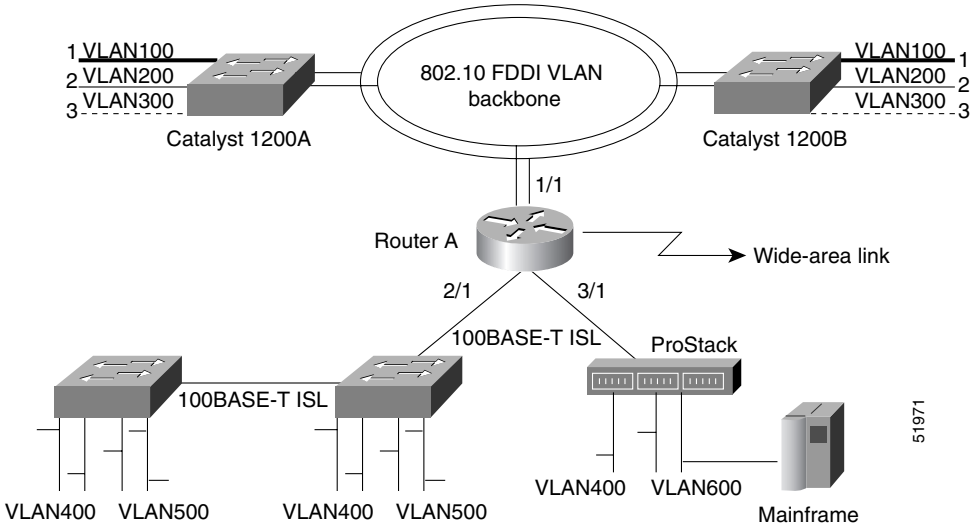
In Figure 4, Router A provides inter-VLAN connectivity between multiple Cisco switching platforms where there are three distinct virtual topologies present. For example, for VLAN 300 across the two Catalyst 1200A segments, traffic originating on LAN interface 1 is "tagged" with a VLAN ID of 300 as it is switched onto the FDDI ring. This ID allows the remote Catalyst 1200A to make an intelligent forwarding decision and only switch the traffic to local interfaces configured as belonging to the same

VLAN broadcast domain. Router A provides an inter-VLAN mechanism that lets Router A function as a gateway for stations on a given LAN segment by sending VLAN encapsulated traffic to and from other switched VLAN domains or simply sending traffic in native (non-VLAN) format.

Figure 4 illustrates the following scenarios:

- Clients on VLAN 300 want to establish sessions with a server attached to a port in a different VLAN (600). In this scenario, packets originating on LAN interface 3 of the Catalyst 1200B switch are tagged with an 802.10 header with a security association identifier of 300 as they are forwarded onto the FDDI ring. Router A can accept these packets because it is configured to route VLAN 300, classify and make a Layer 3 forwarding decision based on the destination network address and the route out (in this case Fast Ethernet 3/1), and adding the ISL VLAN header (color 200) appropriate to the destination subnet as the traffic is switched.
- There is a network requirement to bridge two VLANs together through the system rather than selectively route certain protocols. In this scenario the two VLAN IDs are placed in the same bridge group. Note that they form a single broadcast domain and spanning tree, effectively forming a single VLAN.

Figure 4 Inter-VLAN Connectivity between Multiple Switching Platforms



See the "Routing Between VLANs Configuration Example" section on page 47 for an example configuration of the topology shown in Figure 4.

To configure routing between VLANs, enter the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface type slot/port.subinterface-number`	Specifies a subinterface.
Step 2	`Router(config-if)# encapsulation {sde | isl} domain`	Specifies the encapsulation type (either ISL or SDE) and the VLAN domain.
Step 3	`Router(config-if)# bridge-group bridge-group`	Associates the subinterface with the VLAN.

Configuring a Subscriber Bridge Group

The digital subscriber line (DSL) bridge support feature enables you to configure a router for intelligent bridge flooding for DSL and other bridge applications. To configure a subscriber bridge group, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# bridge bridge-group protocol {ieee | dec | vlan-bridge}`	Defines the bridge Spanning Tree Protocol.
Step 2	`Router(config)# bridge bridge-group subscriber-policy policy`	Defines a subscriber bridge group and specifies the subscriber policy for the group.
Step 3	`Router(config)# subscriber-policy policy [[no] [default] packet [permit] [deny]]`	Defines or modifies the forward and filter decisions of the subscriber policy.
Step 4	`Router(config)# interface type number`	Configures a subinterface.
Step 5	`Router(config-if)# bridge-group bridge-group [subscriber-trunk]`	Assigns a subscriber bridge group and indicates whether the interface is upstream or downstream from the traffic flow.

Note Standard access lists can coexist with the subscriber policy. However, subscriber policy will take precedence over the access list by being checked first. A packet permitted by the subscriber policy will be checked against the access list if it is specified. A packet denied by subscriber policy will be dropped with no further access list checking.

Configuring Transparent Bridging over WANs

You can configure transparent bridging over a variety of networks, as described in the following sections:

Configuring Fast-Switched Transparent Bridging over ATM

Our bridging implementation supports IEEE 802.3 frame formats and IEEE 802.10 frame formats. Our implementation can transparently bridge ARPA style Ethernet packets (also known as Ethernet version 2).

Fast-switched transparent bridging over Asynchronous Transfer Mode (ATM) supports AAL5-SNAP encapsulated packets only. All bridged AAL5-SNAP encapsulated packets are fast switched. Fast-switched transparent bridging supports Ethernet, FDDI, and Token Ring packets sent in AAL5-SNAP encapsulation over ATM. See the "Fast-Switched Transparent Bridging over ATM Example (Cisco 7000)" section on page 54 for an example configuration of fast-switched transparent bridging over ATM.

Support for RFC 1483 was added in Cisco IOS Release 12.0(3)T, enabling transparent bridging between Token Ring LANs (using AAL5-SNAP PVCs) and LANs, VLANs or ELANS (using bridged PDUs). RFC 1483 defines an encapsulation type for transferring LAN data via ATM networks.

For more information on configuring ATM, refer to the "Configuring ATM" chapter in the *Cisco IOS Wide-Area Networking Configuration Guide*.

Configuring Transparent Bridging over DDR

The Cisco IOS software supports transparent bridging over dial-on-demand routing (DDR) and provides you some flexibility in controlling access and configuring the interface.

To configure DDR for bridging, complete the tasks in the following sections:

- Defining the Protocols to Bridge, page 13
- Specifying the Bridging Protocol, page 13
- Determining Access for Bridging, page 14
- Configuring an Interface for Bridging, page 14

For an example of configuring transparent bridging over DDR, see the "Transparent Bridging over DDR Examples" section on page 55.

Defining the Protocols to Bridge

IP packets are routed by default unless they are explicitly bridged; all others are bridged by default unless they are explicitly routed.

To bridge IP packets, use the following command in global configuration mode:

Command	Purpose
`Router(config)# no ip routing`	Disables IP routing.

If you choose *not* to bridge another protocol, use the relevant command to enable routing of that protocol. For more information about tasks and commands, refer to the relevant protocol chapters in the following publications:

- *Cisco IOS IP and IP Routing Configuration Guide*
- *Cisco IOS AppleTalk and Novell IPX Configuration Guide*
- *Cisco IOS Apollo Domain, Banyan VINES, DECnet, ISO CLNS, and XNS Configuration Guide*

Specifying the Bridging Protocol

You must specify the type of spanning-tree bridging protocol to use and also identify a bridge group. To specify the Spanning Tree Protocol and a bridge group number, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge` *bridge-group* `protocol {ieee | dec | vlan-bridge}`	Defines the type of Spanning Tree Protocol and identifies a bridge group.

The bridge group number is used when you configure the interface and assign it to a bridge group. Packets are bridged only among members of the same bridge group.

Determining Access for Bridging

You can determine access by either permitting all bridge packets or by controlling access according to Ethernet type codes.

To permit all transparent bridge packets, use the following command in global configuration mode:

Command	Purpose
`Router(config)# dialer-list` *dialer-group* **protocol bridge permit**	Defines a dialer list that permits all transparent bridge packets.

To control access by Ethernet type codes, use the following commands in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# access-list` *access-list-number* {**permit** | **deny**} *type-code* [*mask*]	Permits packets according to Ethernet type codes (access list numbers must be in the range 200 to 299).
Step 2	`Router(config)# dialer-list` *dialer-group* **protocol bridge list** *access-list-number*	Defines a dialer list for the specified access list.

For a table of some common Ethernet types codes, see the "Ethernet Types Codes" appendix in the *Cisco IOS Bridging and IBM Networking Command Reference* (Volume 1 of 2).

Configuring an Interface for Bridging

You can configure serial interfaces or ISDN interfaces for DDR bridging. To configure an interface for DDR bridging, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface` *type number*	Specifies the serial or ISDN interface and initiates interface configuration mode.
Step 2	`Router(config-if)# dialer string` *dial-string* **dialer map bridge** [**name** *hostname*] [**broadcast**] *dial-string*[**:***isdn-subaddress*]	Configures the dial string to call. or Configures a dialer bridge map.
Step 3	`Router(config-if)# bridge-group` *bridge-group*	Assigns the specified interface to a bridge group.

Configuring Transparent Bridging over Frame Relay

The transparent bridging software supports bridging of packets over Frame Relay networks. This ability is useful for such tasks as sending packets from proprietary protocols across a Frame Relay network. Bridging over a Frame Relay network is supported both on networks that support a multicast facility and those that do not. Both cases are described in this section.

Fast-Switched Transparent Bridging

The transparent bridging software provides fast-switched transparent bridging for Frame Relay encapsulated serial and High-Speed Serial Interface (HSSI) networks.

Switched virtual circuits (SVCs) are not supported for transparent bridging in this release. All the Permanent virtual circuits (PVCs) configured on a subinterface must belong to the same bridge group.

Bridging in a Frame Relay Network with No Multicasts

The Frame Relay bridging software uses the same spanning-tree algorithm as the other bridging functions, but allows packets to be encapsulated for sending across a Frame Relay network. You specify IP-to-data-link connection identifier (DLCI) address mapping and the system maintains a table of both the Ethernet address and the DLCIs.

To configure bridging in a network that does not support a multicast facility, define the mapping between an address and the DLCI used to connect to the address. To bridge with no multicasts, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)#` **`frame-relay map bridge`** *`dlci`* **`broadcast`**	Defines the mapping between an address and the DLCI used to connect to the address.

An example configuration is provided in the "Frame Relay Transparent Bridging Examples" section on page 52. Frame Relay is discussed in more detail in the "Configuring Frame Relay" chapter in the *Cisco IOS Wide-Area Networking Configuration Guide*.

Bridging in a Frame Relay Network with Multicasts

The multicast facility is used to learn about the other bridges on the network, eliminating the need for you to specify any mappings with the **frame-relay map bridge broadcast** command. An example configuration is provided in the "Frame Relay Transparent Bridging Examples" section on page 52 for use as a configuration guide. Frame Relay is discussed in more detail in the "Configuring Frame Relay" chapter in the *Cisco IOS Wide-Area Networking Configuration Guide*.

Configuring Transparent Bridging over Multiprotocol LAPB

Cisco IOS software implements transparent bridging over multiprotocol Link Access Protocol-Balanced (LAPB) encapsulation on serial interfaces. To configure transparent bridging over multiprotocol LAPB, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)#` **`interface serial`** *`number`*	Specifies the serial interface.
Step 2	`Router(config-if)#` **`no ip address`**	Specifies no IP address to the interface.
Step 3	`Router(config-if)#` **`encapsulation lapb multi`**	Configures multiprotocol LAPB encapsulation.
Step 4	`Router(config-if)#` **`bridge-group`** *`bridge-group`*	Assigns the interface to a bridge group.
Step 5	`Router(config-if)#` **`bridge`** *`bridge-group`* **`protocol`** `{`**`ieee`** `|` **`dec`** `|` **`vlan-bridge`**`}`	Specifies the type of Spanning Tree Protocol.

Note Transparent bridging over multiprotocol LAPB requires use of the **encapsulation lapb multi** command. You cannot use the **encapsulation lapb protocol** command with a **bridge** keyword to configure this feature.

For an example of configuring transparent bridging over multiprotocol LAPB, see the "Transparent Bridging over Multiprotocol LAPB Example" section on page 54".

Configuring Transparent Bridging over SMDS

We support fast-switched transparent bridging for Switched Multimegabit Data Service (SMDS) encapsulated serial and HSSI networks. Standard bridging commands are used to enable bridging on an SMDS interface.

To enable transparent bridging over SMDS, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface serial number`	Specifies the serial interface.
Step 2	`Router(config-if)# encapsulation smds`	Configures SMDS encapsulation on the serial interface.
Step 3	`Router(config-if)# bridge-group bridge-group`	Associates the interface with a bridge group.
Step 4	`Router(config-if)# smds multicast bridge smds-address`	Enables transparent bridging of packets across an SMDS network.

Broadcast Address Resolution Protocol (ARP) packets are treated differently in transparent bridging over an SMDS network than in other encapsulation methods. For SMDS, two packets are sent to the multicast address. One is sent using a standard (SMDS) ARP encapsulation; the other is sent with the ARP packet encapsulated in an 802.3 MAC header. The native ARP is sent as a regular ARP broadcast.

Our implementation of IEEE 802.6i transparent bridging for SMDS supports 802.3, 802.5, and FDDI frame formats. The router can accept frames with or without frame check sequence (FCS). Fast-switched transparent bridging is the default and is not configurable. If a packet cannot be fast switched, it is process switched.

An example configuration is provided in the "Fast-Switched Transparent Bridging over SMDS Example" section on page 55. For more information on SMDS, refer to the "Configuring SMDS" chapter in the *Cisco IOS Wide-Area Networking Configuration Guide*.

Configuring Transparent Bridging over X.25

The transparent bridging software supports bridging of packets in X.25 frames. This ability is useful for such tasks as sending packets from proprietary protocols across an X.25 network.

The X.25 bridging software uses the same spanning-tree algorithm as the other bridging functions, but allows packets to be encapsulated in X.25 frames and sent across X.25 media. You specify the IP-to-X.121 address mapping, and the system maintains a table of both the Ethernet and X.121 addresses. To configure X.25 transparent bridging, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# x25 map bridge x.121-address broadcast [options-keywords]`	Specifies IP-to-X.121 mapping for bridging over X.25.

For more information about configuring X.25, refer to the "Configuring X.25 and LAPB" chapter in the *Cisco IOS Wide-Area Networking Configuration Guide*.

Configuring Concurrent Routing and Bridging

You can configure the Cisco IOS software to route a given protocol among one group of interfaces and concurrently bridge that protocol among a separate group of interfaces, all within one router. The given protocol is not switched between the two groups. Rather, routed traffic is confined to the routed interfaces and bridged traffic is confined to the bridged interfaces. A protocol may be either routed or bridged on a given interface, but not both.

The concurrent routing and bridging capability is, by default, disabled. While concurrent routing and bridging is disabled, the Cisco IOS software absorbs and discards bridgeable packets in protocols that are configured for routing on any interface in the router.

When concurrent routing and bridging is first enabled in the presence of existing bridge groups, it will generate a bridge route configuration command for any protocol for which any interface in the bridge group is configured for routing. This is a precaution that applies only when concurrent routing and bridging is not already enabled, bridge groups exist, and the **bridge crb** command is encountered.

To enable concurrent routing and bridging in the Cisco IOS software, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge crb`	Enables concurrent routing and bridging.

Information about which protocols are routed and which are bridged is stored in a table, which can be displayed with the **show interfaces crb** privileged EXEC command.

When concurrent routing and bridging has been enabled, you must configure an explicit bridge route command for any protocol that is to be routed on the interfaces in a bridge group in addition to any required protocol-specific interface configuration.

To configure specific protocols to be routed in a bridge group, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# bridge` *bridge-group* `route` *protocol*	Enables the routing of a specified protocol in a specified bridge group.

Configuring Integrated Routing and Bridging

Perform one or more of the following tasks to configure integrated routing and bridging on your router:

- Assigning a Bridge Group Number and Defining the Spanning Tree Protocol, page 7
- Configuring Interfaces, page 18
- Enabling Integrated Routing and Bridging, page 18
- Configuring the Bridge-Group Virtual Interface, page 18
- Configuring Protocols for Routing or Bridging, page 19

Assigning a Bridge Group Number and Defining the Spanning Tree Protocol

Prior to configuring the router for integrated routing and bridging, you must enable bridging by setting up a bridge group number and specifying a Spanning Tree Protocol. You can choose either the IEEE 802.1D Spanning Tree Protocol or the earlier Digital protocol upon which this IEEE standard is based.

To assign a bridge group number and define a Spanning Tree Protocol, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge` *bridge-group* `protocol {ieee | dec | vlan-bridge}`	Assigns a bridge group number and defines a Spanning Tree Protocol.

The IEEE 802.1D Spanning Tree Protocol is the preferred way of running the bridge. Use the Digital Spanning Tree Protocol only for backward compatibility.

Configuring Interfaces

To configure a router interface in the Cisco IOS software, use the following commands beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface` *type number*	Specifies the interface and enters interface configuration mode.
Step 2	`Router(config-if)# port`	Specifies concentrator port operation.
Step 3	`Router(config-if)# bridge-group` *bridge-group*	Assigns bridge-groups to appropriate interfaces.

Enabling Integrated Routing and Bridging

After you have set up the interfaces in the router, you can enable integrated routing and bridging.

To enable integrated routing and bridging in the Cisco IOS software, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge irb`	Enables integrated routing and bridging.

Use the **show interfaces irb** privileged EXEC command to display the protocols that a given bridged interface can route to the other routed interface when the packet is routable, and to display the protocols that a given bridged interface bridges.

Configuring the Bridge-Group Virtual Interface

The bridge-group virtual interface resides in the router. It acts like a normal routed interface that does not support bridging, but represents the entire corresponding bridge group to routed interfaces within the router. The bridge-group virtual interface is assigned the number of the bridge group that it represents. The bridge-group virtual interface number is the link between the bridge-group virtual interface and its

bridge group. Because the bridge-group virtual interface is a virtual routed interface, it has all the network layer attributes, such as a network address and the ability to perform filtering. Only one bridge-group virtual interface is supported for each bridge group.

When you enable routing for a given protocol on the bridge-group virtual interface, packets coming from a routed interface but destined for a host in a bridged domain are routed to the bridge-group virtual interface, and are forwarded to the corresponding bridged interface. All traffic routed to the bridge-group virtual interface is forwarded to the corresponding bridge group as bridged traffic. All routable traffic received on a bridged interface is routed to other routed interfaces as if it is coming directly from the bridge-group virtual interface.

To create a bridge-group virtual interface, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# interface bvi bridge-group`	Enables a bridge-group virtual interface.

When you intend to bridge and route a given protocol in the same bridge group, you must configure the network-layer attributes of the protocol on the bridge-group virtual interface. Do not configure protocol attributes on the bridged interfaces. No bridging attributes can be configured on the bridge-group virtual interface.

Although it is generally the case that all bridged segments belonging to a bridge group are represented as a single segment or network to the routing protocol, there are situations where several individual networks coexist within the same bridged segment. To make it possible for the routed domain to learn about the other networks behind the bridge-group virtual interface, configure a secondary address on the bridge-group virtual interface to add the corresponding network to the routing process.

Configuring Protocols for Routing or Bridging

When integrated routing and bridging is enabled, the default route/bridge behavior in a bridge group is to bridge all packets.

You could then explicitly configure the bridge group to route a particular protocol, so that routable packets of this protocol are routed, while nonroutable packets of this protocol or packets for protocols for which the bridge group is not explicitly configured to route will be bridged.

You could also explicitly configure the bridge group so that it does not bridge a particular protocol, so that routable packets of this protocol are routed when the bridge is explicitly configured to route this protocol, and nonroutable packets are dropped because bridging is disabled for this protocol.

Note Packets of nonroutable protocols such as LAT are only bridged. You cannot disable bridging for the nonroutable traffic.

To configure specific protocols to be routed or bridged in a bridge group, use one or more of the following commands in global configuration mode, as needed:

Command	Purpose
`Router(config)# bridge bridge-group route protocol`	Enables the routing of a specified protocol in a specified bridge group.
`Router(config)# no bridge bridge-group route protocol`	Disables the routing of a specified protocol in a specified bridge group.

Command	Purpose
`Router(config)# bridge bridge-group bridge protocol`	Specifies that a protocol is to be bridged in the bridge group.
`Router(config)# no bridge bridge-group bridge protocol`	Specifies that a protocol is not to be bridged in the bridge group.

Note When a bridge group contains Token Ring interfaces, the Token Ring packets must not include RIF. The IEEE 802.1d transparent bridge standard specifies that frames with source routing information are to be dropped by transparent bridges; therefore, if Token Ring traffic includes RIF, it will be dropped. RIF is designated by the RII, which is the first bit of the MAC address. RII=1 indicates that the packet comes with RIF, RII=0 indicates that the frame does not come with RIF.

For example, to bridge AppleTalk, bridge and route IPX, and route IP in the same bridge group, you would do the following:

- Bridge AppleTalk—Because integrated routing and bridging bridges everything by default, no configuration is required to bridge AppleTalk.
- Bridge and route IPX—After using the **bridge irb** command to enable integrated routing and bridging, and the **interface bvi** command to create the bridge-group virtual interface for the bridge group, you would use the **bridge route** command to both bridge and route IPX (bridging is already enabled by default; the **bridge route** command enables routing).
- Route IP—Use the **bridge route** command to enable routing, and then use the **no bridge bridge** command to disable bridging.

Note When integrated routing and bridging is not enabled, routing a given protocol means that protocol is not bridged, and bridging a protocol means that protocol is not routed. When integrated routing and bridging is enabled, the disjunct relationship between routing and bridging is broken down, and a given protocol can be switched between routed and bridged interfaces on a selective, independent basis.

Configuring Transparent Bridging Options

You can configure one or more transparent bridging options. To configure transparent bridging options, perform one or more of the tasks in the following sections:

Disabling IP Routing

If you want to bridge IP, you must disable IP routing because IP routing is enabled by default on the Cisco IOS software. You can enable IP routing when you decide to route IP packets. To disable or enable IP routing, use one of the following commands in global configuration mode, as needed:

Command	Purpose
`Router(config)# no ip routing`	Disables IP routing.
`Router(config)# ip routing`	Enables IP routing.

All interfaces in the bridge group that are bridging IP should have the same IP address. However, if you have more than one bridge group, each bridge group should have its own IP address.

Enabling Autonomous Bridging

Normally, bridging takes place on the processor card at the interrupt level. When autonomous bridging is enabled, bridging takes place entirely on the ciscoBus2 controller, significantly improving performance. Autonomous bridging is a high-speed switching feature that allows bridged traffic to be forwarded and flooded on the ciscoBus2 controller between resident interfaces. If you are using the ciscoBus2 controller, you can maximize performance by enabling autonomous bridging on the following ciscoBus2 interfaces:

- MEC
- FCIT transparent
- HSSI HDLC

Although performance improvements will be seen most in the resident interfaces, the autonomous bridging feature can also be used in bridge groups that include interfaces that are not on the ciscoBus2 controller. These interfaces include the CTR, FCI with encapsulation bridging, and HSSI with encapsulation other than HDLC, such as X.25, Frame Relay, or SMDS, MCI, STR, or SBE16.

If you enable autonomous bridging for a bridge group that includes a combination of interfaces that are resident on the ciscoBus2 controller and some that are not, the ciscoBus2 controller forwards only packets between resident interfaces. Forwarding between nonresident and resident interfaces is done in either the fast or process paths. Flooding between resident interfaces is done by the ciscoBus2 controller. Flooding between nonresident interfaces is done conventionally. If a packet is forwarded from a nonresident to a resident interface, the packet is conventionally forwarded. If packets are flooded from a nonresident interface to a resident interface, the packet is autonomously flooded.

To enable autonomous bridging on a per-interface basis, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group* `cbus-bridging`	Enables autonomous bridging (if using the ciscoBus2 controller).

Note You can filter by MAC-layer address on an interface only when autonomous bridging is enabled on that interface. If any filters or priority queueing is configured, autonomous bridging is automatically disabled.

Configuring LAT Compression

The local-area transport (LAT) protocol used by Digital and Digital-compatible terminal servers is one of the common protocols that lacks a well-defined network layer (Layer 3) and so always must be bridged.

To reduce the amount of bandwidth that LAT traffic consumes on serial interfaces, you can specify a LAT-specific form of compression. Doing so applies compression to LAT frames being sent out by the Cisco IOS software through the interface in question. To configure LAT compression, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group* `lat-compression`	Reduces the amount of bandwidth that LAT traffic consumes on a serial interface.

LAT compression can be specified only for serial interfaces. For the most common LAT operations (user keystrokes and acknowledgment packets), LAT compression reduces LAT's bandwidth requirements by nearly a factor of two.

Establishing Multiple Spanning-Tree Domains

The Cisco IEEE 802.1D bridging software supports spanning-tree domains of bridge groups. Domains are a feature specific to Cisco. This feature is only available if you have specified IEEE as the Spanning Tree Protocol. A domain establishes an external identification of the BPDUs sent from a bridge group. The purpose of this identification is as follows:

- Bridge groups defined within the domain can recognize that BPDU as belonging to them.
- Two bridged subnetworks in different domains that are sharing a common connection can use the domain identifier to identify and then ignore the BPDUs that belong to another domain. Each bridged subnetwork establishes its own spanning tree based on the BPDUs that it receives. The BPDUs it receives must contain the domain number to which the bridged subnetwork belongs. Bridged traffic is not domain identified.

Note Domains do not constrain the propagation of bridged traffic. A bridge bridges nonrouted traffic received on its interfaces regardless of domain.

You can place any number of routers or bridges within the domain. Only the devices within a domain share spanning-tree information.

When multiple routers share the same cable and you want to use only certain discrete subsets of those routers to share spanning-tree information with each other, establish spanning-tree domains. This function is most useful when running other applications, such as IP User Datagram Protocol (UDP) flooding, that use the IEEE spanning tree. You also can use this feature to reduce the number of global reconfigurations in large bridged networks.

To establish multiple spanning-tree domains, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge` *bridge-group* `domain` *domain-number*	Establishes a multiple spanning-tree domain.

For an example of how to configure domains, see the "Complex Transparent Bridging Network Topology Example" section on page 56.

Preventing the Forwarding of Dynamically Determined Stations

Normally, the system forwards any frames for stations that it has learned about dynamically. By disabling this activity, the bridge will only forward frames whose address have been statically configured into the forwarding cache. To prevent or allow forwarding of dynamically determined stations, use one of the following command in global configuration mode:

Command	Purpose
`Router(config)# no bridge bridge-group acquire`	Filters out all frames except those whose addresses have been statically configured into the forwarding cache.
`Router(config)# bridge bridge-group acquire`	Forwards any frames for stations that the system has learned about dynamically.

Forwarding Multicast Addresses

A packet with a RIF, indicated by a source address with the multicast bit turned on, is not usually forwarded. However, you can configure bridging support to allow the forwarding of frames that would otherwise be discarded because they have a RIF. Although you can forward these frames, the bridge table will not be updated to include the source addresses of these frames.

To forward frames with multicast addresses, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge bridge-group multicast-source`	Allows the forwarding of frames with multicast source addresses.

Configuring Bridge Table Aging Time

A bridge forwards, floods, or drops packets based on the bridge table. The bridge table maintains both static entries and dynamic entries. Static entries are entered by the network manager or by the bridge itself. 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 hosts on a bridged network are likely to move, decrease the aging-time to enable the bridge to adapt to the change quickly. If hosts do not send continuously, increase the aging time to record the dynamic entries for a longer time and thus reduce the possibility of flooding when the hosts send again.

To set the aging time, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge-group bridge-group aging-time seconds`	Sets the bridge table aging time.

Filtering Transparently Bridged Packets

A bridge examines frames and sends them through the internetwork according to the destination address; a bridge will not forward a frame back to its originating network segment. The bridge software allows you to configure specific administrative filters that filter frames based upon information other than paths to their destinations. You can perform administrative filtering by performing one of the tasks in the following sections:

- Setting Filters at the MAC Layer, page 24
- Filtering LAT Service Announcements, page 28

Note When setting up administrative filtering, remember that there is virtually no performance penalty in filtering by Media Access Control (MAC) address or vendor code, but there can be a significant performance penalty when filtering by protocol type.

When configuring transparent bridging access control, keep the following points in mind:

- You can assign only one access list to an interface.
- The conditions in the access list are applied to all outgoing packets not sourced by the Cisco IOS software.
- Access lists are scanned in the order you enter them; the first match is used.
- An implicit deny everything entry is automatically defined at the end of an access list unless you include an explicit permit everything entry at the end of the list.
- All new entries to an existing list are placed at the end of the list. You cannot add an entry to the middle of a list. This means that if you have previously included an explicit permit everything entry, new entries will never be scanned. The solution is to delete the access list and retype it with the new entries.
- You can create extended access lists to specify more detailed filters, such as address match only.
- You should not use extended access lists on FDDI interfaces doing transit bridging as opposed to translational bridging.
- Configuring bridging access lists of type 700 may cause a momentary interruption of traffic flow.

For more information on access lists, refer to the “Traffic Filtering and Firewalls” chapter of the *Cisco IOS Security Configuration Guide*.

Setting Filters at the MAC Layer

You can filter the sending of frames at the MAC layer by performing tasks in one of the following sections:

- Filtering by Specific MAC Address, page 25
- Filtering by Vendor Code, page 25
- Filtering by Protocol Type, page 26

When filtering by a MAC-layer address, you can use two kinds of access lists: standard access lists that specify a simple address, and extended access lists that specify two addresses. You can also further restrict access by creating filters for these lists. After you have completed one of the preceding tasks, perform the task in the “Defining and Applying Extended Access Lists” section on page 27.

Note MAC addresses on Ethernets are "bit swapped" when compared with MAC addresses on Token Ring and FDDI. For example, address 0110.2222.3333 on Ethernet is 8008.4444.CCCC on Token Ring and FDDI. Access lists always use the canonical Ethernet representation. When using different media and building access lists to filter on MAC addresses, keep this point in mind. Note that when a bridged packet traverses a serial link, it has an Ethernet-style address.

Filtering by Specific MAC Address

You can filter frames with a particular MAC-layer station source or destination address. Any number of addresses can be configured into the system without a performance penalty. To filter by MAC-layer address, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge bridge-group address mac-address {forward | discard}[interface]`	Filters particular MAC-layer station addresses.

When filtering specific MAC destination addresses, allow for multicast or broadcast packets that are required by the bridged network protocols. Refer to the example in the "Multicast or Broadcast Packets Bridging Example" section on page 50 to guide you in building your configuration to allow for multicast or broadcast packets.

Filtering by Vendor Code

The bridging software allows you to create access lists to administratively filter MAC addresses. These access lists can filter groups of MAC addresses, including those with particular vendor codes. There is no noticeable performance loss in using these access lists, and the lists can be of indefinite length. You can filter groups of MAC addresses with particular vendor codes by performing the first task and one or both of the other tasks that follow:

- Establish a vendor code access list
- Filter source addresses
- Filter destination addresses

To establish a vendor code access list, use the following command in global configuration mode:

Command	Purpose
`Router(config)# access-list access-list-number {permit | deny} address mask`	Prepares access control information for filtering of frames by canonical (Ethernet-ordered) MAC address.

The vendor code is the first three bytes of the MAC address (left to right). For an example of how to filter by vendor code, see the "Multicast or Broadcast Packets Bridging Example" section on page 50.

Note Remember that, as with any access list using MAC addresses, Ethernets swap their MAC address bit ordering, and Token Rings and FDDI do not. Therefore, an access list that works for one medium might not work for others.

Once you have defined an access list to filter by a particular vendor code, you can assign an access list to a particular interface for filtering on the MAC *source* addresses of packets *received* on that interface or the MAC *destination* addresses of packets that would ordinarily be *forwarded* out that interface. To filter by source or destination addresses, use one of the following commands in interface configuration mode, as needed:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group* **input-address-list** *access-list-number*	Assigns an access list to a particular interface.
`Router(config-if)# bridge-group` *bridge-group* **output-address-list** *access-list-number*	Assigns an access list to an interface for filtering by the MAC destination addresses.

Filtering by Protocol Type

You can filter by protocol type by using the access-list mechanism and specifying a protocol type code. To filter by protocol type, perform the first task and one or more of the other tasks that follow:

- Establish a protocol type access list
- Filter Ethernet- and SNAP-encapsulated packets on input
- Filter Ethernet- and SNAP-encapsulated packets on output
- Filter IEEE 802.2-encapsulated packets on input
- Filter IEEE 802.2-encapsulated packets on output

Note It is a good idea to have both input and output type code filtering on different interfaces.

The order in which you enter **access-list** commands affects the order in which the access conditions are checked. Each condition is tested in succession. A matching condition is then used to execute a permit or deny decision. If no conditions match, a "deny" decision is reached.

Note Protocol type access lists can have an impact on system performance; therefore, keep the lists as short as possible and use wildcard bit masks whenever possible.

Access lists for Ethernet- and IEEE 802.2-encapsulated packets affect only bridging functions. It is not possible to use such access lists to block frames with protocols that are being routed.

You can establish protocol type access lists. Specify either an Ethernet type code for Ethernet-encapsulated packets or a DSAP/SSAP pair for 802.3 or 802.5-encapsulated packets. Ethernet type codes are listed in the "Ethernet Type Codes" appendix of the *Cisco IOS Bridging and IBM Networking Command Reference* (Volume 1 of 2).

To establish protocol type access lists, use the following command in global configuration mode:

Command	Purpose
`Router(config)#` **access-list** *access-list-number* {**permit** | **deny**} *type-code wild-mask*	Prepares access control information for filtering frames by protocol type.

You can filter Ethernet- and SNAP-encapsulated packets on input. For SNAP-encapsulated frames, the access list you create is applied against the two-byte TYPE field given after the DSAP/SSAP/OUI fields in the frame. The access list is applied to all Ethernet and SNAP frames received on that interface prior to the bridge learning process. SNAP frames also must pass any applicable IEEE 802.2 DSAP/SSAP access lists.

You can also filter Ethernet- and SNAP-encapsulated packets on output. The access list you create is applied just before sending out a frame to an interface.

To filter these packets on input or output, use the following commands in interface configuration mode, as needed:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group* **input-type-list** *access-list-number*	Adds a filter for Ethernet- and SNAP-encapsulated packets on input.
`Router(config-if)# bridge-group` *bridge-group* **output-type-list** *access-list-number*	Adds a filter for Ethernet- and SNAP-encapsulated packets on output.

You can filter IEEE 802-encapsulated packets on input. The access list you create is applied to all IEEE 802 frames received on that interface prior to the bridge-learning process. SNAP frames also must pass any applicable Ethernet type-code access list.

You can also filter IEEE 802-encapsulated packets on output. SNAP frames also must pass any applicable Ethernet type-code access list. The access list you create is applied just before sending out a frame to an interface.

To filter these packets on input or output, use the following commands in interface configuration mode, as needed:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group* **input-lsap-list** *access-list-number*	Adds a filter for IEEE 802-encapsulated packets on input.
`Router(config-if)# bridge-group` *bridge-group* **output-lsap-list** *access-list-number*	Adds a filter for IEEE 802-encapsulated packets on output.

Access lists for Ethernet- and IEEE 802-encapsulated packets affect only bridging functions. You cannot use such access lists to block frames with protocols that are being routed.

Defining and Applying Extended Access Lists

If you are filtering by the MAC-layer address, whether it is by a specific MAC address, vendor code, or protocol type, you can define and apply extended access lists. Extended access lists allow finer granularity of control. They allow you to specify both source and destination addresses and arbitrary bytes in the packet.

To define an extended access list, use the following command in global configuration mode:

Command	Purpose
`Router(config)#` **access-list** *access-list-number* {**permit** | **deny**} *source source-mask destination destination-mask offset size operator operand*	Defines an extended access list for finer control of bridged traffic.

To apply an extended access list to an interface, use the following commands in interface configuration mode, as needed:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group* `input-pattern-list` *access-list-number*	Applies an extended access list to the packets being received by an interface.
`Router(config-if)# bridge-group` *bridge-group* `output-pattern-list` *access-list-number*	Applies an extended access list to the packet being sent by an interface.

After an access list is created initially, any subsequent additions (possibly entered from the terminal) are placed at the *end* of the list. In other words, you cannot selectively add or remove access list command lines from a specific access list.

Caution Because of their complexity, only use extended access lists if you are very familiar with the Cisco IOS software. Further, do not specify an offset value that is greater than the size of the packet.

Filtering LAT Service Announcements

The bridging software allows you to filter LAT frames. LAT bridge filtering allows the selective inclusion or exclusion of LAT multicast service announcements on a per-interface basis.

Note The LAT filtering commands are not implemented for Token Ring interfaces.

In the LAT protocol, a *group code* is defined as a decimal number in the range 0 to 255. Some of the LAT configuration commands take a list of group codes; this is referred to as a *group code list*. The rules for entering numbers in a group code list follow:

- Entries can be individual group code numbers separated with a space. (The Digital LAT implementation specifies that a list of numbers be separated by commas; however, our implementation expects the numbers to be separated by spaces.)
- Entries can also specify a range of numbers. This is done by separating an ascending order range of group numbers with hyphens.
- Any number of group codes or group code ranges can be listed in one command; just separate each with a space.

In LAT, each node sends a periodic service advertisement message that announces its existence and availability for connections. Within the message is a group code list; this is a mask of up to 256 bits. Each bit represents a group number. In the traditional use of LAT group codes, a terminal server only will connect to a host system when there is an overlap between the group code list of the user on the terminal server and the group code list in the service advertisement message. In an environment with many bridges and many LAT hosts, the number of multicast messages that each system has to deal with becomes unreasonable. The 256 group codes might not be enough to allocate local assignment policies, such as giving each DECserver 200 device its own group code in large bridged networks. LAT group code filtering allows you to have very fine control over which multicast messages actually get bridged. Through a combination of input and output permit and deny lists, you can implement many different LAT control policies.

You can filter LAT service advertisements by performing any of the tasks in the following sections:

- Enabling LAT Group Code Service Filtering, page 29
- Specifying Deny or Permit Conditions for LAT Group Codes on Input, page 29
- Specifying Deny or Permit Conditions for LAT Group Codes on Output, page 29

Enabling LAT Group Code Service Filtering

You can specify LAT group-code filtering to inform the system that LAT service advertisements require special processing. To enable LAT group-code filtering, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge bridge-group lat-service-filtering`	Enables LAT service filtering.

Specifying Deny or Permit Conditions for LAT Group Codes on Input

You can specify the group codes by which to deny or permit access upon input. Specifying deny conditions causes the system to not bridge any LAT service advertisement that contain any of the specified groups. Specifying permit conditions causes the system to bridge only those service advertisements that match at least one group in the specified group list.

To specify deny or permit conditions for LAT groups on input, use one of the following commands in interface configuration mode, as needed:

Command	Purpose
`Router(config-if)# bridge-group bridge-group input-lat-service-deny group-list`	Specifies the group codes with which to deny access upon input.
`Router(config-if)# bridge-group bridge-group input-lat-service-permit group-list`	Specifies the group codes with which to permit access upon input.

If a message specifies group codes in both the deny and permit list, the message is not bridged.

Specifying Deny or Permit Conditions for LAT Group Codes on Output

You can specify the group codes by which to deny or permit access upon output. Specifying deny conditions causes the system to not bridge onto the output interface any LAT service advertisements that contain any of the specified groups. Specifying permit conditions causes the system to bridge onto the output interface only those service advertisements that match at least one group in the specified group list.

To specify deny or permit conditions for LAT groups on output, use one of the following commands in interface configuration mode, as needed:

Command	Purpose
`Router(config-if)# bridge-group bridge-group output-lat-service-deny group-list`	Specifies the group codes with which to deny access upon output.
`Router(config-if)# bridge-group bridge-group output-lat-service-permit group-list`	Specifies the group codes with which to permit access upon output.

If a message matches both a deny and a permit condition, it will not be bridged.

Adjusting Spanning-Tree Parameters

You might need to adjust certain spanning-tree parameters if the default values are not suitable for your bridge 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.

You can adjust spanning-tree parameters by performing any of the tasks in the following sections:

- Setting the Bridge Priority, page 30
- Setting an Interface Priority, page 30
- Assigning Path Costs, page 31
- Adjusting BPDU Intervals, page 31
- Disabling the Spanning Tree on an Interface, page 32

Note Only network administrators with a good understanding of how bridges and the Spanning Tree Protocol work should make adjustments to spanning-tree parameters. Poorly planned adjustments to these parameters can have a negative impact on performance. A good source on bridging is the IEEE 802.1D specification; see the "References and Recommended Reading" appendix in the *Cisco IOS Configuration Fundamentals Command Reference* for other references.

Setting the Bridge Priority

You can globally configure the priority of an individual bridge when two bridges tie for position as the root bridge, or you can configure the likelihood that a bridge will be selected as the root bridge. This priority is determined by default; however, you can change it. To set the bridge priority, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge` *bridge-group* `priority` *number*	Sets the bridge priority.

Setting an Interface Priority

You can set a priority for an interface. When two bridges tie for position as the root bridge, you configure an interface priority to break the tie. The bridge with the lowest interface value is elected. To set an interface priority, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group* `priority` *number*	Establishes a priority for a specified interface.

Assigning Path Costs

Each interface has a path cost associated with it. By convention, the path cost is 1000/data rate of the attached LAN, in millions of bits per second (Mbps). You can set different path costs. Refer to the entry for this command in the *Cisco IOS Bridging and IBM Networking Command Reference* (Volume 1 of 2) for the various media defaults. To assign path costs, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group* `path-cost` *cost*	Sets a path cost different from the defaults.

Adjusting BPDU Intervals

You can adjust BPDU intervals as described in the following sections:

- Adjusting the Interval between Hello BPDUs, page 31
- Defining the Forward Delay Interval, page 31
- Defining the Maximum Idle Interval, page 32

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

Adjusting the Interval between Hello BPDUs

You can specify the interval between hello BPDUs. To adjust this interval, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge` *bridge-group* `hello-time` *seconds*	Specifies the interval between hello BPDUs.

Defining the Forward Delay Interval

The forward delay interval is the amount of time spent listening for topology change information after an interface has been activated for bridging and before forwarding actually begins. To change the default interval setting, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge` *bridge-group* `forward-time` *seconds*	Sets the default of the forward delay interval.

Defining the Maximum Idle Interval

If a bridge does not hear BPDUs from the root bridge within a specified interval, it assumes that the network has changed and recomputes the spanning-tree topology. To change the default interval setting, using the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge` *bridge-group* `max-age` *seconds*	Changes the amount of time a bridge will wait to hear BPDUs from the root bridge.

Disabling the Spanning Tree on an Interface

When a *loop-free* path exists between any two bridged subnetworks, you can prevent BPDUs generated in one transparent bridging subnetwork from impacting nodes in the other transparent bridging subnetwork, yet still permit bridging throughout the bridged network as a whole. For example, when transparently bridged LAN subnetworks are separated by a WAN, BPDUs can be prevented from traveling across the WAN link.

To disable the spanning tree on an interface, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group* `spanning-disabled`	Disables the spanning tree on an interface.

Configuring Transparent and IRB Bridging on a PA-12E/2FE Ethernet Switch

The PA-12E/2FE Ethernet switch port adapter provides Cisco 7200 series routers with up to twelve 10-Mbps and two 10/100-Mbps switched Ethernet (10BASE-T) and Fast Ethernet (100BASE-TX) interfaces for an aggregate bandwidth of 435 Mbps, full-duplex. The PA-12E/2FE port adapter supports the Ethernet, IEEE 802.3, and IEEE 802.3u specifications for 10-Mbps and 100-Mbps transmission over UTP cables.

The PA-12E/2FE port adapter offloads Layer 2 switching from the host CPU by using store-and-forward or cut-through switching technology between interfaces within the same VLAN on the PA-12E/2FE port adapter. The PA-12E/2FE port adapter supports up to four VLANs (bridge groups).

Note The PA-12E/2FE port adapter is a dual-width port adapter, which means it occupies two horizontally aligned port adapter slots when installed in a Cisco 7200 series router. (Single-width port adapters occupy individual port adapter slots in a Cisco 7200 series router.)

All interfaces on the PA-12E/2FE port adapter support autosensing and autonegotiation of the proper transmission mode (half-duplex or full-duplex) with an attached device. The first two PA-12E/2FE interfaces (port 0 and port 1) also support autosensing and autonegotiation of the proper connection speed (10 Mbps or 100 Mbps) with an attached device. If an attached device does not support autosensing and autonegotiation of the proper transmission mode, the PA-12E/2FE interfaces attached to the device automatically enter half-duplex mode. Use the **show running-config** command to determine if a PA-12E/2FE interface is autosensing and autonegotiating the proper transmission mode with an attached device. Use the **full-duplex** and the **half-duplex** commands to change the transmission mode of a PA-12E/2FE interface. After changing the transmission mode, use the **show interfaces** command to verify the interface's transmission mode.

Note If you use the **full-duplex** and the **half-duplex** commands to change the transmission mode of the first two PA-12E/2FE interfaces (port 0 and port 1), the transmission speed of the two PA-12E/2FE interfaces automatically defaults to 100-Mbps. The first two PA-12E/2FE interfaces only operate at 10-Mbps when the interfaces are autosensing and autonegotiating the proper connection speed (10-Mbps or 100-Mbps) with an attached device.

To configure the PA-2E/2FE port adapter, perform the tasks in the following sections. The first task is required, all other tasks are optional.

- Configuring the PA-12E/2FE Port Adapter, page 33
- Monitoring and Maintaining the PA-12E/2FE Port Adapter, page 35
- Configuring Bridge Groups Using the 12E/2FE VLAN Configuration WebTool, page 35

Note If you plan to use a PA-12E/2FE interface to boot from a network (TFTP), ensure that the interface is configured for a loop-free environment, an IP address is configured for the interface's bridge-group virtual interface, and system boot image in release 11.2(10)P is installed on your router (use the **show version** command to view your router's system boot image). Then, *before* booting from the network server, use the **bridge-group** *bridge-group number* **spanning-disabled** command to disable the Spanning Tree Protocol configured on the interface to keep the TFTP server from timing out and closing the session.

For detailed information about boot from a network (TFTP), loading a system image from a network server, and configuring the Spanning Tree Protocol on your Cisco 7200 series router, refer to the *PA-12E/2FE Ethernet Switch10BASE-T and 100BASE-TX Port Adapter Installation and Configuration* that accompanies the hardware and to the *Cisco IOS Configuration Fundamentals Configuration Guide* and *Cisco IOS Bridging and IBM Networking Configuration Guide* publications.

For information on other commands that can be used to configure a PA-12E/2FE port adapter, refer to the "Configuring Interfaces" chapter in the *Cisco IOS Configuration Fundamentals Configuration Guide*.

For PA-2E/2FE port adapter configuration examples, see the "Configuration of Transparent Bridging for PA-12E/2FE Port Adapter Example" section on page 61 and the "Configuration of IRB for PA-12E/2FE Port Adapter Example" section on page 61.

Configuring the PA-12E/2FE Port Adapter

This section provides instructions for a basic configuration. You might also need to enter other configuration commands depending on the requirements for your system configuration and the protocols you plan to route on the interface.

To configure the interfaces on the PA-12E/2FE port adapter, perform the following tasks beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# bridge bridge-group protocol ieee`	Specifies the type of Spanning Tree Protocol. The PA-12E/2FE port adapter supports DEC and IEEE Spanning Tree Protocols; however, we recommend using the IEEE protocol when configuring bridge groups.
Step 2	`Router(config)# interface fastethernet slot/port` (for ports 0 and 1) `interface ethernet slot/port` (for ports 2 through 13)	Enters the interface you want to configure.
Step 3	`Router(config-if)# bridge-group bridge-group`	Assigns a bridge group to the interface.
Step 4	`Router(config-if)# cut-through [receive | transmit]`	(Optional) configures the interface for cut-through switching technology. The default is store-and-forward.
Step 5	`Router(config-if)# full-duplex`	(Optional) if an attached device does not support autosensing or autonegotiation, configures the transmission mode for full-duplex. The default is half-duplex.
Step 6	`Router(config-if)# no shutdown`	Changes the shutdown state to up.
Step 7	`Router(config-if)# exit`	Returns to global configuration mode.
Step 8		Repeat Step 1 through Step 7 for each interface.
Step 9	`Router(config)# exit`	Exits global configuration mode.
Step 10	`Router# copy running-config startup-config`	Saves the new configuration to memory.

To enable integrated routing and bridging on the bridge groups, perform the following tasks beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# bridge irb`	Enables integrated routing and bridging.
Step 2	`Router(config)# interface bvi bridge-group`	Enables a virtual interface on a bridge group.
Step 3	`Router(config-if)# ip address address mask`	Assigns an IP address and subnet mask to the bridge group virtual interface.
Step 4	`Router(config-if)# no shutdown`	Changes the shutdown state to up.
Step 5	`Router(config-if)# exit`	Returns to global configuration mode.
Step 6		Repeat Step 1 through Step 5 for each interface.
Step 7	`Router(config)# bridge bridge-group route protocol`	Specifies the protocol for each bridge group.
Step 8	`Router(config)# exit`	Exits global configuration mode.
Step 9	`Router# copy running-config startup-config`	Saves the new configuration to memory.

Monitoring and Maintaining the PA-12E/2FE Port Adapter

After configuring the new interface, you can display its status and verify other information. To display information about the PA-12E/2FE port adapter, perform the following tasks in privileged EXEC mode:

Command	Purpose
`Router# show version`	Displays the configuration of the system hardware, the software version, the names and sources of configuration files, and the boot image.
`Router# show controllers`	Displays all current port adapters and their interfaces.
`Router# show interface fastethernet` *slot/port* (for ports 0 and 1) **show interface ethernet** *slot/port* (for ports 2 through 13)	Verifies the interfaces have the correct slot number and that the interface and line protocol are in the correct state.
`Router# show bridge group`	Verifies all bridge groups and their interfaces.
`Router# show interface ethernet` *slot/port* **irb** (for ports 2 through 13) **show interface fastethernet** *slot/port* **irb** (for ports 0 and 1)	Verifies the correct routed protocol is configured for each interface.
`Router# show protocols`	Displays the protocols configured for the entire system and specific interfaces.
`Router# show pas eswitch addresses fastethernet` *slot/port* (for ports 0 and 1) **show pas eswitch addresses ethernet** *slot/port* (for ports 2 through 13)	Displays the Layer 2 learned addresses for each interface.
`Router# show running-config`	Displays the running configuration file.
`Router# show startup-config`	Displays the configuration stored in NVRAM.

Configuring Bridge Groups Using the 12E/2FE VLAN Configuration WebTool

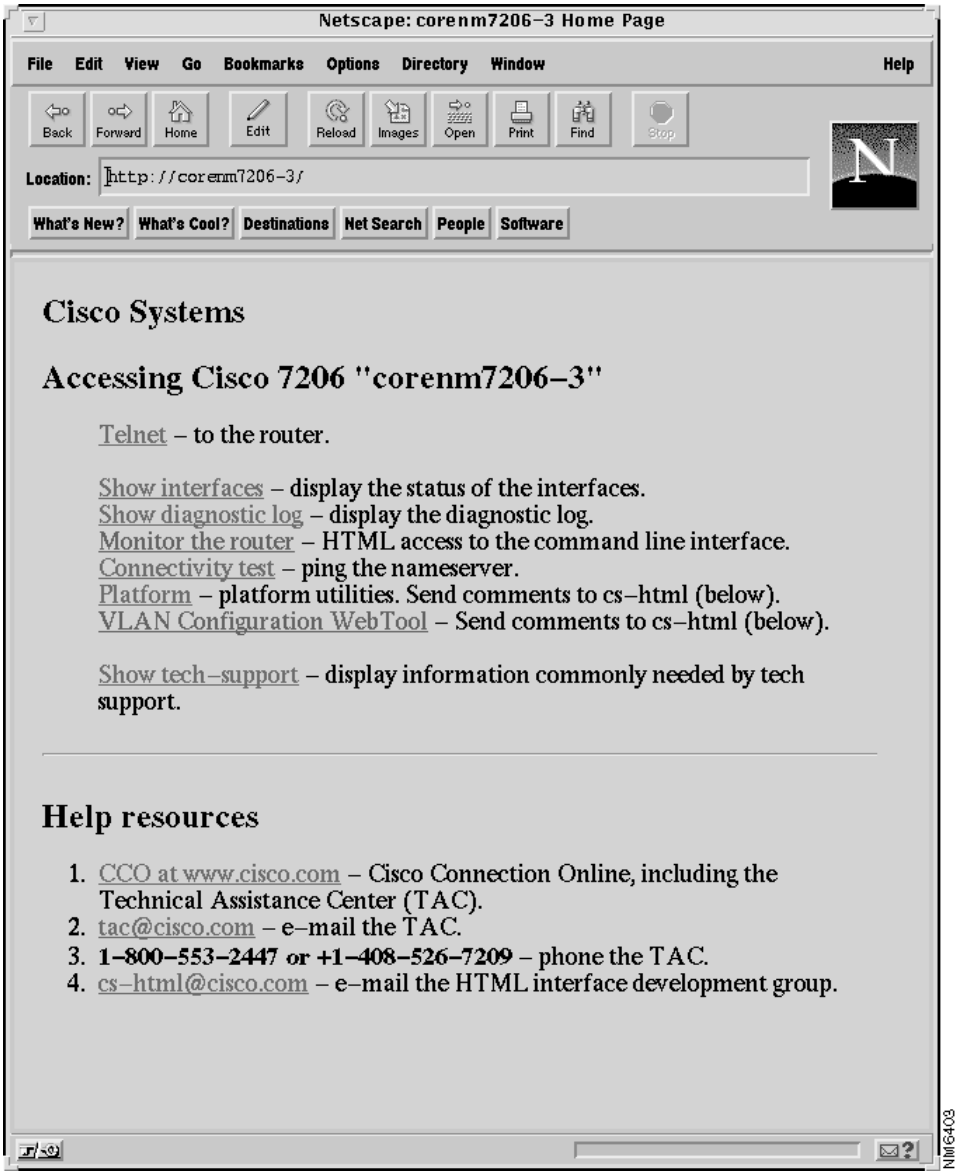
The 12E/2FE VLAN Configuration WebTool, shown in Figure 5, is a Web browser-based Java applet that displays configured interfaces and bridge groups for PA-12E/2FE port adapters installed in Cisco routers. With the WebTool you can perform the following tasks:

- Create and delete bridge groups (also referred to as VLANs)
- Add and remove PA-12E/2FE interfaces from bridge groups
- Assign colors to bridge groups and PA-12E/2FE interfaces
- Administratively shut down (disable) and bring up (enable) PA-12E/2FE interfaces
- View the bridge-group status of each PA-12E/2FE interface

You can access the 12E/2FE VLAN Configuration WebTool from your router's home page. For more information on the router's home page, refer to the *Cisco IOS Configuration Fundamentals Configuration Guide*.

For complete procedures on how to use the VLAN Configuration WebTool, refer to the *PA-12E/2FE Ethernet Switch10BASE-T and 100BASE-TX Port Adapter Installation and Configuration* that accompanies the hardware.

Figure 5 Example Home Page for a Cisco 7200 Series Router (Cisco 7206 Shown)



Note You must use a Java enabled Web browser to access the 12E/2FE VLAN Configuration WebTool from your router's home page.

All Cisco routers running Cisco IOS Release 11.0 or later have a home page. If your router has an installed PA-12E/2FE port adapter, you can access the 12E/2FE VLAN Configuration WebTool from the router's home page.

Note All Cisco router home pages are password protected. Contact your network administrator if you do not have the name or password for your Cisco 7200 series router.

Note The VLAN Configuration WebTool hypertext link is listed in the router's home page *only* when a PA-12E/2FE port adapter is installed in the router.

Tuning the Transparently Bridged Network

The following sections describe how to configure features that enhance network performance by reducing the number of packets that traverse the backbone network:

- Configuring Circuit Groups, page 37
- Configuring Constrained Multicast Flooding, page 38

Configuring Circuit Groups

In the process of loop elimination, the spanning-tree algorithm always blocks all but one of a group of parallel network segments between two bridges. When those segments are of limited bandwidth, it might be preferable to augment the aggregate bandwidth between two bridges by forwarding across multiple parallel network segments. Circuit groups can be used to group multiple parallel network segments between two bridges to distribute the load while still maintaining a loop-free spanning tree.

Deterministic load distribution distributes traffic between two bridges across multiple parallel network segments grouped together into a single circuit group. As long as one port of the circuit group is in the forwarding state, all ports in that circuit group will participate in load distribution regardless of their spanning-tree port states. This process guarantees that the computed spanning tree is still adaptive to any topology change and the load is distributed among the multiple segments. Deterministic load distribution guarantees packet ordering between source-destination pairs, and always forwards traffic for a source-destination pair on the same segment in a circuit group for a given circuit-group configuration.

Note You should configure all parallel network segments between two bridges into a single circuit group. Deterministic load distribution across a circuit group adjusts dynamically to the addition or deletion of network segments, and to interface state changes.

If a circuit-group port goes down and up as a result of configuration or a line protocol change, the spanning-tree algorithm will bypass port transition and will time out necessary timers to force the eligible circuit-group ports to enter the forwarding state. This avoids the long disruption time caused by spanning-tree topology recomputation and therefore resumes the load distribution as quickly as possible.

To tune the transparently bridged network, perform the following tasks:

1. Define a circuit group.
2. Optionally, configure a transmission pause interval.
3. Modify the load distribution strategy.

To define a circuit group, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# bridge-group` *bridge-group* `circuit-group` *circuit-group*	Adds a serial interface to a circuit group.

For circuit groups of mixed-bandwidth serial interfaces, it might be necessary to configure a pause interval during which the sending of data is suspended to avoid ordering packets incorrectly following changes in the composition of a circuit group. Changes in the composition of a circuit group include the addition or deletion of an interface and interface state changes. To configure a transmission pause interval, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge` *bridge-group* `circuit-group` *circuit-group* `pause` *milliseconds*	Configures a transmission pause interval.

For applications that depend on the ordering of mixed unicast and multicast traffic from a given source, load distribution must be based upon the source MAC address only. To modify the load distribution strategy to accommodate such applications, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge` *bridge-group* `circuit-group` circuit-group `source-based`	Distributes base load on the source MAC address only.

For an example of how to configure a circuit group, see the "Complex Transparent Bridging Network Topology Example" section later in this chapter.

Configuring Constrained Multicast Flooding

In a transparent bridge, multicast packets are flooded on all forwarding ports on the bridge. For some protocols, it is possible for a bridge to determine the membership of multicast groups, and constrain the flooding of multicasts to a subset of the forwarding ports. Constrained multicast flooding enables a bridge to determine group membership of IP multicast groups dynamically and flood multicast packets only on those ports that reach group members.

To enable constrained multicast flooding, use the following command in global configuration mode:

Command	Purpose
`Router(config)# bridge cmf`	Enables constrained multicast flooding for all configured bridge groups.

Monitoring and Maintaining the Transparent Bridge Network

To monitor and maintain activity on the bridged network, use one of the following commands in privileged EXEC mode, as needed:

Command	Purpose
Router# **clear bridge** *bridge-group*	Removes any learned entries from the forwarding database and clears the transmit and receive counts for any statically configured forwarding entries.
Router# **clear bridge** [*bridge-group*] **multicast** [**router-ports** | **groups** | **counts**] [*group-address*] [*interface-unit*] [**counts**]	Removes multicast-group state information and clears the transmit and receive counts.
Router# **clear sse**	Reinitializes the Silicon Switch Processor (SSP) on the Cisco 7000 series router.
Router# **clear vlan statistics**	Removes VLAN statistics from any statically or system-configured entries.
Router# **show bridge** [*bridge-group*] [*interface*]	Displays details of the bridge group.
Router# **show bridge** [*bridge-group*] [*interface*] [*address* [*mask*]] [**verbose**]	Displays classes of entries in the bridge forwarding database.
Router# **show bridge** [*bridge-group*] **circuit-group** [*circuit-group*] [*src-mac-address*] [*dst-mac-address*]	Displays the interfaces configured in each circuit group and shows whether they are participating in load distribution.
Router# **show bridge** [*bridge-group*] **multicast** [**router-ports** | **groups**] [*group-address*]	Displays transparent bridging multicast state information.
Router# **show bridge group** [**verbose**]	Displays information about configured bridge groups.
Router# **show bridge vlan**	Displays IEEE 802.10 transparently bridged VLAN configuration.
Router# **show interfaces crb**	Displays the configuration for each interface that has been configured for routing or bridging.
Router# **show interfaces** [*interface*] **irb**	Displays the protocols that can be routed or bridged for the specified interface.
Router# **show span**	Displays the spanning-tree topology known to the router, including whether or not filtering is in effect.
Router# **show sse summary**	Displays a summary of SSP statistics.
Router# **show subscriber-policy** *policy*	Displays the details of a subscriber policy.
Router# **show vlans**	Displays VLAN subinterfaces.

Transparent and SRT Bridging Configuration Examples

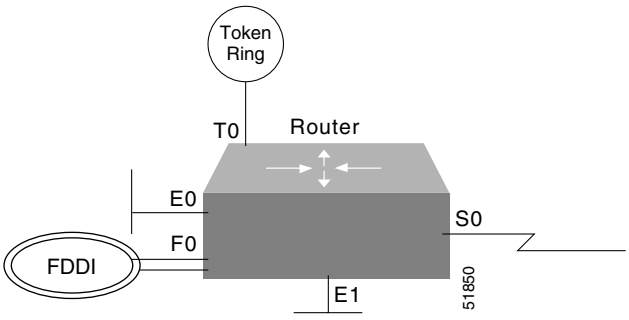
The following sections provide example configurations that you can use as a guide to configuring your bridging environment:

- Basic Bridging Example, page 40
- Concurrent Routing and Bridging Example, page 41
- Basic Integrated Routing and Bridging Example, page 42
- Complex Integrated Routing and Bridging Example, page 42

Basic Bridging Example

Figure 6 is an example of a basic bridging configuration. The system has two Ethernets, one Token Ring, one FDDI port, and one serial line. IP traffic is routed and everything else is bridged. The Digital-compatible bridging algorithm with default parameters is being used.

Figure 6 Example of Basic Bridging



The configuration file for the router in Figure 6 is as follows:

```
interface tokenring 0
 ip address 131.108.1.1 255.255.255.0
 bridge-group 1
!
interface fddi 0
 ip address 131.108.2.1 255.255.255.0
 bridge-group 1
```

```
!
interface ethernet 0
 ip address 192.31.7.26 255.255.255.240
 bridge-group 1
!
interface serial 0
 ip address 192.31.7.34 255.255.255.240
 bridge-group 1
!
interface ethernet 1
 ip address 192.31.7.65 255.255.255.240
 bridge-group 1
!
bridge 1 protocol dec
```

Concurrent Routing and Bridging Example

In the following example DECnet and IPX are concurrently routed and bridged. IP and AppleTalk are routed on all interfaces, DECnet and IP are routed on all interfaces not in the bridge group, and all protocols other than IP and AppleTalk are bridged on all interfaces in the bridge group:

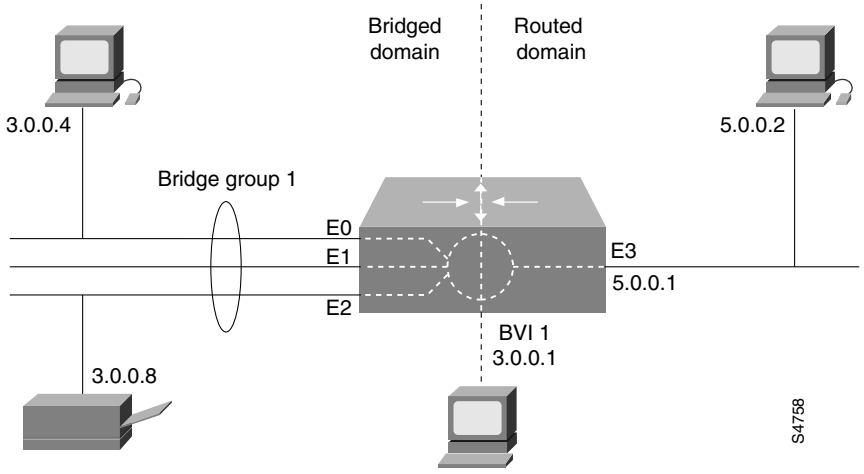
```
!
ipx routing 0000.0c36.7a43
appletalk routing
!
decnet routing 9.65
decnet node-type routing-iv
!
interface Ethernet0/0
 ip address 172.19.160.65 255.255.255.0
 ipx network 160
 appletalk address 160.65
 decnet cost 7
!
interface Ethernet0/1
 ip address 172.19.161.65 255.255.255.0
 ipx network 161
 appletalk address 161.65
 decnet cost 7
!
interface Ethernet0/2
 ip address 172.19.162.65 255.255.255.0
 appletalk address 162.65
 bridge-group 1
!
interface Ethernet0/3
 ip address 172.19.14.65 255.255.255.0
 appletalk address 14.65
 appletalk zone california
 bridge-group 1
!
router igrp 666
network 172.19.0.0


!
bridge crb
bridge 1 protocol ieee
bridge 1 route appletalk
bridge 1 route ip
!
```

Basic Integrated Routing and Bridging Example

Figure 7 is an example of integrated routing and bridging that uses Bridge-Group 1 to bridge and route IP. The router has three bridged Ethernet interfaces and one routed Ethernet interface.

Figure 7 Basic IP Routing using Integrated Routing and Bridging



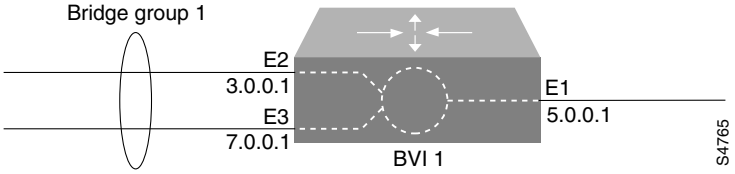
The following example shows the relevant portions of the configuration for the router in Figure 7:

```
interface Ethernet 0
 bridge-group 1
!
interface Ethernet 1
 bridge-group 1
!
interface Ethernet 2
 bridge-group 1
!
interface Ethernet 3
 ip address 5.0.0.1 255.0.0.0
!
interface BVI 1
 ip address 3.0.0.1 255.0.0.0
!
bridge irb
bridge 1 protocol ieee
 bridge 1 route ip
```

Complex Integrated Routing and Bridging Example

Figure 8 is a more complex example of integrated routing and bridging, where bridge group 1 is used to route IP traffic, bridge IPX traffic, and bridge and route AppleTalk traffic.

Figure 8 Complex Integrated Routing and Bridging Example



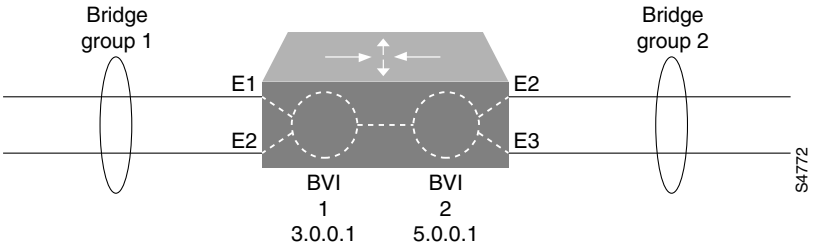
The following example shows the relevant portions of the configuration for the router:

```
appletalk routing
!
interface Ethernet 1
 ip address 5.0.0.1 255.0.0.0
 appletalk cable-range 35-35 35.1
 appletalk zone Engineering
!
interface Ethernet 2
 ip address 3.0.0.1 255.0.0.0
 bridge-group 1
!
interface Ethernet 3
 ip address 7.0.0.1 255.0.0.0
 bridge-group 1
!
interface BVI 1
 no ip address
 appletalk cable-range 33-33 33.1
 appletalk zone Accounting
!
bridge irb
bridge 1 protocol ieee
 bridge 1 route appletalk
 bridge 1 route ip
 no bridge 1 bridge ip
```

Integrated Routing and Bridging with Multiple Bridge Groups Example

In the example illustrated in Figure 9, integrated routing and bridging is used to route and bridge IP between two bridge groups.

Figure 9 Integrated Routing and Bridging with Multiple Bridge Groups



The following example shows the relevant portions of the configuration for the router in Figure 9:

```
interface Ethernet 1
 bridge-group 1
!
interface Ethernet 2
 bridge-group 1
!
interface Ethernet 3
 bridge-group 2
!
interface Ethernet 4
 bridge-group 2
!
interface BVI 1
 ip address 3.0.0.1 255.0.0.0
!
interface BVI 2
 ip address 5.0.0.1 255.0.0.0
!
bridge irb
bridge 1 protocol ieee
 bridge 1 route ip
bridge 2 protocol ieee
 bridge 2 route ip
```

Transparently Bridged VLANs Configuration Example

The following example shows the configuration for the topology in Figure 3. The “striped” VLAN is identified as security association identifier 45; the “dot” VLAN is identified as security association identifier 1008; the “sliced” VLAN is identified as security association identifier 4321. Note that the assignment of bridge group, interface, and subinterface numbers is of local significance only. You must coordinate only the configuration of a common Security Association Identifier across bridges.

Router One

```
bridge 18 protocol ieee
interface ethernet 0/1
 bridge-group 18
!
interface ethernet 0/2
 bridge-group 18
```

```
!
interface ethernet 0/3
 bridge-group 18
!
interface fddi 4/0.8
 encapsulation sde 45
 bridge-group 18
!
 bridge 54 protocol ieee

interface ethernet 1/1
 bridge-group 54
!
interface ethernet 1/2
 bridge-group 54
!
interface ethernet 1/3
 bridge-group 54
!
interface fddi 4/0.13
 encapsulation sde 1008
 bridge-group 54
!
bridge 3 protocol ieee
!
interface ethernet 2/1
 bridge-group 3
!
interface ethernet 2/2
 bridge-group 3
!
interface ethernet 2/3
 bridge-group 3
!
interface fddi 4/0.30
 encapsulation sde 4321
 bridge-group 3
```

Router Two

```
bridge 7 protocol ieee
interface ethernet 0/1
 bridge-group 7
!
interface ethernet 0/2
 bridge-group 7

interface ethernet 0/3
 bridge-group 7
!
interface ethernet 0/4
 bridge-group 7
!
interface fddi 2/0.11
 encapsulation sde 4321
 bridge-group 7


!
bridge 8 protocol ieee
interface ethernet 1/1
 bridge-group 8
!
interface ethernet 1/2
```

```
 bridge-group 8
!
interface ethernet 1/3
 bridge-group 8
!
interface ethernet 1/4
 bridge-group 8
!
interface fddi 2/0.14
 encapsulation sde 1008
 bridge-group 8
```

Router Three

```
bridge 1 protocol ieee
interface ethernet 0/1
 bridge-group 1
!
interface ethernet 0/2
 bridge-group 1
!
interface ethernet 0/3
 bridge-group 1
!
interface fddi 2/0.5
 encapsulation sde 4321
 bridge-group 1
!
bridge 6 protocol ieee
interface ethernet 1/1
 bridge-group 6
!
interface ethernet 1/2
 bridge-group 6
!
interface ethernet 1/3
 bridge-group 6
!
interface fddi 2/0.3
 encapsulation sde 45
 bridge-group 6
```

Routing Between VLANs Configuration Example

The following example shows the configuration for the topology shown in Figure 4. IP traffic is routed to and from switched VLAN domains 300, 400, and 600 to any other IP routing interface, as is IPX for VLANs 500 and 600. Because Fast Ethernet interfaces 2/1.20 and 3/1.40 are combined in bridge group 50, all other nonrouted traffic is bridged between these two subinterfaces.

```
interface FDDI 1/0.10
 ip address 131.108.1.1 255.255.255.0
 encap sde 300
!
interface Fast Ethernet 2/1.20.
 ip address 171.69.2.2 255.255.255.0
 encap isl 400
 bridge-group 50
!
interface Fast Ethernet 2/1.30
 ipx network 1000
 encap isl 500
!
interface Fast Ethernet 3/1.40
 ip address 198.92.3.3 255.255.255.0
 ipx network 1001
 encap isl 600
 bridge-group 50
!
bridge 50 protocol ieee
```

Ethernet-to-FDDI Transparent Bridging Example

The following configuration example shows the configuration commands that enable transparent bridging between Ethernet and FDDI interfaces. Transparent bridging on an FDDI interface is allowed only on the CSC-C2FCIT interface card.

```
hostname tester
!
buffers small min-free 20
buffers middle min-free 10
buffers big min-free 5
!
no ip routing
!
interface ethernet 0
 ip address 131.108.7.207 255.255.255.0
 no ip route-cache
 bridge-group 1
!
interface ethernet 2
 ip address 131.108.7.208 255.255.255.0
 no ip route-cache
 bridge-group 1
!
interface Fddi 0
 ip address 131.108.7.209 255.255.255.0
 no ip route-cache
 no keepalive
 bridge-group 1
!
bridge 1 protocol ieee
```

If the other side of the FDDI ring were an FDDI interface running in encapsulation mode rather than in transparent mode, the following additional configuration commands would be needed:

```
interface fddi 0
 fddi encapsulate
```

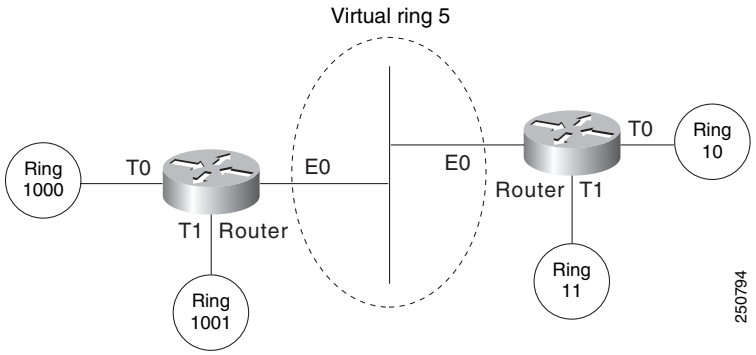
Ethernet Bridging Example

In the following example, two buildings have networks that must be connected via a T1 link. For the most part, the systems in each building use either IP or DECnet, and therefore, should be routed. There are some systems in each building that must communicate, but they can use only a proprietary protocol.

The example places two Ethernets in each building. One of the Ethernets is attached to the hosts that use a proprietary protocol, and the other is used to attach to the rest of the building network running IP and DECnet. The Ethernet attached to the hosts using a proprietary protocol is enabled for bridging to the serial line and to the other building.

Figure 10 shows an example configuration. The interfaces marked with an asterisk (*) are configured as part of spanning tree 1. The routers are configured to route IP and DECnet. This configuration permits hosts on any Ethernet to communicate with hosts on any other Ethernet using IP or DECnet. In addition, hosts on Ethernet 1 in either building can communicate using protocols not supported for routing.

Figure 10 Ethernet Bridging Configuration Example



Router/Bridge in Building 1

The configuration file for the router in Building 1 would be as follows. Note that no bridging takes place over Ethernet 0. Both IP and DECnet routing are enabled on all interfaces.

```
decnet address 3.34
interface ethernet 0
 ip address 128.88.1.6 255.255.255.0
 decnet cost 10
!
interface serial 0
 ip address 128.88.2.1 255.255.255.0
 bridge-group 1
 decnet cost 10
!
interface ethernet 1
 ip address 128.88.3.1 255.255.255.0
 bridge-group 1
 decnet cost 10
!
bridge 1 protocol dec
```

Router/Bridge in Building 2

The configuration file for the router in Building 2 is similar to Building 1:

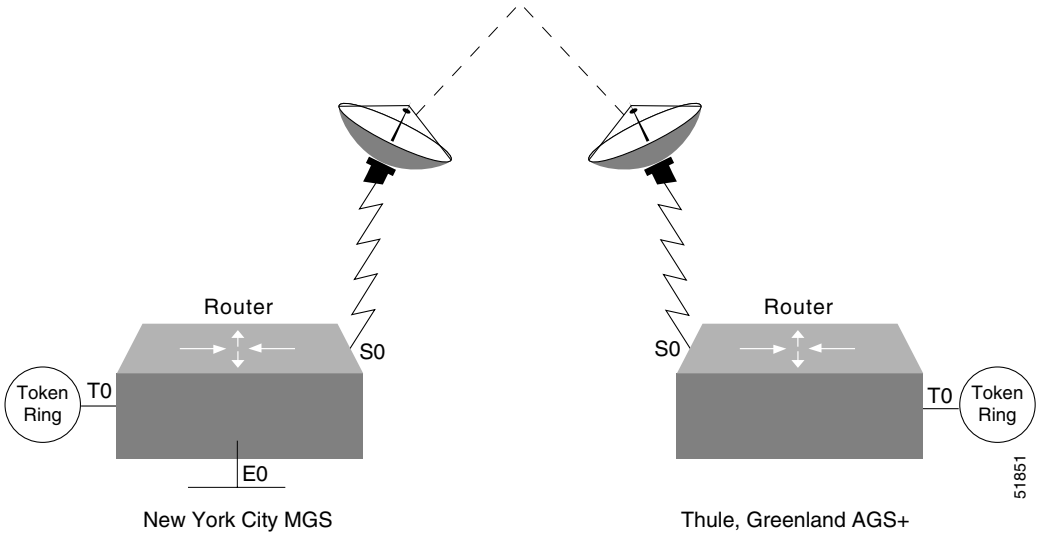
```
decnet address 3.56
!
interface ethernet 0
 ip address 128.88.11.9 255.255.255.0
 decnet cost 10
!
interface serial 0
 ip address 128.88.2.2 255.255.255.0
 bridge-group 1
 decnet cost 10
!
interface ethernet 1
 ip address 128.88.16.8 255.255.255.0
 bridge-group 1
 decnet cost 10
!
bridge 1 protocol dec
```

SRT Bridging Example

In Figure 11, a Token Ring and an Ethernet at a remote sales site in New York City must be configured to pass unroutable bridged traffic across a satellite link to the backbone Token Ring at the corporate headquarters in Thule, Greenland. IP is the only routed protocol. They are running the IEEE Spanning Tree Protocol to comply with the SRT bridging standard.

If there were source-routed traffic to bridge, the **source-bridge** command would also be used to configure source routing.

Figure 11 Network Configuration Example



Configuration for the New York City Router

```
interface tokenring 0
```

```
 ip address 150.136.1.1 255.255.255.128
 bridge-group 1
!
interface ethernet 0
 ip address 150.136.2.1 255.255.255.128
 bridge-group 1
!
interface serial 0
 ip address 150.136.3.1 255.255.255.128
 bridge-group 1
!
bridge 1 protocol ieee
```

Configuration for the Thule, Greenland Router

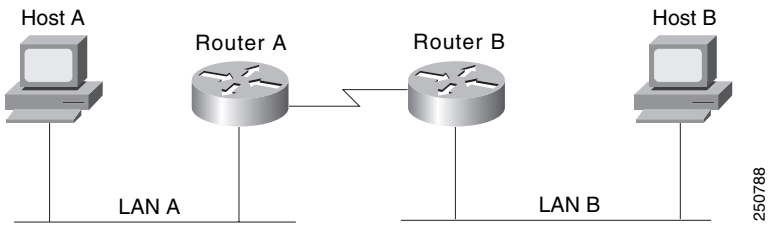
```
interface tokenring 0
 ip address 150.136.10.1 255.255.255.128
 bridge-group 1
!
interface serial 0
 ip address 150.136.11.1 255.255.255.128
 bridge-group 1
!
bridge 1 protocol ieee
```

Multicast or Broadcast Packets Bridging Example

When filtering specific MAC destination addresses, allow for multicast or broadcast packets that are required by the bridged network protocols.

Assume you are bridging IP in your network as illustrated in Figure 12.

Figure 12 Network Demonstrating Output Address List Filtering



The MAC address of Host A is 0800.0907.0207, and the MAC address of Host B is 0260.8c34.0864. The following configuration would work as expected, because input addresses work on the source address on the incoming interface:

```
access-list 700 permit 0260.8c34.0864 0000.0000.0000
access-list 700 deny 0000.0000.0000 FFFF.FFFF.FFFF
interface ethernet 0
 bridge-group 1 input-address-list 700
```

However, the following configuration might work initially but will eventually fail. The failure occurs because the configuration does not allow for an ARP broadcast with a destination address of FFFF.FFFF.FFFF, even though the destination address on the output interface is correct:

```
access-list 700 permit 0260.8c34.0864 0000.0000.0000
access-list 700 deny 0000.0000.0000 FFFF.FFFF.FFFF
interface ethernet 0
 bridge-group 1 output-address-list 700
```

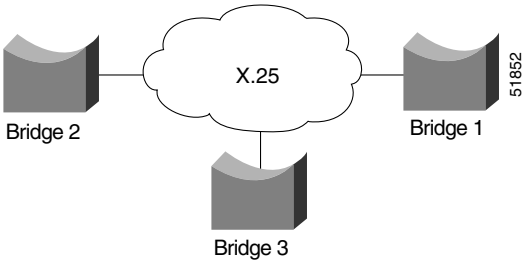
The correct access list would be as follows:

```
access-list 700 permit 0260.8c34.0864 0000.0000.0000
access-list 700 permit FFFF.FFFF.FFFF 0000.0000.0000
access-list 700 deny 0000.0000.0000 FFFF.FFFF.FFFF
interface ethernet 0
 bridge-group 1 output-address-list 700
```

X.25 Transparent Bridging Example

Figure 13 is an example configuration illustrating three bridges connected to each other through an X.25 network.

Figure 13 X.25 Bridging Examples



Following are the configuration commands for each of the bridges depicted in Figure 13:

Configuration for Bridge 1

```
interface ethernet 2
 bridge-group 5
 ip address 128.88.11.9 255.255.255.0
!
interface serial 0
 encapsulation x25
 x25 address 31370019027
 bridge-group 5
 x25 map bridge 31370019134 broadcast
 x25 map bridge 31370019565 broadcast
!
bridge 5 protocol ieee
```

Configuration for Bridge 2

```
interface serial 1
 encapsulation x25
 x25 address 31370019134
 bridge-group 5
 x25 map bridge 31370019027 broadcast
 x25 map bridge 31370019565 broadcast
!
bridge 5 protocol ieee
```

Configuration for Bridge 3

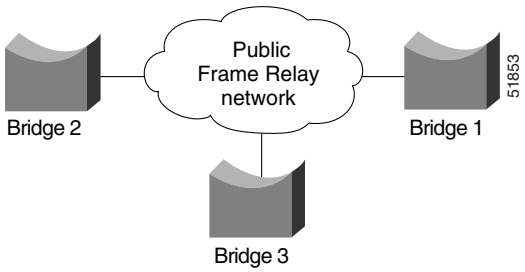
```
interface serial 0
 encapsulation x25
 x25 address 31370019565
 bridge-group 5
 x25 map bridge 31370019027 broadcast
```

```
 x25 map bridge 31370019134 broadcast
!
bridge 5 protocol ieee
```

Frame Relay Transparent Bridging Examples

Figure 14 illustrates three bridges connected to each other through a Frame Relay network.

Figure 14 Frame Relay Bridging Example



Bridging in a Frame Relay Network with No Multicasts

The Frame Relay bridging software uses the same spanning-tree algorithm as the other bridging functions, but allows packets to be encapsulated for sending across a Frame Relay network. The command specifies IP-to-DLCI address mapping and maintains a table of both the Ethernet and DLCIs. Following are the configuration commands for each of the bridges in a network that does not support a multicast facility:

Configuration for Bridge 1

```
interface ethernet 2
 bridge-group 5
 ip address 128.88.11.9 255.255.255.0
!
interface serial 0
 encapsulation frame-relay
 bridge-group 5
 frame-relay map bridge 134 broadcast
 frame-relay map bridge 565 broadcast
!
bridge 5 protocol ieee
```

Configuration for Bridge 2

```
interface serial 1
 encapsulation frame-relay
 bridge-group 5
 frame-relay map bridge 27 broadcast
 frame-relay map bridge 565 broadcast
!
bridge 5 protocol ieee
```

Configuration for Bridge 3

```
interface serial 0
 encapsulation frame-relay
 bridge-group 5
```

```
 frame-relay map bridge 27 broadcast
 frame-relay map bridge 134 broadcast
!
bridge 5 protocol ieee
```

Bridging in a Frame Relay Network with Multicasts

The multicast facility is used to learn about the other bridges on the network, eliminating the need for the **frame-relay map** commands.

Following are the configuration commands for each of the bridges in a network that supports a multicast facility:

Configuration for Bridge 1

```
interface ethernet 2
 bridge-group 5
 ip address 128.88.11.9 255.255.255.0
!
interface serial 0
 encapsulation frame-relay
 bridge-group 5
!
bridge 5 protocol ieee
```

Configuration for Bridge 2

```
interface serial 1
 encapsulation frame-relay
 bridge-group 5
!
bridge 5 protocol ieee
```

Configuration for Bridge 3

```
interface serial 0
 encapsulation frame-relay
 bridge-group 5
!
bridge 5 protocol ieee
```

Transparent Bridging over Multiprotocol LAPB Example

The following example illustrates a router configured for transparent bridging over multiprotocol LAPB encapsulation:

```
!
no ip routing
!
interface ethernet 1
 no ip address
 no mop enabled
 bridge-group 1
!
interface serial 0
 no ip address
 encapsulation lapb multi
 bridge-group 1
!
 bridge 1 protocol ieee
```

Fast-Switched Transparent Bridging over ATM Example (Cisco 7000)

The following configuration example enables fast-switched transparent bridging over ATM:

```
interface atm 4/0
 ip address 1.1.1.1 255.0.0.0
 atm pvc 1 1 1 aal5snap
 atm pvc 2 2 2 aal5snap
 atm pvc 3 3 3 aal5snap
 bridge-group 1
!
bridge 1 protocol dec
```

Transparent Bridging over DDR Examples

The following two examples differ only in the packets that cause calls to be placed. The first example specifies by protocol (any bridge packet is permitted to cause a call to be made); the second example allows a finer granularity by specifying the Ethernet type codes of bridge packets.

The first example configures the serial 1 interface for DDR bridging. Any bridge packet is permitted to cause a call to be placed.

```
no ip routing
!
interface Serial1
 no ip address
 encapsulation ppp
 dialer in-band
 dialer enable-timeout 3
 dialer map bridge name urk broadcast 8985
 dialer hold-queue 10
 dialer-group 1
 ppp authentication chap
 bridge-group 1
 pulse-time 1
!
dialer-list 1 protocol bridge permit
bridge 1 protocol ieee
bridge 1 hello 10
```

The second example also configures the serial 1 interface for DDR bridging. However, this example includes an **access-list** command that specifies the Ethernet type codes that can cause calls to be placed and a **dialer list protocol list** command that refers to the specified access list.

```
no ip routing
!
interface Serial1
 no ip address
 encapsulation ppp
 dialer in-band
 dialer enable-timeout 3
 dialer map bridge name urk broadcast 8985
 dialer hold-queue 10
 dialer-group 1
 ppp authentication chap
 bridge-group 1
 pulse-time 1
!
access-list 200 permit 0x0800 0xFFF8
!
dialer-list 1 protocol bridge list 200
bridge 1 protocol ieee
bridge 1 hello 10
```

Fast-Switched Transparent Bridging over SMDS Example

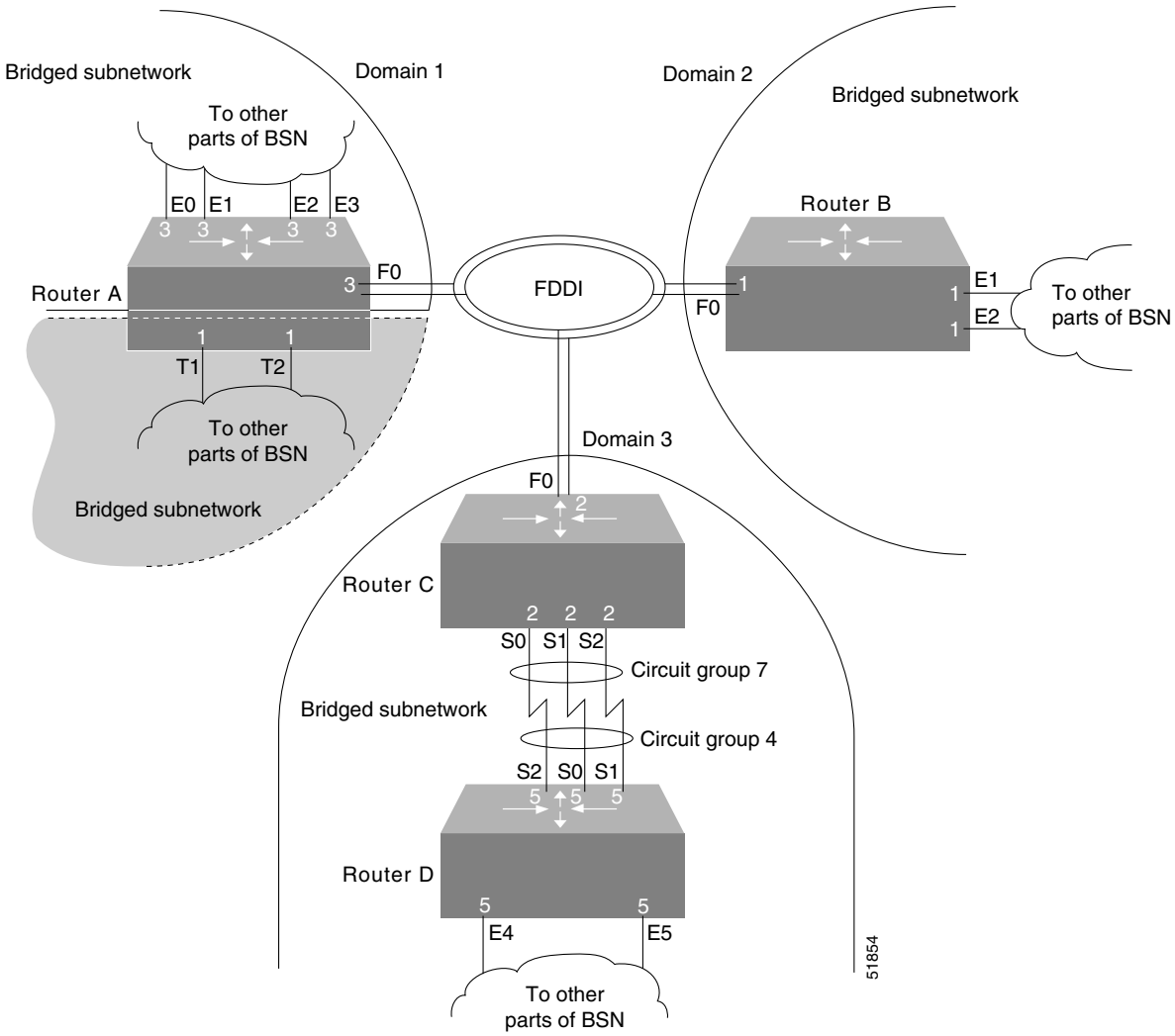
The following configuration example enables fast-switched transparent bridging over SMDS:

```
interface serial 0
 encapsulation smds
 bridge-group 1
 smds multicast bridge c141.5797.1313.ffff
```

Complex Transparent Bridging Network Topology Example

Figure 15 shows a network topology made up of four bridged subnetworks. Each bridged subnetwork is defined by the scope of a spanning tree. However, the scope of each spanning tree is not shown in detail because it is unnecessary for purposes of this discussion. Instead, it is shown by a half cloud labeled "To other parts of BSN."

Figure 15 Bridged Subnetworks with Domains



For proper bridging operation, the bridged subnetworks cannot have connections between them, but they can be connected to the same backbone. In this example, three of the four bridged subnetworks are connected to the FDDI backbone and each belongs to a separate domain.

Domains used in this topology allow the bridged subnetworks to be independent of one another while still bridging traffic onto the backbone destined for other connected bridged subnetworks. Domains can be used in this manner only if the bridged subnetworks have a single point of attachment to one another. In this case, the connection to the FDDI backbone is that single point of attachment.

Each router on which a domain is configured and that has a single point of attachment to the other bridged subnetworks, checks whether a BPDU on the backbone is its own. If the BPDU does not belong to the bridged subnetwork, the Cisco IOS software ignores the BPDU.

Separate bridged subnetworks, as in this example, allow spanning-tree reconfiguration of individual bridged subnetworks without disrupting bridging among the other bridged subnetworks.

Note To get spanning-tree information by bridge group, use the **show span** command. Included in this information is the root bridge of the spanning tree. The root bridge for each spanning tree can be any router in the spanning tree.

The routers in this network are configured for bridging and demonstrate some of the bridging features available.

Configuration for Router A

Router A demonstrates multiple bridge groups in one router for bridged traffic separation.

In Router A, the Token Ring interfaces are bridged together entirely independently of the other bridged interfaces in the router and belong to bridge group 1. Bridge group 1 does not use a bridge domain because the interfaces are bridged independently of other bridged subnetworks in the network topology and it has no connection to the FDDI backbone.

Also in Router A, the Ethernet interfaces belong to bridge group 3. Bridge group 3 has a connection to the FDDI backbone and has a domain defined for it so that it can ignore BPDUs for other bridged subnetworks.

```
interface ethernet 0
 bridge-group 3
!
interface ethernet 1
 bridge-group 3
!
interface ethernet 2
 bridge-group 3
!
interface ethernet 3
 bridge-group 3
!
interface fddi 0
 bridge-group 3
!
interface tokenring 1
 bridge-group 1
!
interface tokenring 2
 bridge-group 1
!
bridge 1 protocol ieee
bridge 3 domain 1
bridge 3 protocol ieee
```

Configuration for Router B

Router B demonstrates a simple bridge configuration. It is connected to the FDDI backbone and has domain 2 defined. As such it can bridge traffic with the other FDDI-connected BSNs. Note that bridge group 1 has no relationship to bridge group 1 in Router A; bridge groups are an organization internal to each router.

```
interface ethernet 1
 bridge-group 1
!
interface ethernet 2
 bridge-group 1
!
interface fddi 0
 bridge-group 1
!
bridge 1 domain 2
bridge 1 protocol ieee
```

Configuration for Router C

Router C and Router D combine to demonstrate load balancing by means of circuit groups. Circuit groups are used to load balance across multiple parallel serial lines between a pair of routers. The router on each end of the serial lines must have a circuit group defined. The circuit group number can be the same or can be different. In this example, they are different.

Router C and Router D are configured with the same domain, because they must understand one another's BPDUs. If they were configured with separate domains, Router D would ignore Router C's BPDUs and vice versa.

```
interface fddi 0
 bridge-group 2
!
interface serial 0
 bridge-group 2
 bridge-group 2 circuit-group 7
!
interface serial 1
 bridge-group 2
 bridge-group 2 circuit-group 7
!
interface serial 2
 bridge-group 2
 bridge-group 2 circuit-group 7
!
bridge 2 domain 3
bridge 2 protocol ieee
```

Configuration for Router D

```
interface ethernet 4
 bridge-group 5
!
interface ethernet 5
 bridge-group 5
!
interface serial 0
 bridge-group 5
 bridge-group 5 circuit-group 4
!
interface serial 1
 bridge-group 5
 bridge-group 5 circuit-group 4
!
```

```
interface serial 2
 bridge-group 5
 bridge-group 5 circuit-group 4
!
bridge 5 domain 3
bridge 5 protocol ieee
```

Fast Ethernet Subscriber Port, Frame Relay Trunk Example

The following example uses the Fast Ethernet subinterface as the subscriber port and Frame Relay as the trunk:

```
bridge 1 protocol ieee

# Form a subscriber bridge group using policy 1
#
bridge 1 subscriber-policy 1
bridge 1 protocol ieee
interface fast0.1
encapsulation isl 1
#
# Put fast0.1 into subscriber group 1
#
bridge-group 1
interface fast0.2
encapsulation isl 2
#
# put fast0.2 into subscriber group 1
#
bridge-group 1
interface serial0
encapsulation frame-relay
int s0.1 point-to-point
#
# Use PVC 155 as the signal channel for setting up connections with the access-server
#
frame-relay interface-dlci 155
#
# Set the trunk to go upstream
#
bridge-group 1 trunk
```

ATM Subscriber Ports, ATM Trunk Example

The following example uses ATM subinterfaces as the subscriber ports and the ATM as the trunk:

```
bridge 1 protocol ieee
#
# Use subscriber policy 3
#
bridge 1 subscriber-policy 3
#
# Change the ARP behavior from permit to deny
#
subscriber-policy 3 arp deny
#
# Change the multicast from permit to deny
#
subscriber-policy 3 multicast deny
```

```
int atm0
int atm0.1 point-to-point
#
# Use AAL5 SNAP encapsulation
#
atm pvc 1 0 101 aal5snap
bridge-group 1
int atm0.2
#
# Use AAL5 SNAP encapsulation
#
atm pvc 2 0 102 aal5snap
bridge-group 1

#
# Configure ATM trunk port
#
int atm1.1
#
# Use AAL5 SNAP encapsulation
#
atm pvc 1 0 101 aal5snap
#
# Specify trunk
#
bridge-group 1 trunk
```

Configuration of Transparent Bridging for PA-12E/2FE Port Adapter Example

Following is an example of a configuration for the PA-12E/2FE port adapter interface. Bridge groups 10, 20, and 30 use IEEE Spanning Tree Protocol. The first four interfaces of a PA-12E/2EF port adapter in port adapter slot 3 use bridge groups 10 and 20. Each interface is assigned to a bridge group and the shutdown state is set to up. The PA-12E/2FE port adapter supports store-and-forward or cut-through switching technology between interfaces within the same bridge group; store-and-forward is the default. In the following example, the **cut-through** command is used to configure each interface for cut-through switching of received and sent data.

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# bridge 10 protocol ieee
Router(config)# bridge 20 protocol ieee
Router(config)# bridge 30 protocol ieee

Router(config)# int fastethernet 3/0
Router(config-if)# bridge-group 10
Router(config-if)# cut-through
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface Fast Ethernet3/0, changed
state to up
%LINK-3-UPDOWN: Interface Fast Ethernet3/0, changed state to up

Router(config)# int fastethernet 3/1
Router(config-if)# bridge-group 10
Router(config-if)# cut-through
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface Fast Ethernet3/1, changed
state to up
%LINK-3-UPDOWN: Interface Fast Ethernet3/1, changed state to up

Router(config)# int ethernet 3/2
Router(config-if)# bridge-group 20
Router(config-if)# cut-through
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet3/2, changed state to up
%LINK-3-UPDOWN: Interface Ethernet3/2, changed state to up

Router(config)# int ethernet 3/3
Router(config-if)# bridge-group 20
Router(config-if)# cut-through
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet3/3, changed state to up
%LINK-3-UPDOWN: Interface Ethernet3/3, changed state to up
```

Configuration of IRB for PA-12E/2FE Port Adapter Example

The following example shows integrated routing and bridging enabled on the bridge groups. Bridge group 10 is assigned an IP address and subnet mask and the shutdown state is changed to up. Bridge group 10 is configured to route IP.

```
Router(config)# bridge irb
Router(config)# interface bvi 10
Router(config-if)# ip address 1.1.15.1 255.255.255.0
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface BVI10, changed state to up

Router(config)# bridge 10 route ip
Router(config)# exit
Router#
```