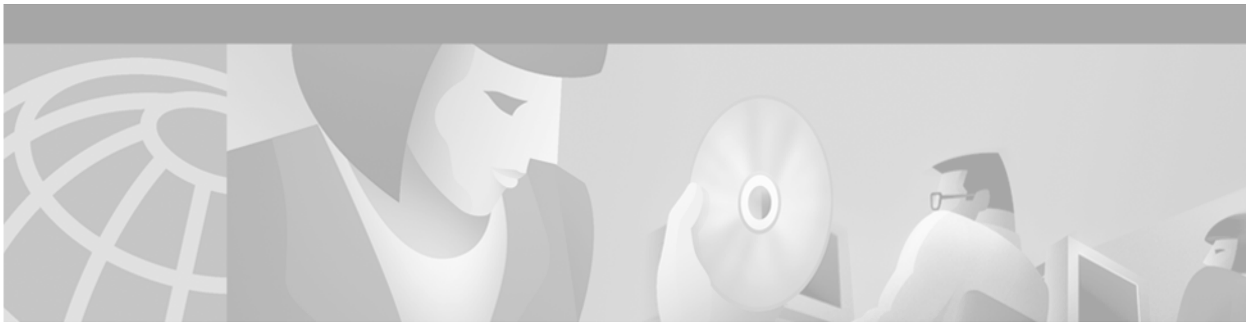


Configuring Data-Link Switching Plus

This chapter describes how to configure data-link switching plus (DLSw+), Cisco's implementation of the DLSw standard for Systems Network Architecture (SNA) and NetBIOS devices. Refer to the *DLSw+ Design and Implementation Guide* for more complex configuration instructions. For a complete description of the DLSw+ commands mentioned in this chapter, refer to the "DLSw+ Commands" chapter of 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:

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the "Identifying Platform Support for Cisco IOS Software Features" section on page lv in the "Using Cisco IOS Software" chapter.

Technology Overview

DLSw+ is a method of transporting SNA and NetBIOS. It complies with the DLSw standard documented in RFC 1795 and the DLSw Version 2 standard. DLSw+ is an alternative to RSRB that addresses several inherent problems that exist in RSRB, such as:

- SRB hop-count limits (SRB's limit is seven)
- Broadcast traffic (including SRB explorer frames or NetBIOS name queries)
- Unnecessary traffic (acknowledgments and keepalives)
- Data-link control timeouts

DLSw Standard

The DLSw standard, documented in RFC 1795, defines the switch-to-switch protocol between DLSw routers. The standard also defines a mechanism to terminate data-link control connections locally and multiplex the traffic from the data-link control connections to a TCP connection. The standard always calls for the transport protocol to be TCP and always requires that data-link control connections be locally terminated (the equivalent of Cisco's local acknowledgment option). The standard also requires that the SRB RIF be terminated at the DLSw router. The standard describes a means for prioritization and flow control and defines error recovery procedures that ensure data-link control connections are appropriately disabled if any part of their associated circuits breaks.

The DLSw standard does not specify when to establish TCP connections. The capabilities exchange allows compliance to the standard, but at different levels of support. The standard does not specify how to cache learned information about MAC addresses, RIFs, or NetBIOS names. It also does not describe how to track either capable or preferred DLSw partners for either backup or load-balancing purposes. The standard does not provide the specifics of media conversion, but leaves the details up to the implementation. It does not define how to map switch congestion to the flow control for data-link control. Finally, the MIB is documented under a separate RFC.

DLSw Version 2 Standard

In the Version 1 standard, a network design requires fully meshed connectivity so that all peers were connect to every other peer. This design creates unnecessary broadcast traffic because an explorer propagates to every peer for every broadcast.

The Version 2 standard is documented in RFC 2166. It includes RFC 1795 and adds the following enhancements:

- IP Multicast, page 282
- UDP Unicast, page 283
- Enhanced Peer-on-Demand Routing Feature, page 283
- Expedited TCP Connection, page 283

Users implement DLSw Version 2 for scalability if they are using multivendor DLSw devices with an IP multicast network. DLSw Version 2 requires complex planning because it involves configuration changes across an IP network.

IP Multicast

Multicast service avoids duplication and excessive bandwidth of broadcast traffic because it replicates and propagates messages to its multicast members only as necessary. It reduces the amount of network overhead in the following ways:

- Avoids the need to maintain TCP Switch-to-Switch Protocol (SSP) connections between two DLSw peers when no circuits are available
- Ensures that each broadcast results in only a single explorer over every link

DLSw Version 2 is for customers who run a multicast IP network and do not need the advantages of border peering.

UDP Unicast

DLSw Version 2 uses UDP unicast in response to an IP multicast. When address resolution packets (CANUREACH_EX, NETBIOS_NQ_ex, NETBIOS_ANQ, and DATAFRAME) are sent to multiple destinations (IP multicast service), DLSw Version 2 sends the response frames (ICANREACH_ex and NAME_RECOGNIZED_ex) via UDP unicast.

UDP unicast uses UDP source port 0. However, some firewall products treat packets that use UDP source port 0 as security violations, discarding the packets and preventing DLSw connections. To avoid this situation, use one of the following procedures:

- Configure the firewall to allow UDP packets to use UDP source port 0.
- Use the **dlsw udp-disable** command to disable UDP unicast and send address resolution packets in the existing TCP session.

Enhanced Peer-on-Demand Routing Feature

DLSw Version 2 establishes TCP connections only when necessary and the TCP connections are brought down when there are no circuits to a DLSw peer for a specified amount of time. This method, known as peer-on-demand routing, was recently introduced in DLSw Version 2, but has been implemented in Cisco DLSw+ border peer technology since Cisco IOS Release 10.3.

Expedited TCP Connection

DLSw Version 2 efficiently establishes TCP connections. Previously, DLSw created two unidirectional TCP connections and then disconnected one after the capabilities exchange took place. With DLSw Version 2, a single bidirectional TCP connection establishes if the peer is brought up as a result of an IP multicast/UDP unicast information exchange.

DLSw+ Features

DLSw+ is Cisco’s version of DLSw and it supports several additional features and enhancements. DLSw+ is a means of transporting SNA and NetBIOS traffic over a campus or WAN. The end systems can attach to the network over Token Ring, Ethernet, Synchronous Data Link Control (SDLC) Protocol, Qualified Logical Link Control (QLLC), or Fiber Distributed Data Interface (FDDI). See the *DLSw+ Design and Implementation Guide* Appendix B, “DLSw+ Support Matrix,” for details. DLSw+ switches between diverse media and locally terminates the data links, keeping acknowledgments, keepalives, and polling off the WAN. Local termination of data links also eliminates data-link control timeouts that can occur during transient network congestion or when rerouting around failed links. Finally, DLSw+ provides a mechanism for dynamically searching a network for SNA or NetBIOS resources and includes caching algorithms that minimize broadcast traffic.

DLSw+ is fully compatible with any vendor’s RFC 1795 implementation and the following features are available when both peers are using DLSw+:

- Peer groups and border peers
- Backup peers
- Promiscuous and on-demand peers
- Explorer firewalls and location learning
- NetBIOS dial-on-demand routing feature support

- UDP unicast support
- Load balancing
- Support for LLC1 circuits
- Support for multiple bridge groups
- Support for RIF Passthrough
- SNA type of service feature support
- Local acknowledgment for Ethernet-attached devices and media conversion for SNA PU 2.1 and PU 2.0 devices
- Conversion between LLC2 to SDLC between PU 4 devices
- Local or remote media conversion between LANs and either SDLC Protocol or QLLC
- SNA View, Blue Maps, and Internetwork Status Monitor (ISM) support

MIB enhancements that allow DLSw+ features to be managed by the CiscoWorks Blue products, SNA Maps, and SNA View. Also, new traps alert network management stations of peer or circuit failures. For more information, refer to the current Cisco IOS release note for the location of the Cisco MIB website.

Local Acknowledgment

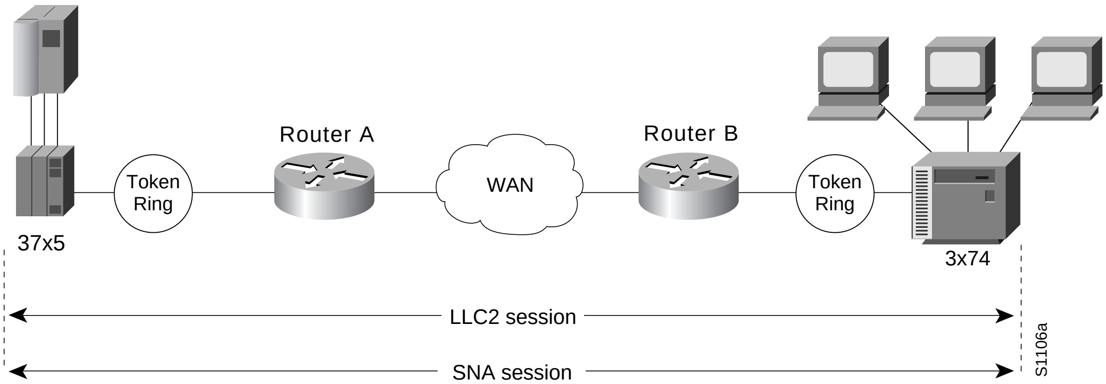
When you have LANs separated by wide geographic distances, and you want to avoid sending data multiple times, and the loss of user sessions that can occur with time delays, encapsulate the source-route bridged traffic inside IP datagrams passed over a TCP connection between two routers with local acknowledgment enabled.

Logical Link Control, type 2 (LLC2) is an ISO standard data-link level protocol used in Token Ring networks. LLC2 was designed to provide reliable sending of data across LAN media and to cause minimal or at least predictable time delays. However, DLSw+ and WAN backbones created LANs that are separated by wide, geographic distances-spanning countries and continents. As a result, LANs have time delays that are longer than LLC2 allows for bidirectional communication between hosts. Local acknowledgment addresses the problem of unpredictable time delays, multiple sendings, and loss of user sessions.

In a typical LLC2 session, when one host sends a frame to another host, the sending host expects the receiving host to respond positively or negatively in a predefined period of time commonly called the *T1 time.* If the sending host does not receive an acknowledgment of the frame it sent within the T1 time, it retries a few times (normally 8 to 10). If there is still no response, the sending host drops the session.

Figure 127 illustrates an LLC2 session in which a 37x5 on a LAN segment communicates with a 3x74 on a different LAN segment separated via a wide-area backbone network. Frames are transported between Router A and Router B by means of DLSw+. However, the LLC2 session between the 37x5 and the 3x74 is still end-to-end; that is, every frame generated by the 37x5 traverses the backbone network to the 3x74, and the 3x74, on receipt of the frame, acknowledges it.

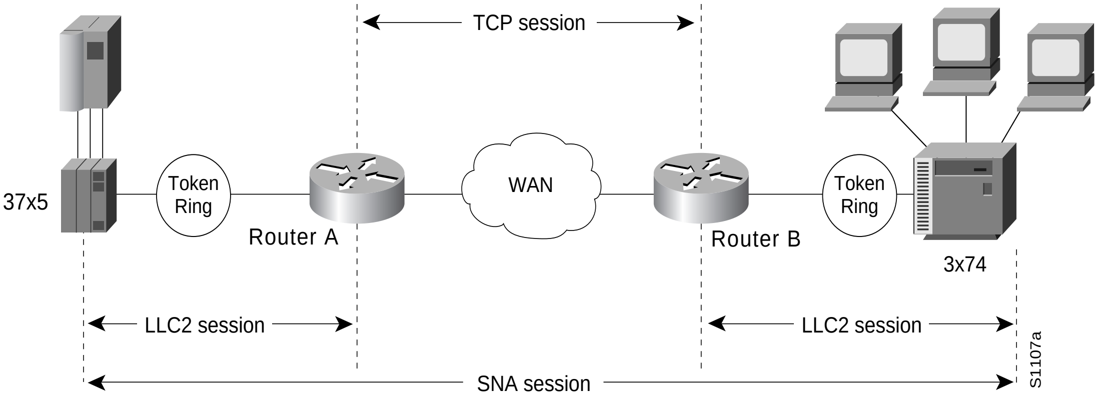
Figure 127 LLC2 Session without Local Acknowledgment



On backbone networks consisting of slow serial links, the T1 timer on end hosts could expire before the frames reach the remote hosts, causing the end host to resend. Resending results in duplicate frames reaching the remote host at the same time as the first frame reaches the remote host. Such frame duplication breaks the LLC2 protocol, resulting in the loss of sessions between the two IBM machines.

One way to solve this time delay is to increase the timeout value on the end nodes to account for the maximum transit time between the two end machines. However, in networks consisting of hundreds or even thousands of nodes, every machine would need to be reconfigured with new values. With local acknowledgment for LLC2 enabled, the LLC2 session between the two end nodes would not be not end-to-end, but instead, would terminate at two local routers. Figure 128 shows the LLC2 session with the 37x5 ending at Router A and the LLC2 session with the 3x74 ending at Router B. Both Router A and Router B execute the full LLC2 protocol as part of local acknowledgment for LLC2.

Figure 128 LLC2 Session with Local Acknowledgment



With local acknowledgment for LLC2 enabled in both routers, Router A acknowledges frames received from the 37x5. The 37x5 still operates as if the acknowledgments it receives are from the 3x74. Router A looks like the 3x74 to the 37x5. Similarly, Router B acknowledges frames received from the 3x74. The 3x74 operates as if the acknowledgments it receives are from the 37x5. Router B looks like the 3x74 to 37x5. Because the frames do not have to travel the WAN backbone networks to be acknowledged, but are locally acknowledged by routers, the end machines do not time out, resulting in no loss of sessions.

Enabling local acknowledgment for LLC2 has the following advantages:

- Local acknowledgment for LLC2 solves the T1 timer problem without having to change any configuration on the end nodes. The end nodes are unaware that the sessions are locally acknowledged. In networks consisting of hundreds or even thousands of machines, this is a definite advantage. All the frames acknowledged by the Cisco IOS software appear to the end hosts to be coming from the remote IBM machine. In fact, by looking at a trace from a protocol analyzer, one cannot say whether a frame was acknowledged by the local router or by a remote IBM machine. The MAC addresses and the RIFs generated by the Cisco IOS software are identical to those generated by the remote IBM machine. The only way to find out whether a session is locally acknowledged is to use either a **show local-ack** command or a **show source-bridge** command on the router.
- All the supervisory (RR, RNR, REJ) frames that are locally acknowledged go no farther than the router. Without local acknowledgment for LLC2, *every* frame traverses the backbone.

  With local acknowledgment, only data (I-frames) traverse the backbone, resulting in less traffic on the backbone network. For installations in which customers pay for the amount of traffic passing through the backbone, this could be a definite cost-saving measure. A simple protocol exists between the two *peers* to bring up or down a TCP session.

Notes on Using LLC2 Local Acknowledgment

LLC2 local acknowledgment is enabled with TCP and DLSw+ Lite remote peers.

If the LLC2 session between the local host and the router terminates in either router, the other will be informed to terminate its connection to its local host.

If the TCP queue length of the connection between the two routers reaches the high-water mark, the routers sends Receiver-Not-Ready (RNR) messages to the local hosts until the queue limit is reduced to below this limit. It is possible, however, to prevent the RNR messages from being sent by using the **dlsw llc2 nornr** command.

The configuration of the LLC2 parameters for the local Token Ring interfaces can affect overall performance. Refer to the chapter “Configuring LLC2 and SDLC Parameters” in this manual for more details about fine-tuning your network through the LLC2 parameters.

The routers at each end of the LLC2 session execute the full LLC2 protocol, which could result in significant router overhead. The decision to use local acknowledgment for LLC2 should be based on the speed of the backbone network in relation to the Token Ring speed. For LAN segments separated by slow-speed serial links (for example, 56 kbps), the T1 timer problem could occur more frequently. In such cases, it might be wise to turn on local acknowledgment for LLC2. For LAN segments separated by a T1, backbone delays will be minimal; in such cases, DLSw+, FST or direct encapsulation should be considered in order to disable local acknowledgement. Speed mismatch between the LAN segments and the backbone network is one criterion to help you decide to use local acknowledgment for LLC2.

There are some situations (such as the receiving host failing between the time the sending host sends data and the time the receiving host receives it), in which the sending host would determine, *at the LLC2 layer*, that data was received when it actually was not. This error occurs because the router acknowledges that it received data from the sending host before it determines that the receiving host can actually receive the data. But because both NetBIOS and SNA have error recovery in situations where an end device goes down, these higher-level protocols will resend any missing or lost data. Because these transaction request/confirmation protocols exist above LLC2, they are not affected by tight timers, as is LLC2. They also are transparent to local acknowledgment.

If you are using NetBIOS applications, note that there are two NetBIOS timers—one at the link level and one at the next higher level. Local acknowledgment for LLC2 is designed to solve link timeouts only. If you are experiencing NetBIOS session timeouts, you have two options:

- Experiment with increasing your NetBIOS timers and decreasing your maximum NetBIOS frame size.
- Avoid using NetBIOS applications on slow serial lines.

Note By default, the Cisco IOS software translates Token Ring LLC2 to Ethernet 802.3 LLC2. To configure the router to translate Token Ring LLC2 frames into Ethernet 0x80d5 format frames, refer to the section "Enable Token Ring LLC2-to-Ethernet Conversion" in the "Configuring Source-Route Bridging" chapter of the *Cisco IOS Bridging and IBM Networking Command Reference* (Volume 1 of 2).

DLSw+ Support for Other SNA Features

DLSw+ can be used as a transport for SNA features such as LNM, DSPU, SNA service point, and SNA Switching Services (SNASw) through a Cisco IOS feature called virtual data-link control (VDLC).

LNM over DLSw+ allows DLSw+ to be used in Token Ring networks that are managed by IBM's LNM software. Using this feature, LNM can be used to manage Token Ring LANs, control access units, and Token Ring attached devices over a DLSw+ network. All management functions continue to operate as they would in a source-route bridged network or an RSRB network.

DSPU over DLSw+ allows Cisco's DSPU feature to operate in conjunction with DLSw+ in the same router. DLSw+ can be used either upstream (toward the mainframe) or downstream (away from the mainframe) of DSPU. DSPU concentration consolidates the appearance of multiple PUs into a single PU appearance to VTAM, minimizing memory and cycles in central site resources (VTAM, NCP, and routers) and speeding network startup.

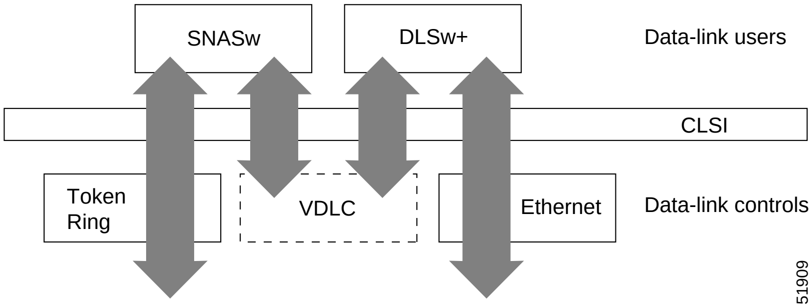
SNA service point over DLSw+ allows Cisco's SNA service point feature to be used in conjunction with DLSw+ in the same router. Using this feature, SNA service point can be configured in remote routers, and DLSw+ can provide the path for the remote service point PU to communicate with NetView. This allows full management visibility of resources from a NetView 390 console, while concurrently offering the value-added features of DLSw+ in an SNA network.

SNASw over DLSw+ allows Cisco's APPN Branch Extender functionality to be used in conjunction with DLSw+ in the same router. With this feature, DLSw+ can be used to access SNASw in the data center. DLSw+ can also be used as a transport for SNASw upstream connectivity, providing nondisruptive recovery from failures.

Using DLSw+ as a transport for other Cisco IOS SNA features requires a feature called VDLC. Cisco IOS data-link users (such as LNM, DSPU, SNA service point, and SNASw) write to a virtual data-link control interface. DLSw+ then reads from this interface and sends out the traffic. Similarly, DLSw+ can receive traffic destined for one of these data-link users and write it to the virtual data-link control interface, from which the appropriate data-link user will read it.

In Figure 129, SNASw and DLSw+ use Token Ring and Ethernet, respectively, as "real" data-link controls, and use virtual data-link control to communicate between themselves. When one of the high-layer protocols passes data to the virtual data-link control, the virtual data-link control must pass it to a higher-layer protocol; nothing leaves the virtual data-link control without going through a data-link user.

Figure 129 VDLC Interaction with Higher-Layer Protocols



The higher-layer protocols make no distinction between the VDLC and any other data-link control, but they do identify the VDLC as a destination. In the example shown in Figure 129, SNASw has two ports: a physical port for Token Ring and a virtual port for the VDLC. When you define the SNASw VDLC port, you can specify the MAC address assigned to it. Data transport from SNASw to DLSw+ by way of the VDLC is directed to the VDLC MAC address. The type of higher-layer protocol you use determines how the VDLC MAC address is assigned.

DLSw+ Configuration Task List

DLSw+ supports local or remote media conversion between LANs and SDLC or QLLC.

To configure DLSw+, complete the tasks in the following sections:

- Defining a DLSw+ Local Peer for the Router, page 288
- Defining a DLSw+ Remote Peer, page 289
- Mapping DLSw+ to a Local Data-Link Control, page 292
- Configuring Advanced Features, page 295
- Configuring DLSw+ Timers, page 310

See the "DLSw+ Configuration Examples" section on page 312 for examples.

Defining a DLSw+ Local Peer for the Router

Defining a DLSw+ local peer for a router enables DLSw+. Specify all local DLSw+ parameters as part of the local peer definition. To define a local peer, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw local peer** [**peer-id** *ip-address*] [**group** *group*] [**border**] [**cluster** *cluster-id*] [**cost** *cost*] [**lf** *size*] [**keepalive** *seconds*] [**passive**] [**promiscuous**] [**init-pacing-window** *size*] [**max-pacing-window** *size*] [**biu-segment**]	Defines the DLSw+ local peer.

The following is a sample **dlsw local peer** statement:

```
dlsw local peer peer-id 10.2.34.3
```

Defining a DLSw+ Remote Peer

Defining a remote peer in DLSw+ is optional, however, usually at least one side of a peer connection has a **dlsw remote-peer** statement. If you omit the **dlsw remote-peer** command from a DLSw+ peer configuration, then you must configure the **promiscuou**s keyword on the dlsw local-peer statement. Promiscuous routers will accept any peer connection requests from other routers that are not preconfigured. To define a remote peer, use the **dlsw remote-peer** command in global configuration mode.

One of the options in the remote peer statement is to specify an encapsulation type. Configure one of the following types of encapsulations with the **dlsw remote-peer** statement:

- TCP Encapsulation, page 289
- TCP/IP with RIF Passthrough Encapsulation, page 290
- FST Encapsulation, page 290
- Direct Encapsulation, page 291
- DLSw Lite Encapsulation, page 291

Which encapsulation type you choose depends on several factors, including whether you want to terminate the LLC flows. TCP and DLSw+ Lite terminate the LLC, but the other encapsulation types do not. For details on each encapsulation type, see the *DLSw+ Design and Implementation Guide*. See the "Local Acknowledgement" section in the overview chapter of this publication for a discussion on local acknowledgement.

TCP Encapsulation

To configure TCP encapsulation on a remote peer, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw remote-peer** *list-number* **tcp** *ip-address* [[*ip-address* | **frame-relay interface serial** *number dlci-number* | **interface** *name*]] [**bytes-netbios-out** bytes-list-name] [**circuit-weight** *weight*] [**cluster** *cluster-id*] [**cost** *cost*] [**dest-mac** *mac-address*] [**dmac-output-list** *access-list-number*] [**host-netbios-out** *host-list-name*] [**inactivity**] [**dynamic**] [**keepalive** *seconds*] [**lf** *size*] [**linger** *minutes*] [**lsap-output-list** *list*] [**no-llc** *minutes*] [**passive**] [**priority**] [**rif-passthru** virtual-ring-number] [**tcp-queue-max** *size*] [**timeout** *seconds*]	Defines a remote peer with TCP encapsulation.

The following command specifies a **dlsw remote peer** with TCP encapsulation:

```
dlsw remote-peer 0 tcp 10.23.4.5
```

TCP/IP with RIF Passthrough Encapsulation

To configure TCP/IP with RIF Passthrough encapsulation, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw remote-peer** *list-number* **tcp** *ip-address* [**backup-peer** [*ip-address* | **frame-relay interface serial** *number dlci-number* | **interface** *name*]] [**bytes-netbios-out** *bytes-list-name*] [**circuit-weight** *weight*] [**cost** *cost*] [**dest-mac** *mac-address*] [**dmac-output-list** *access-list-number*] [**host-netbios-out** *host-list-name*] [**inactivity**] [**dynamic**] [**keepalive** *seconds*] [**lf** *size*] [**linger** *minutes*] [**lsap-output-list** *list*] [**no-llc** *minutes*] [**passive**] [**priority**] [**rif-passthru** *virtual-ring-number*] [**tcp-queue-max** *size*] [**timeout** *seconds*]	Defines a remote peer with TCP/IP with RIF Passthrough encapsulation.

The following command specifies a remote peer with TCP/IP with RIF Passthrough encapsulation:

```
dlsw remote-peer 0 tcp 10.2.23.5 rif-passthru 100
```

FST Encapsulation

To configure FST encapsulation on a remote peer, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw remote-peer** *list-number* **fst** *ip-address* [**backup-peer** [*ip-address* | **frame-relay interface serial** *number dlci-number* | **interface** *name*]] [**bytes-netbios-out** *bytes-list-name*] [**circuit-weight** *weight*] [**cost** *cost*] [**dest-mac** *mac-address*] [**dmac-output-list** *access-list-number*] [**host-netbios-out** *host-list-name*] [**keepalive** *seconds*] [**lf** *size*] [**linger** *minutes*] [**lsap-output-list** *list*]	Defines a remote peer with FST encapsulation.

The following command specifies a DLSw remote peer with FST encapsulation:

```
dlsw remote-peer 0 fst 10.2.23.5
```

Direct Encapsulation

To configure direct encapsulation, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw remote-peer** *list-number* **frame-relay interface serial** *number dlci-number* [**backup-peer** [*ip-address* | **frame-relay interface serial** *number dlci-number* | **interface** *name*]] [**bytes-netbios-out** *bytes-list-name*] [**circuit-weight** *weight*] [**cost** *cost*] [**dest-mac** *mac-address*] [**dmac-output-list** *access-list-number*] [**host-netbios-out** host-list-name] [**keepalive** *seconds*] [**lf** *size*] [**linger** *minutes*] [**lsap-output-list** *list*] **pass-thru**	Defines a remote peer with direct encapsulation.

Direct encapsulation is supported over High-Level Data Link Control (HDLC) and Frame Relay.

The following command specifies a DLSw remote peer with direct encapsulation over HDLC:

```
dlsw remote-peer 0 interface serial 01
```

Direct encapsulation over Frame Relay comes in two forms: DLSw Lite (LLC2 encapsulation) and Passthrough. Specifying the **pass-thru** option configures the router so that the traffic will not be locally acknowledged. (DLSw+ normally locally acknowledges traffic to keep traffic on the WAN to a minimum.)

The following command specifies a DLSw remote peer with Direct encapsulation with pass-thru over Frame Relay:

```
dlsw remote-peer 0 frame-relay interface serial 01 pass-thru
```

DLSw+ Lite is described in the "DLSw Lite Encapsulation" section on page 291.

DLSw Lite Encapsulation

To configure DLSw Lite encapsulation, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw remote-peer** *list-number* **frame-relay interface serial** *number dlci-number* [**backup-peer** [*ip-address* | **frame-relay interface serial** *number dlci-number* | **interface** *name*]] [**bytes-netbios-out** *bytes-list-name*] [**circuit-weight** *weight*] [**cost** *cost*] [**dest-mac** *mac-address*] [**dmac-output-list** *access-list-number*] [**host-netbios-out** *host-list-name*] [**keepalive** *seconds*] [**lf** *size*] [**linger** *minutes*] [**lsap-output-list** *list*] **pass-thru**	Defines a remote peer with DLSw Lite encapsulation.

The following command specifies a DLSw remote peer with DLSw Lite encapsulation over Frame Relay:

```
dlsw remote-peer 0 frame-relay interface serial 01
```

Mapping DLSw+ to a Local Data-Link Control

In addition to configuring local and remote peers, you must map one of the following local data-link controls to DLSw+:

- Token Ring, page 292
- Ethernet, page 293
- SDLC, page 293
- QLLC, page 294
- FDDI, page 295

Token Ring

Traffic that originates from Token Ring is source-route bridged from the local ring onto a source-bridge ring group and then picked up by DLSw+. You must include a **source-bridge ring-group** command that specifies a virtual ring number when configuring Token Ring with DLSw+. In addition, you must configure the **source-bridge** command that tells the DLSw+ router to bridge from the physical Token Ring to the virtual ring.

To specify a virtual ring number, use the following command in global configuration mode:

Command	Purpose
Router(config)# **source-bridge ring-group** *ring-group* [*virtual-mac-address*]	Defines a virtual ring.

To enable DLSw+ to bridge from the physical Token Ring ring to the virtual ring, use the following command in interface mode:

Command	Purpose
Router(config-if)# **source-bridge source**-*ring-number bridge-number target-ring-number*	Defines SRB on interface.

To enable single-route explorers, use the following command in interface mode:

Command	Purpose
Router(config-if)# **source-bridge** *spanning*	Enables single-route explorers.

Configuring the **source-bridge spanning** command is required because DLSw+ uses single-route explorers by default.

The following command configures a source-bridge ring-group and a virtual ring with a value of 100 to DLSw+:

```
source-bridge ring-group 100
int T0
 source-bridge 1 1 100
 source-bridge spanning
```

The *ring-group* number specified in the **source-bridge** command must be the number of a defined source-bridge ring-group or DLSw+ will not see this interface.

Ethernet

Traffic that originates from Ethernet is picked up from the local Ethernet interface bridge group and transported across the DLSw+ network. Therefore, you must map a specific Ethernet bridge group to DLSw+.

To map an Ethernet bridge group to DLSw+, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw bridge-group** *group-number* [**llc2** [**N2** *number*] [**ack-delay-time** *milliseconds*] [**ack-max** *number*] [**idle-time** *milliseconds*] [**local-window** *number*] [**t1-time** *milliseconds*] [**tbusy-time** *milliseconds*] [**tpf-time** *milliseconds*] [**trej-time** *milliseconds*] [**txq-max** *number*] [**xid-neg-val-time** *milliseconds*] [**xid-retry-time** *milliseconds*]] [**locaddr-priority** *lu address priority list number*] [**sap-priority** *priority list number*]	Links DLSw+ to the bridge group of the Ethernet LAN.

To assign the Ethernet interface to a bridge group, use the following command in interface configuration mode:

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

The following command maps bridge-group 1 to DLSw+:

```
dlsw bridge-group 1
int E1
 bridge-group 1
bridge 1 protocol ieee
```

SDLC

Configuring SDLC devices is more complicated than configuring Ethernet and Token Ring. There are several considerations that affect which interface commands are configured. See the *DLSw+ Design and Implementation Guide* for more details.

To establish devices as SDLC stations, use the following commands in interface configuration mode:

	Command	Purpose
Step 1	Router(config-if)# **encapsulation sdlc**	Sets the encapsulation type of the serial interface to SDLC.
Step 2	Router(config-if)# **sdlc role** {**none** | **primary** | **secondary** | **prim-xid-poll**}	Establishes the role of the interface.
Step 3	Router(config-if)# **sdlc vmac** *mac-address*[1]	Configures a MAC address for the serial interface.
Step 4	Router(config-if)# **sdlc address** *hexbyte* [**echo**]	Assigns a set of secondary stations attached to the serial link.
Step 5	Router(config-if)# **sdlc partner** *mac-address sdlc-address* {**inbound** | **outbound**}	Specifies the destination address with which an LLC session is established for the SDLC station.

	Command	Purpose
Step 6	Router(config-if)# **sdlc xid**	Specifies an XID value appropriate for the designated SDLC station associated with this serial interface.
Step 7	Router(config-if)# **sdlc dlsw** {*sdlc-address* | **default** | **partner** *mac-address* [**inbound** | **outbound**]}	Enables DLSw+ on an SDLC interface.

[1] The last byte of the MAC address must be 00.

Use the **default** option if you have more than 10 SDLC devices to attach to the DLSw+ network. To configure an SDLC multidrop line downstream, you configure the SDLC role as either **primary** or **prim-xid-poll**. SDLC role **primary** specifies that any PU without the **xid-poll** parameter in the **sdlc address** command is a PU 2.0 device. SDLC role **prim-xid-poll** specifies that every PU is type 2.1. We recommend that you specify **sdlc role primary** if all SDLC devices are type PU 2.0 or a mix of PU 2.0 and PU 2.1. Specify **sdlc role prim-xid-poll** if all devices are type PU 2.1.

To configure DLSw+ to support LLC2-to-SDLC conversion for PU 4 or PU 5 devices, specify the **echo** option in the **sdlc address** command. A PU 4-to-PU 4 configuration requires that **none** be specified in the **sdlc role** command.

Refer to the "DLSw+ with SDLC Multidrop Support Configuration Examples" section on page 318 and the "DLSw+ with LLC2-to-SDLC Conversion Between PU 4-to-PU 4 Communication Example" section on page 319 for sample configurations.

The following configuration shows a DLSw+ router configured for SDLC:

```
dlsw local-peer peer-id 10.2.2.2
dlsw remote-peer 0 tcp 10.1.1.1
interface Serial1
mtu 6000
no ip address
encapsulation sdlc
no keepalive
nrzi-encoding
clockrate 9600
sdlc vmac 4000.3745.0000
sdlc N1 48016
sdlc address 04 echo
sdlc partner 4000.1111.0020 04
sdlc dlsw 4
```

QLLC

SNA devices use QLLC when connecting to X.25 networks. QLLC essentially emulates SDLC over x.25. Therefore, configuring QLLC devices is also complicated. There are several considerations that affect which interface commands are configured. See the *DLSw+ Design and Implementation Guide* for details.

You can configure DLSw+ for QLLC connectivity, which enables both of the following scenarios:

- Remote LAN-attached devices (physical units) or SDLC-attached devices can access an FEP or an AS/400 over an X.25 network.

  Our QLLC support allows remote X.25-attached SNA devices to access an FEP without requiring X.25 NCP Packet Switching Interface (NPSI) in the FEP. This may eliminate the requirement for NPSI (if GATE and DATE are not required), thereby eliminating the recurring license cost. In addition, because the QLLC attached devices appear to be Token Ring-attached to the Network Control Program (NCP), they require no preconfiguration in the FEP. Remote X.25-attached SNA devices can also connect to an AS/400 over Token Ring using this support.

- Remote X.25-attached SNA devices can access an FEP or an AS/400 over a Token Ring or over SDLC.

  For environments just beginning to migrate to LANs, our QLLC support allows deployment of LANs in remote sites while maintaining access to the FEP over existing NPSI links. Remote LAN-attached devices (physical units) or SDLC-attached devices can access a FEP over an X.25 network without requiring X.25 hardware or software in the LAN-attached devices. The Cisco IOS software supports direct attachment to the FEP over X.25 without the need for routers at the data center for SNA traffic.

To enable QLLC connectivity for DLSw+, use the following commands in interface configuration mode:

	Command	Purpose
Step 1	`Router(config-if)#` **encapsulation x 25**	Specifies an interface as an X.25 device.
Step 2	`Router(config-if)#` **x25 address** *subaddress*	Activates X.25 subaddresses.
Step 3	`Router(config-if)#` **x25 map qllc** *virtual-mac-addr x121-addr* [**cud** *cud-value*] [*x25-map-options*]	Associates a virtual MAC address with the X.121 address of the remote X.25 device.
Step 4	`Router(config-if)#` **qllc dlsw** {**subaddress** *subaddress* | **pvc** *pvc-low* [*pvc-high*]} [**vmac** *vmacaddr* [*poolsize*]] [**partner** partner-*macaddr*] [**sap** *ssap dsap*] [**xid** *xidstring*] [**npsi-poll**]	Enables DLSw+ over QLLC.

The following configuration enables QLLC connectivity for DLSw+:

```
dlsw local-peer peer-id 10.3.12.7
dlsw remote-peer 0 tcp 10.3.1.4
interface S0
 encapsulation x25
 x25 address 3110212011
 x25 map qllc 1000.0000.0001 3 1104150101
 qllc dlsw partner 4000.1151.1234
```

FDDI

Configure an FDDI interface the same as a Token Ring or Ethernet interface, depending on whether you are configuring SRB or Transparent Bridging. If you are configuring the router for SRB, configure the FDDI interface for Token Ring. If you are configuring the router for Transparent Bridging, configure the FDDI interface for Ethernet.

Configuring Advanced Features

DLSw+ goes beyond the standard to include additional functionality in the following areas:

- Scalability, page 296—Constructs IBM internetworks in a way that reduces the amount of broadcast traffic, which enhances their scalability.
- Availability, page 303—Dynamically finds alternate paths and, optionally, load-balances across multiple active peers, ports, and channel gateways.

- Modes of Operation, page 306—Dynamically detects the capabilities of the peer router and operates according to those capabilities.
- Network Management, page 307—Works with enhanced network management tools such as CiscoWorks Blue Maps, CiscoWorks SNA View, and CiscoWorks Blue Internetwork Status Monitor (ISM).
- Traffic Bandwidth and Queueing Management, page 307—Offers several bandwidth management and queueing features to enhance the overall performance of your DLSw+ network. Controls different types of explorer traffic using multiple queues, each with a wide range of depth settings.
- Access Control, page 307—Provides access control to various resources throughout a network.

Scalability

One significant factor that limits the size of Token Ring internet works is the amount of explorer traffic that traverses the WAN. DLSw+ includes the following features to reduce the number of explorers:

- Peer Groups and Border Peers, page 296
- Explorer Firewalls, page 300
- NetBIOS Dial-on-Demand Routing, page 300
- SNA Dial-on-Demand Routing, page 301
- UDP Unicast Feature, page 301
- LLC1 Circuits, page 302
- Dynamic Peers, page 302
- Promiscuous Peer Defaults, page 302

Peer Groups and Border Peers

Perhaps the most significant optimization in DLSw+ is a feature known as *peer groups*. Peer groups are designed to address the broadcast replication that occurs in a fully meshed network. When any-to-any communication is required (for example, for NetBIOS or Advanced Peer-to-Peer Networking [APPN] environments), RSRB or standard DLSw implementations require peer connections between every pair of routers. This setup is not only difficult to configure, but it results in branch access routers having to replicate search requests for each peer connection. This setup wastes bandwidth and router cycles. A better concept is to group routers into clusters and designate a focal router to be responsible for broadcast replication. This capability is included in DLSw+.

With DLSw+, a cluster of routers in a region or a division of a company can be combined into a peer group. Within a peer group, one or more of the routers is designated to be the *border peer.* Instead of all routers peering to one another, each router within a group peers to the border peer; and border peers establish peer connections with each other. When a DLSw+ router receives a TEST frame or NetBIOS NAME-QUERY, it sends a single explorer frame to its border peer. The DLSw+ border peer router checks its local, remote and group cache for any reachability information before forwarding the explorer. If no match is found, the border peer forwards the explorer on behalf of the peer group member. If a match is found, the border peer sends the explorer to the appropriate peer or border peer. This setup eliminates duplicate explorers on the access links and minimizes the processing required in access routers.

You can further segment DLSw+ routers within the same border peer group that are serving the same LANs into a *peer cluster.* This segmentation reduces explorers because the border peer recognizes that it only has to forward an explorer to one member within a *peer cluster.* Only TCP encapsulation can be used with the DLSw+ Peer Clusters feature.

The DLSw+ Peer Clusters feature is configured locally on the member peer or on a border peer. Although both options can be configured, we recommend that the *cluster-id* of a particular peer is defined in either the border peer or on the member peer, but not both because of potential configuration confusion.

To define peer groups, configure border peers and assign the local peer to a peer cluster, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw local-peer** [**peer-id** *ip-address*] [**group** *group*] [**border**] [**cost** *cost*] [**cluster** *cluster-id*] [**lf** *size*] [**keepalive** *seconds*] [**passive**] [**promiscuous**] [**biu-segment**] [**init-pacing-window** *size*] [**max-pacing-window** *size*]	Enables peer groups and border peers.

Use the **group** keyword to define a peer group, the **border** keyword to define a border peer and the **cluster** keyword to assign the local peer to a peer cluster. When the user defines the **cluster** option in the **dlsw local-peer** command on the member peer router, the cluster information is exchanged with the border peer during the capabilities exchange as the peers become active. The border peer uses this information to make explorer replication and forwarding decisions.

The following command configures the router as the Border peer that is a member of group 2:

```
dlsw local-peer peer-id 10.2.13.4 group 2 border
```

Configure the **cluster** option in the **dlsw remote-peer** command on a border peer to enable the DLSw+ Peer Clusters feature without forcing every DLSw+ router in the network to upgrade their software. To enable the DLSw+ Peer Clusters feature on a Border Peer, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw remote-peer** *list-number* **tcp** *ip-address* [**backup-peer** [*ip-address* | **frame-relay interface serial** *number dlci-number* | **interface** *name*]] [**bytes-netbios-out** *bytes-list-name*] [**circuit-weight** *weight*] [**cluster** *cluster-id*] [**cost** *cost*] [**dest-mac** *mac-address*] [**dmac-output-list** *access-list-number*] [**host-netbios-out** *host-list-name*] [**inactivity**] [**dynamic**] [**keepalive** *seconds*] [**lf** *size*] [**linger** *minutes*] [**lsap-output-list** *list*] [**no-llc** *minutes*] [**passive**] [**priority**] [**rif-passthru** *virtual-ring-number*] [**tcp-queue-max** *size*] [**timeout** *seconds*]	Defines the border peer router as part of a particular cluster and enables the DLSw+ Peer Clusters feature.

The following command configures a border router as a member of cluster 5:

```
dlsw remote-peer tcp 10.2.13.5 cluster 5
```

A peer-on-demand peer is a non-configured remote-peer that was connected because of an LLC2 session established through a border peer DLSw+ network. On-demand peers greatly reduce the number of peers that must be configured. You can use on-demand peers to establish an end-to-end circuit even though the DLSw+ routers servicing the end systems have no specific configuration information about the peers. This configuration permits casual, any-to-any connection without the burden of configuring the connection in advance. It also allows any-to-any switching in large internetworks where persistent TCP connections would not be possible.

To configure peer-on-demand defaults, use the following command in global configuration mode:

Command	Purpose
`Router(config)# dlsw peer-on-demand-defaults [fst] [bytes-netbios-out bytes-list-name] [cost cost] [dest-mac destination mac-address] [dmac-output-list access-list-number] [host-netbios-out host-list-name] [inactivity minutes] [keepalive seconds] [lf size] [lsap-output-list list] [port-list port-list-number] [priority] [tcp-queue-max]`	Configures peer-on-demand defaults.

To define the maximum entries maintained in a border peer's group cache, use the following command in global configuration mode:

Command	Purpose
`Router(config)# dlsw group-cache max-entries number`	Defines the maximum entries in a group cache.

To remove all entries from the DLSw+ reachability cache, use the following command in privileged EXEC mode:

Command	Purpose
`Router# clear dlsw reachability`	Removes all entries from the DLSw+ reachability cache.

To reset to zero the number of frames that have been processed in the local, remote and group caches, use the following command in privileged EXEC mode:

Command	Purpose
`Router# clear dlsw statistics`	Resets to zero the number of frames that have been processed in the local, remote, and group caches.

To disable the border peer caching feature, use the following command in global configuration mode:

Command	Purpose
`Router(config-if)# dlsw group-cache disable`	Disables the border peer caching feature.

To verify that the peer cluster feature is enabled or that the border peer is configured, issue the **show dlsw capabilities** command on the router. To verify the cluster id number of which the peer is a member, issue the **show dlsw capabilities local** command on the local router.

To display the contents of the reachability caches, use the following command in privileged EXEC command mode:

Command	Purpose
Router# **show dlsw reachability** [[**group** [*value*] | **local** | **remote**] | [**mac-address** [*address*] [**netbios-names** [*name*]	Displays content of group, local and remote caches.

Use the **group** keyword to display the reachability information for the border peer.

Explorer Firewalls

An explorer firewall permits only a single explorer for a particular destination MAC address or NetBIOS name to be sent across the WAN. While an explorer is outstanding and awaiting a response from the destination, subsequent explorers for that MAC address or NetBIOS name are merely stored. When the explorer response is received at the originating DLSw+, all explorers receive an immediate local response. This eliminates the start-of-day explorer storm that many networks experience. Configure the **dlsw timer** command to enable explorer firewalls. See the "Configuring DLSw+ Timers" section on page 310 for details of the command.

To enable explorer firewalls, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw timer** {**icannotreach-block-time** | **netbios-cache-timeout** | **netbios-explorer-timeout** | **netbios-group-cache** | **netbios-retry-interval** | **netbios-verify-interval** | **sna-cache-timeout** | **explorer-delay-time** | **sna-explorer-timeout** | **explorer-wait-time** | **sna-group-cache** | **sna-retry-interval** | **sna-verify-interval**} *time*	Tunes an existing configuration parameter.

NetBIOS Dial-on-Demand Routing

This feature allows you to transport NetBIOS in a dial-on-demand routing (DDR) environment by filtering NetBIOS Session Alive packets from the WAN. NetBIOS periodically sends Session Alive packets as LLC2 I-frames. These packets do not require a response and are superfluous to the function of proper data flow. Furthermore, these packets keep dial-on-demand interfaces up and this up time causes unwanted per-packet charges in DDR networks. By filtering these NetBIOS Session Alive packets, you reduce traffic on the WAN and you reduce some costs that are associated with dial-on-demand routing.

To enable NetBIOS DDR, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw netbios keepalive-filter**	Enables NetBIOS DDR.

The following command enables NetBIOS DDR:

```
dlsw netbios keepalive-filter
```

SNA Dial-on-Demand Routing

This feature allows you to run DLSw+ over a switched line and have the Cisco IOS software take the switched line down dynamically when it is not in use. Utilizing this feature gives the IP Routing table more time to converge when a network problem hinders a remote peer connection. In small networks with good IP convergence time and ISDN lines that start quickly, it is not as necessary to use the **keepalive** option. To use this feature, you must set the **keepalive** value to zero, and you may need to use a lower value for the **timeout** option than the default, which is 90 seconds.

To configure SNA DDR, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw remote-peer** *list-number* **tcp** *ip-address* [**backup-peer** [*ip-address* | **frame-relay interface serial** *number dlci-number* | **interface** *name*]] [**bytes-netbios-out** *bytes-list-name*] [**circuit-weight** *weight*] [**cluster** *cluster-id*] [**cost** *cost*] [**dest-mac** *mac-address*] [**dmac-output-list** *access-list-number*] [**host-netbios-out** *host-list-name*] [**inactivity**] [**dynamic**] [**keepalive** *seconds*] [**lf** *size*] [**linger** *minutes*] [**lsap-output-list** *list*] [**no-llc** *minutes*] [**passive**] [**priority**] [**rif-passthru** *virtual-ring-number*] [**tcp-queue-max** *size*] [**timeout** *seconds*]	Configures SNA DDR.

The following command configures the SNA DDR feature:

```
dlsw remote-peer 0 tcp 10.2.13.4 keepalive 0
```

UDP Unicast Feature

The UDP Unicast feature sends the SSP address resolution packets via UDP unicast service rather than TCP. (SSP packets include: CANUREACH_EX, NETBIOS_NQ_ex, NETBIOS_ANQ, and DATAFRAME.) The UDP unicast feature allows DLSw+ to better control address resolution packets and unnumbered information frames during periods of congestion. Previously, these frames were carried over TCP. TCP resends frames that get lost or delayed in transit, and hence aggravate congestion. Because address resolution packets and unnumbered information frames are not sent on a reliable transport on the LAN, sending them reliably over the WAN is unnecessary. By using UDP for these frames, DLSw+ minimizes network congestion.

Note UDP unicast enhancement has no affect on DLSw+ FST or direct peer encapsulation.

This feature is enabled by default. To disable User Datagram Protocol (UDP) Unicast, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw udp-disable**	Disables UDP Unicast.

LLC1 Circuits

Support for LLC1 circuits more efficiently transports LLC1 UI traffic across a DLSw+ cloud. With LLC1 circuit support, the LLC1 unnumbered information frames (UI) are no longer subject to input queueing and are guaranteed to traverse the same path for the duration of the flow. This feature improves transportation of LLC1 UI traffic because there is no longer the chance of having a specifically routed LLC1 UI frame broadcast to all remote peers. The circuit establishment process has not changed except that the circuit is established as soon as the specifically routed LLC1 UI frame is received and the DLSw+ knows of reachability for the destination MAC address. Furthermore, the connection remains in the CIRCUIT_ESTABLISHED state (rather than proceeding to the CONNECT state) until there is no UI frame flow for a MAC/SAP pair for 10 minutes.

This feature is enabled by default.

Dynamic Peers

In TCP encapsulation, the **dynamic** option and its suboptions **no-llc** and **inactivity** allow you to specify and control the activation of dynamic peers, which are configured peers that are activated only when required. Dynamic peer connections are established only when there is DLSw+ data to send. The dynamic peer connections are taken down when the last LLC2 connection using them terminates and the time period specified in the **no-llc** option expires. You can also use the **inactivity** option to take down dynamic peers when the circuits using them are inactive for a specified number of minutes.

Note Because the **inactivity** option may cause active LLC2 sessions to be terminated, you should not use this option unless you want active LLC2 sessions to be terminated.

To configure a dynamic peer, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw remote-peer** *list-number* **tcp** **ip-address** [**backup-peer** [*ip-address* | **frame-relay interface serial** *number dlci-number* | **interface** *name*]] [**bytes-netbios-out** *bytes-list-name*] [**circuit-weight** *weight*] [**cluster** *cluster-id*] [**cost** *cost*] [**dest-mac** *mac-address*] [**dmac-output-list** *access-list-number*] [**host-netbios-out** *host-list-name*] [**inactivity**] [**dynamic**] [**keepalive** *seconds*] [**lf** *size*] [**linger** *minutes*] [**lsap-output-list** *list*] [**no-llc** *minutes*] [**passive**] [**priority**] [**rif-passthru** *virtual-ring-number*] [**tcp-queue-max** *size*] [**timeout** *seconds*]	Configures a dynamic peer.

The following command specifies a dynamic peer with TCP encapsulation:

```
dlsw remote-peer 0 tcp 10.23.4.5 dynamic
```

Promiscuous Peer Defaults

If you do not configure a **dlsw remote-peer** statement on the DLSw+ router, then you must specify the **promiscuous** keyword on the **dlsw local-peer** statement. The **promiscuous** keyword enables the router to accept peer connection requests from those routers that are not preconfigured. Setting the **dlsw prom-peer-defaults** command allows the user to determine various settings for the promiscuous transport.

To configure promiscuous peer defaults, use the following command in global configuration mode:

Command	Purpose
`Router(config)# dlsw prom-peer-defaults [bytes-netbios-out bytes-list-name] [cost cost] [dest-mac destination-mac-address] [dmac-output-list access-list-number] [host-netbios-out host-list-name] [keepalive seconds] [lf size] [lsap-output-list list] [tcp-queue-max size]`	Configures promiscuous peer defaults.

Availability

DLSw+ supports the following features that allow it to dynamically finds alternate paths quickly and optionally load balances across multiple active peers, ports, and channel gateways:

- Load Balancing, page 303
- Ethernet Redundancy, page 305
- Backup Peers, page 305

Load Balancing

DLSw+ offers enhanced availability by caching multiple paths to a given MAC address or NetBIOS name (where a path is either a remote peer or a local port). Maintaining multiple paths per destination is especially attractive in SNA networks. A common technique used in the hierarchical SNA environment is assigning the same MAC address to different Token Ring interface couplers (TICs) on the IBM FEPs. DLSw+ ensures that duplicate TIC addresses are found, and, if multiple DLSw+ peers can be used to reach the FEPs, they are cached.

The way that multiple capable peers are handled with DLSw+ can be configured to meet either of the following network needs:

- Fault tolerance—To rapidly reconnect if a data-link connection is lost. If load balancing is not enabled, the Cisco IOS software, by default, maintains a preferred path and one or more capable paths to each destination. The preferred path is either the peer or port that responds first to an explorer frame or the peer with the least cost. If the preferred path to a given destination is unavailable, the next available capable path is promoted to the new preferred path. No additional broadcasts are required, and recovery through an alternate peer is immediate. Maintaining multiple cache entries facilitates a timely reconnection after session outages.

  A peer with the least cost can also be the preferred path. You can specify cost in either the **dlsw local peer** or **dlsw remote peer** commands. See the *DLSw+ Design and Implementation Guide* for details on how cost can be applied to control which path sessions use.

- Load balancing—To distribute the network traffic over multiple DLSw+ peers in the network. Alternately, when there are duplicate paths to the destination end system, you can configure load balancing. DLSw+ alternates new circuit requests in either a round-robin or *enhanced* load balancing fashion through the list of capable peers or ports. If round-robin is configured, the router distributes the new circuit in a round-robin fashion, basing it's decision on which peer or port established the last circuit. If enhanced load balancing is configured, the router distributes new circuits based on existing loads and the desired ratio. It detects the path that is underloaded in comparison to the other capable peers and will assign new circuits to that path until the desired ratio is achieved.

For multiple peer connections, peer costs must be applied. The DLSw+ Enhanced Load Balancing feature works only with the lowest (or equal) cost peers. For example, if the user specifies dlswrtr1, dlswrtr2 and dlswrtr3 with costs of 4, 3, and 3 respectively, DLSw+ establishes new circuits with only dlswrtr 2 and dlswrtr3.

To enable the DLSw+ Enhanced Load Balancing feature on the local router, use the following command in global configuration mode:

Command	Purpose
`Router(config)#` **`dlsw load-balance`** `[`**`round-robin`** `|` **`circuit count`** *`circuit-weight`*`]`	Configures the DLSw+ Enhanced Load Balancing feature on the local router.

To adjust the circuit weight for a remote peer with TCP encapsulation, use the following command in global configuration mode:

Command	Purpose
`Router(config)#` **`dlsw remote-peer tcp`** `[`**`circuit-weight`** *`value`*`]`	Adjusts the circuit weight on the remote peer.

To adjust the circuit weight for a remote peer with DLSw+ Lite encapsulation, use the following command in global configuration mode:

Command	Purpose
`Router(config)#` **`dlsw remote-peer frame-relay interface serial`** *`number`* *`dlci number`* `[`**`circuit-weight`** *`value`*`]`	Adjusts the circuit weight on the remote peer.

The circuit-weight of a remote peer controls the number of circuits that peer can take. If multiple, equally low-cost peers can reach a remote source, the circuits to that remote source are distributed among the remote peers based on the ratio of their configured circuit-weights. The peer with the highest circuit-weight takes more circuits.

Because a DLSw+ peer selects its new circuit paths from within its reachability cache, the user must configure the **dlsw timer explorer-wait-time** command with enough time to allow for all the explorer responses to be received. If the new DLSw+ Enhanced Load Balancing Feature is enabled, a message is displayed on the console to alert the user if the timer is not set.

To configure the amount of time needed for all the explorer responses to be received, use the following command in global configuration mode:

Command	Purpose
`Router(config)#` **`dlsw timer`** `{`**`explorer-wait-time`**`}`	Sets the time to wait for all stations to respond to explorers.

See the *DLSw+ Design and Implementation Guide* for details on how to configure load balancing in DLSw+. Refer to the "DLSw+ with Enhanced Load Balancing Configuration Example" section on page 327 for a sample configuration.

Ethernet Redundancy

The DLSw+ Ethernet Redundancy feature, introduced in Cisco IOS Release 12.0(5)T, provides redundancy and load balancing between multiple DLSw+ peers in an Ethernet environment. It enables DLSw+ to support parallel paths between two points in an Ethernet environment, ensuring resiliency in the case of a router failure and providing load balancing for traffic load. The feature also enables DLSw+ to support multiple DLSw+ routers on the same transparent bridged domain that can reach the same MAC address in a switched environment.

To enable the DLSw+ Ethernet Redundancy feature, issue the following command in interface configuration mode:

Command	Purpose
`Router(config-if)#` **`dlsw transparent redundancy-enable`**	Configures transparent redundancy.

To enable the DLSw+ Ethernet Redundancy feature in a switched environment, enter the following commands in interface configuration mode:

	Command	Purpose
Step 1	`Router(config-if)#` **`dlsw transparent switch-support`**	Enables DLSw+ Ethernet Redundancy feature when using a switch device.
Step 2	`Router(config-if)#` **`dlsw transparent map local mac`** *`mac address`* **`remote mac`** *`mac address`* **`neighbor`** *`mac address`*	Configures a single destination MAC address to which multiple MAC addresses on a transparent bridged are mapped.

The Ethernet Redundancy feature is a complex feature. See the *DLSw+ Design and Implementation Guide* for more details. Refer to the "DLSw+ with Ethernet Redundancy Configuration Example" section on page 331 and the "DLSw+ with Ethernet Redundancy Enabled for Switch Support Configuration Example" section on page 332 for sample configurations.

Backup Peers

The **backup-peer** option is common to all encapsulation types on a remote peer and specifies that this remote peer is a backup peer for the router with the specified IP-address, Frame Relay Data-Link Control Identifier (DLCI) number, or interface name. When the primary peer fails, all circuits over this peer are disconnected and the user can start a new session via their backup peer. Prior to Cisco IOS Release 11.2(6)F, you could configure backup peers only for primary FST and TCP.

Also, when you specify the **backup-peer** option in a **dlsw remote-peer tcp** command, the backup peer is activated only when the primary peer becomes unreachable. Once the primary peer is reactivated, all new sessions use the primary peer and the backup peer remains active only as long as there are LLC2 connections using it. You can use the **linger** option to specify a period (in minutes) that the backup peer remains connected after the connection to the primary peer is reestablished. When the linger period expires, the backup peer connection is taken down.

Note If the **linger** keyword is set to 0, all existing sessions on the backup router immediately drop when the primary recovers. If the **linger** keyword is omitted, all existing sessions on the backup router remain active (as long as the session is active) when the primary recovers, however, all new sessions establish via the primary peer. If the **linger** keyword is set to *x* minutes, all existing sessions on the backup router remain active for *x* minutes once the primary recovers, however, all new sessions establish via the primary peer. Once *x* minutes expire, all existing sessions on the backup router drop and the backup peer connection is terminated. The **linger** keyword can be used to minimize line costs if the backup peer is accessed over dial lines, but can be set high enough to allow an operator warning to be sent to all the SNA end users. It will not, however, pass explorers and will not create any new circuits while the primary is up.

To configure a backup peer, use the following command in global configuration mode:

Command	Purpose
Router(config)# **dlsw remote peer backup-peer** *ip-address*	Configures a backup peer.

Modes of Operation

It is sometimes necessary for DLSw+ and RSRB to coexist in the same network and in the same router (for example, during migration from RSRB to DLSw+). Cisco DLSw+ supports this environment. In addition, DLSw+ must also interoperate with other vendors' implementations that are based upon other DLSw RFC standards, such as DLSw Version 1 and Version 2.

Cisco routers, implementing Cisco DLSw+, automatically supports three different modes of operation:

- Dual mode—A Cisco router can communicate with some remote peers using RSRB and with others using DLSw+, providing a smooth migration path from RSRB to DLSw+; in dual mode, RSRB and DLSw+ coexist on the same box; the local peer must be configured for both RSRB and DLSw+; and the remote peers must be configured for either RSRB or DLSw, but not both.
- Standards compliance mode—DLSw+ can detect automatically (via the DLSw capabilities exchange) if the participating router is manufactured by another vendor, therefore operating in DLSw standard mode (DLSw Version 1 RFC 1795 and DLSw Version 2 RFC 2166).
- Enhanced mode—DLSw+ can detect automatically that the participating router is another DLSw+ router, therefore operating in enhanced mode, making all of the features of DLSw+ available to the SNA and NetBIOS end systems.

Note DLSw+ does not interoperate with the DLSw RFC 1434 standard.

Some enhanced DLSw+ features are also available when a Cisco router is operating in standards compliance mode with another vendor's router. In particular, enhancements that are locally controlled options on a router can be accessed even though the remote router does not have DLSw+. These include reachability caching, explorer firewalls and media conversion.

Network Management

There are several network management tools available to the user to help them more easily manage and troubleshoot their DLSw+ network. CiscoWorks Blue Maps provides a logical view of the portion of your router network relevant to DLSw+ (there is a similar tool for RSRB and APPN). CiscoWorks Blue SNA View adds to the information provided by Maps by correlating SNA PU and LU names with DLSw+ circuits and DLSw+ peers. CiscoWorks Blue Internetwork Status Monitor (ISM) support allows you to manage your router network from the mainframe console using IBM's NetView or Sterling's SOLVE:Netmaster. See the *DLSw+ Design and Implementation Guide* "Using CiscoWorks Blue: Maps, SNA View, and Internetwork Status Monitor" chapter for more details.

Traffic Bandwidth and Queueing Management

Cisco offers several bandwidth management and queueing features (such as DLSw+ RSVP) to enhance the overall performance of your DLSw+ network. The queueing and bandwidth management features are described in detail in the *DLSw Design and Implementation Guide* "Bandwidth Management Queueing" chapter.

Access Control

DLSw+ offers the following features that allow it to control access to various resources throughout a network:

- DLSw+ Ring List or Port List, page 307
- DLSw+ Bridge Group List, page 308
- Static Paths, page 309
- Static Resources Capabilities Exchange, page 309
- Filter Lists in the Remote-Peer Command, page 309

DLSw+ Ring List or Port List

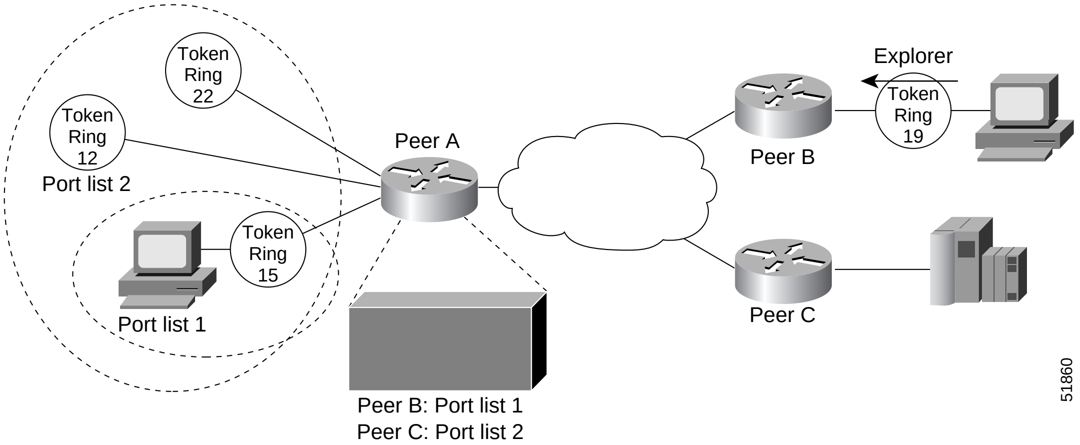
DLSw+ ring lists map traffic on specific local rings to remote peers. You can create a ring list of local ring numbers and apply the list to remote peer definitions. Traffic received from a remote peer is only forwarded to the rings specified in the ring list. Traffic received from a local interface is only forwarded to peers if the input ring number appears in the ring list applied to the remote peer definition. The definition of a ring list is optional. If you want all peers and all rings to receive all traffic, you do not have to define a ring list. Simply specify 0 for the list number in the remote peer statement.

To define a ring list, use the following command in global configuration mode:

Command	Purpose
`Router(config)# dlsw ring-list list-number rings ring-number`	Defines a ring list.

DLSw+ port lists map traffic on a local interface (either Token Ring or serial) to remote peers. Port lists do not work with Ethernet interfaces, or any other interface types connected to DLSw+ by means of a bridge group. You can create a port list of local ports and apply the list to remote peer definitions. Traffic received from a remote peer is only forwarded to peers if the input port number appears in the port list applied to the remote peer definition. The port list command provides a single command to specify both serial and Token Ring interfaces. Figure 130 shows how port lists are used to map traffic.

Figure 130 Mapping Traffic Using Port Lists



The definition of a port list is optional. If you want all peers and all interfaces to receive all traffic, you do not have to define a port list. Simply specify 0 for the list number in the remote peer statement.

To define a port list, use the following command in global configuration mode:

Command	Purpose
`Router(config)# dlsw port-list list-number type number`	Defines a port list.

Note Either the ring list or the port list command can be used to associate rings with a given ring list. The ring list command is easier to type in if you have a large number of rings to define.

DLSw+ Bridge Group List

DLSw+ bridge group lists map traffic on the local Ethernet bridge group interface to remote peers. You can create a bridge group list and apply the list to remote peer definitions. Traffic received from a remote peer is only forwarded to the bridge group specified in the bridge group list. Traffic received from a local interface is only forwarded to peers if the input bridge group number appears in the bridge group list applied to the remote peer definition. The definition of a bridge group list is optional. Because each remote peer has a single list number associated with it, if you want traffic to go to a bridge group and to either a ring list or port list, you should specify the same list number in each definition

To define a bridge-group list, use the following command in global configuration mode:

Command	Purpose
`Router(config)# dlsw bgroup-list list-number bgroups number`	Defines a ring list.

Static Paths

Static path definitions allow a router to setup circuits without sending explorers. The path specifies the peer to use to access a MAC address or NetBIOS name.

To configure static paths to minimize explorer traffic originating in this peer, use one of the following commands in global configuration mode, as needed:

Command	Purpose
Router(config)# **dlsw mac-addr** *mac-addr* {**ring** *ring number* | **remote-peer** {**interface serial** *number* | **ip-address** *ip-address*} | **rif** *rif string* | **group** *group*}	Configures the location or path of a static MAC address.
or	or
Router(config)# **dlsw netbios-name** *netbios-name* {**ring** *ring number* | **remote-peer** {**interface serial** *number* | **ip-address** *ip-address*} | **rif** *rif string* | **group** *group*}	Configures a static NetBIOS name.

Static Resources Capabilities Exchange

To reduce explorer traffic destined for this peer, the peer can send other peers a list of resources for which it has information (**icanreach**) or does not have information (**icannotreach**). This information is exchanged as part of a capabilities exchange.To configure static resources that will be exchanged as part of a capabilities exchange, use one of the following commands in global configuration mode, as needed:

Command	Purpose
Router(config)# **dlsw icannotreach saps** *sap* [*sap...*]	Configures a resource not locally reachable by the router.
or	or
Router(config)# **dlsw icanreach** {**mac-exclusive** | **netbios-exclusive** | **mac-address** *mac-addr* [**mask** *mask*] | **netbios-name** *name* | **saps**}	Configures a resource locally reachable by the router.

Filter Lists in the Remote-Peer Command

The **dest-mac** and **dmac-output-list** options allow you to specify filter lists as part of the **dlsw remote-peer** command to control access to remote peers. For static peers in direct, FST, or TCP encapsulation, these filters control which explorers are sent to remote peers. For dynamic peers in TCP encapsulation, these filters also control the activation of the dynamic peer. For example, you can specify at a branch office that a remote peer is activated only when there is an explorer frame destined for the Media Access Control (MAC) address of an FEP.

The **dest-mac** option permits the connection to be established only when there is an explorer frame destined for the specified MAC address. The **dmac-output-list** option permits the connection to be established only when the explorer frame passes the specified access list. To permit access to a single MAC address, use the **dest-mac** option, because it is a configuration “shortcut” compared to the **dmac-output-list** option.

Configuring DLSw+ Timers

To configure DLSw+ timers, use the following command in global configuration mode:

Command	Purpose
`Router(config)#` **`dlsw timer`** {**`icannotreach-block-time`** | **`netbios-cache-timeout`** | **`netbios-explorer-timeout`** | **`netbios-group-cache`** |**`netbios-retry-interval`** | **`netbios-verify-interval`** |**`sna-cache-timeout`** | **`sna-explorer-timeout`** | **`sna-group-cache`** | **`sna-retry-interval`** | **`sna-verify-interval`**} *`time`*	Configures DLSw+ timers.

See the *DLSw+ Design and Implementation Guide* “Customization” chapter and the *Cisco IOS Bridging and IBM Networking Command Reference* (Volume 1 of 2) for command details.

Verifying DLSw+

To verify that DLSw+ is configured on the router, use the following command in privileged EXEC mode:

Command	Purpose
`Router#` **`show dlsw capabilities local`**	Displays the DLSw+ configuration of a specific peer.

The following sample shows that DLSw+ is configured on router milan:

```
milan#show dlsw capabilities local
DLSw:Capabilities for peer 1.1.1.6(2065)
vendor id (OUI)         :'00C' (cisco)
  version number          :1
  release number          :0
  init pacing window      :20
  unsupported saps        :none
  num of tcp sessions     :1
  loop prevent support    :no
  icanreach mac-exclusive :no
  icanreach netbios-excl. :no
  reachable mac addresses :none
  reachable netbios names :none
  cisco version number    :1
  peer group number       :0
  border peer capable     :no
  peer cost               :3
  biu-segment configured  :no
  UDP Unicast support     :yes
  local-ack configured    :yes
  priority configured     :no
Cisco Internetwork Operating System Software IOS GS Software (GS7-K-M),
Experimental Version 11.1(10956) [sbales 139]
Copyright (c) 1986-1996 by cisco Systems, Inc.
Compiled Thu 30-May-96 09:12 by sbales8
```

If only a command prompt appears, then DLSw+ is not configured for the router.

Alternately, to verify that DLSw+ is configured, issue the following command in privileged EXEC mode:

Command	Purpose
Router# **show running configuration**	Displays the running configuration of a device.

The global DLSw+ configuration statements, including the **dlsw local-peer** statement, appear in the output before the interface configuration statements. The following sample shows that DLSw+ is configured on router milan:

```
milan# show run
version 12.0
!
hostname Sample
!
source-bridge ring-group 110
dlsw local-peer peer-id 10.1.1.1 promiscuous
!
interface TokenRing0/0
no ip address
ring-speed 16
source-bridge 222 1 110
source-bridge spanning
!
```

Monitoring and Maintaining the DLSw+ Network

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

Command	Purpose
Router# **show dlsw capabilities interface** *type number*	Displays capabilities of a direct-encapsulated remote peer.
Router# **show dlsw capabilities ip-address** *ip-address*	Displays capabilities of a TCP/FST remote peer.
Router# **show dlsw capabilities local**	Displays capabilities of the local peer.
Router# **show dlsw circuits**	Displays DLSw+ circuit information.
Router# **show dlsw fastcache**	Displays the fast cache for FST and direct-encapsulated peers.
Router# **show dlsw local-circuit**	Displays DLSw+ circuit information when doing local conversion.
Router# **show dlsw peers**	Displays DLSw+ peer information.
Router# **show dlsw reachability**	Displays DLSw+ reachability information.
Router# **dlsw disable**	Disables and re-enable DLSw+ without altering the configuration.
Router# **show dlsw statistics** [**border-peers**]	Displays the number of frames that have been processed in the local, remote, and group caches.
Router# **clear dlsw circuit**	Closes all the DLSw+ circuits[1]. Also used to reset to zero the number of frames that have been processed in the local, remote, and group cache.

[1] Issuing the **clear dlsw circuits** command will cause the loss of any associated LLC2 sessions.

See the *DLSw+ Design and Implementation Guide* “Using Show and Debug Commands” chapter and the *Cisco IOS Bridging and IBM Networking Command Reference* (Volume 1 of 2) for details of the commands.

DLSw+ Configuration Examples

The following sections provide DLSw+ configuration examples:

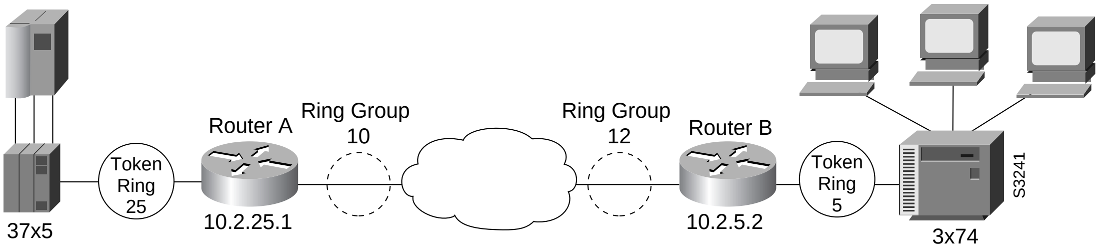
DLSw+ Using TCP Encapsulation and LLC2 Local Acknowledgment—Basic Configuration Example

This sample configuration requires the following tasks, which are described in earlier sections of this document:

- Define a Source-Bridge Ring Group for DLSw+
- Define a DLSw+ Local Peer for the Router
- Define DLSw+ Remote Peers
- Assign DLSw+ to a local data-link control

Figure 131 illustrates a DLSw+ configuration with local acknowledgment. Because the RIF is terminated, the ring group numbers do not have to be the same.

Figure 131 DLSw+ with Local Acknowledgment—Simple Configuration



Router A

```
source-bridge ring-group 10
!
dlsw local-peer peer-id 10.2.25.1
dlsw remote-peer 0 tcp 10.2.5.2
 interface loopback 0
 ip address 10.2.25.1 255.255.255.0
!
interface tokenring 0
 no ip address
 ring-speed 16
 source-bridge 25 1 10
 source-bridge spanning
```

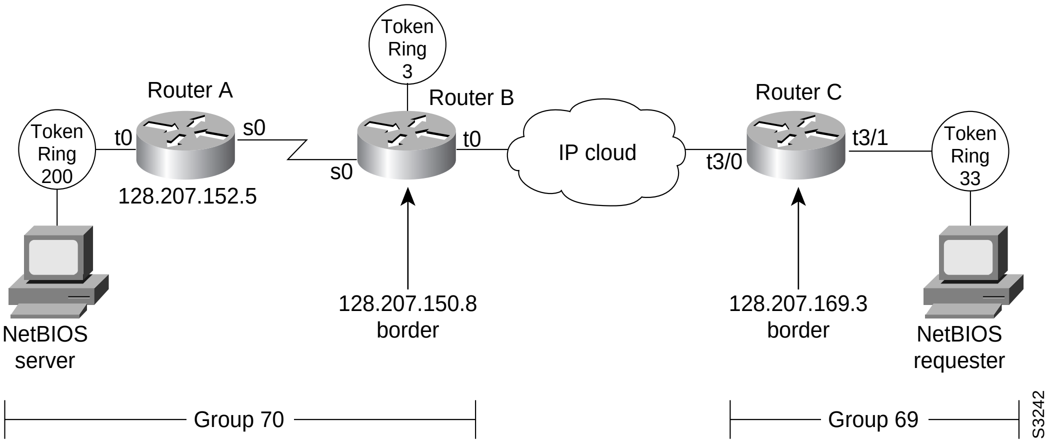
Router B

```
source-bridge ring-group 12
dlsw local-peer peer-id 10.2.5.2
dlsw remote-peer 0 tcp 10.2.25.1
 interface loopback 0
 ip address 10.2.5.2 255.255.255.0
!
interface tokenring 0
 no ip address
 ring-speed 16
 source-bridge 5 1 12
 source-bridge spanning
```

DLSw+ Using TCP Encapsulation with Local Acknowledgment—Peer Group Configuration Example 1

Figure 132 illustrates border peers with TCP encapsulation. Router A is configured to operate in promiscuous mode, and border peers Routers B and C forward broadcasts. This configuration reduces processing requirements in Router A (the access router) and still supports any-to-any networks. Configure Border peer B and C so that they peer to each other.

Figure 132 DLSw+ with Peer Groups Specified (Example 1)



Router A

```
hostname Router A
!
source-bridge ring group 31
dlsw local-peer peer-id 128.207.152.5 group 70 promiscuous
dlsw remote peer 0 tcp 128.207.150.8
interface loopback 0
ip address 128.207.152.5 255.255.255.0
!
interface serial 0
 ip unnumbered tokenring
 clockrate 56000
!
interface tokenring 0
 ip address 128.207.152.5 255.255.255.0
 ring-speed 16
 source-bridge 200 13 31
 source-bridge spanning
!
router igrp 777
network 128.207.0.0
```

Router B

```
hostname Router B
!
source-bridge ring-group 31
dlsw local-peer peer-id 128.207.150.8 group 70 border promiscuous
dlsw remote-peer 0 tcp 128.207.169.3
interface loopback 0
ip address 128.207.150.8 255.255.255.0
```

```
!
interface serial 0
 ip unnumbered tokenring 0
 bandwidth 56
!
interface tokenring 0
 ip address 128.207.150.8 255.255.255.0
 ring-speed 16
source-bridge 3 14 31
 source-bridge spanning
!
router igrp 777
network 128.207.0.0
```

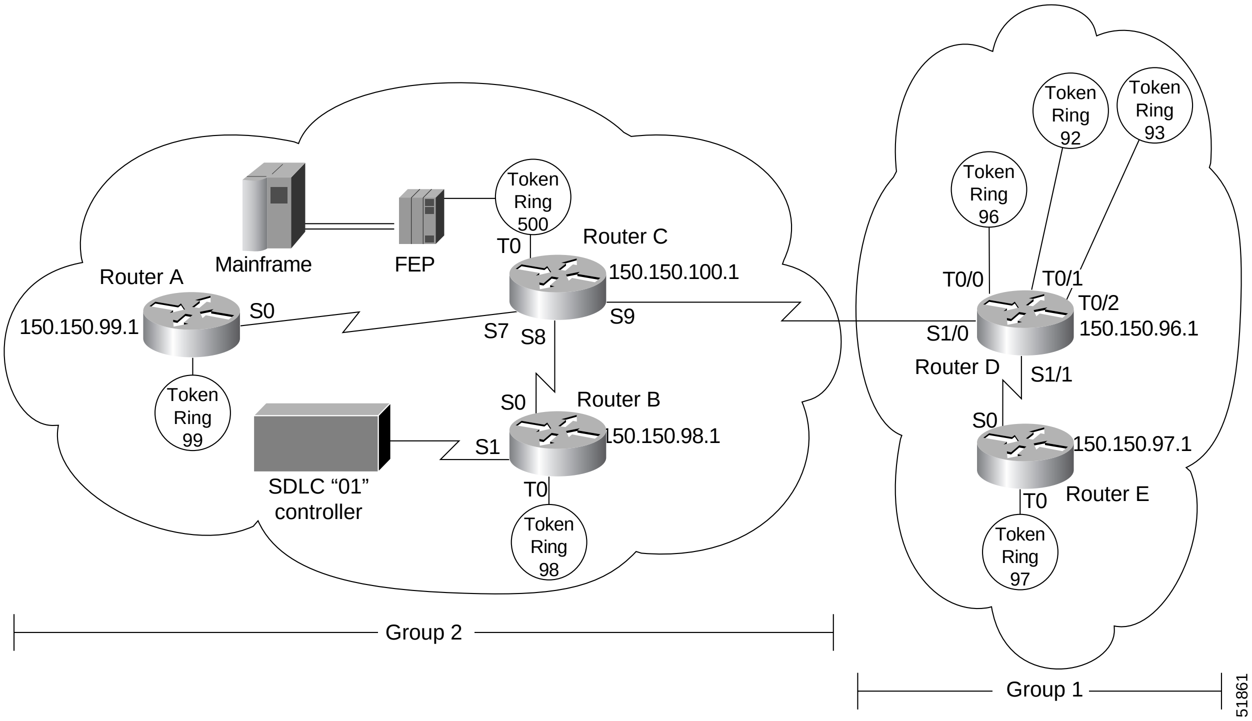
Router C

```
hostname Router C
!
source-bridge ring-group 69
dlsw local-peer peer-id 128.207.169.3 group 69 border promiscuous
dlsw remote-peer 0 tcp 128.207.150.8
interface loopback 0
ip address 128.207.169.3 255.255.255.0
!
interface tokenring 3/0
description fixed to flashnet
 ip address 128.207.2.152 255.255.255.0
 ring-speed 16
 multiring all
!
interface tokenring 3/1
 ip address 128.207.169.3 255.255.255.0
 ring-speed 16
source-bridge 33 2 69
 source-bridge spanning
!
router igrp 777
network 128.207.0.0
```

DLSw+ Using TCP Encapsulation with Local Acknowledgment—Peer Group Configuration Example 2

Figure 133 illustrates a peer group configuration that allows any-to-any connection except for Router B. Router B has no connectivity to anything except router C because the **promiscuous** keyword is omitted.

Figure 133 DLSw+ with Peer Groups Specified (Example 2)



Router A

```
hostname Router A
!
source-bridge ring-group 2000
dlsw local-peer peer-id 150.150.99.1 group 2 promiscuous
dlsw remote-peer 0 tcp 150.150.100.1
!
interface loopback 0
 ip address 150.150.99.1 255.255.255.192
!
interface tokenring 0
 no ip address
 ring-speed 16
source-bridge 99 1 2000
 source-bridge spanning
!
router eigrp 202
network 150.150.0.0
```

Router B

```
hostname Router B
!
source-bridge ring-group 2000
```

```
dlsw local-peer peer-id 150.150.98.1 group 2
dlsw remote-peer 0 tcp 150.150.100.1
!
interface loopback 0
 ip address 150.150.98.1 255.255.255.192
!
interface serial 1
 no ip address
 encapsulation sdlc
 no keepalive
 clockrate 9600
 sdlc role primary
 sdlc vmac 4000.8888.0100
 sdlc address 01
 sdlc xid 01 05d20006
 sdlc partner 4000.1020.1000 01
 sdlc dlsw 1
!
interface tokenring 0
 no ip address
 ring-speed 16
source-bridge 98 1 2000
 source-bridge spanning
!
router eigrp 202
network 150.150.0.0
```

Router C

```
hostname Router C
!
source-bridge ring-group 2000
dlsw local-peer peer-id 150.150.100.1 group 2 border promiscuous
dlsw remote-peer 0 tcp 150.150.96.1
!
interface loopback 0
 ip address 150.150.100.1 255.255.255.192
interface tokenring 0
 no ip address
 ring-speed 16
 source-bridge 500 1 2000
 source-bridge spanning
!
router eigrp 202
network 150.150.0.0
```

Router D

```
hostname Router D
!
source-bridge ring-group 2000
dlsw local-peer peer-id 150.150.96.1 group 1 border promiscuous
dlsw remote-peer 0 tcp 150.150.100.1
!
interface loopback 0
 ip address 150.150.96.1 255.255.255.192
!
interface tokenring 0/0
 no ip address
 ring-speed 16
 source-bridge 96 1 2000
 source-bridge spanning
!
interface tokenring 0/1
```

```
 no ip address
 ring-speed 16
 source-bridge 92 1 2000
 source-bridge spanning
!
.interface tokenring 0/2
 no ip address
 ring-speed 16
 source-bridge 93 1 2000
 source-bridge spanning
!
router eigrp 202
network 150.150.0.0
```

Router E

```
hostname Router E
!
source-bridge ring-group 2000
dlsw local-peer peer-id 150.150.97.1 group 1 promiscuous
dlsw remote-peer 0 tcp 150.150.96.1
!
interface loopback 0
 ip address 150.150.97.1 255.255.255.192
!
interface tokenring 0
 no ip address
 ring-speed 16
 source-bridge 97 1 2000
 source-bridge spanning
!
router eigrp 202
network 150.150.0.0
```

DLSw+ with SDLC Multidrop Support Configuration Examples

In the following example, all devices are type PU 2.0:

```
interface serial 2
 mtu 4400
 no ip address
 encapsulation sdlc
 no keepalive
 clockrate 19200
 sdlc role primary
 sdlc vmac 4000.1234.5600
 sdlc address C1
 sdlc xid C1 05DCCCC1
 sdlc partner 4001.3745.1088 C1
 sdlc address C2
 sdlc xid C2 05DCCCC2
 sdlc partner 4001.3745.1088 C2
 sdlc dlsw C1 C2
```

The following example shows mixed PU 2.0 (device using address C1) and PU 2.1 (device using address C2) devices:

```
interface serial 2
 mtu 4400
 no ip address
 encapsulation sdlc
 no keepalive
 clockrate 19200
 sdlc role primary
 sdlc vmac 4000.1234.5600
 sdlc address C1
 sdlc xid C1 05DCCCC1
 sdlc partner 4001.3745.1088 C1
 sdlc address C2 xid-poll
 sdlc partner 4001.3745.1088 C2
 sdlc dlsw C1 C2
```

In the following example, all devices are type PU 2.1 (Method 1):

```
interface serial 2
 mtu 4400
 no ip address
 encapsulation sdlc
 no keepalive
 clockrate 19200
 sdlc role primary
 sdlc vmac 4000.1234.5600
 sdlc address C1 xid-poll
 sdlc partner 4001.3745.1088 C1
 sdlc address C2 xid-poll
 sdlc partner 4001.3745.1088 C2
 sdlc dlsw C1 C2
```

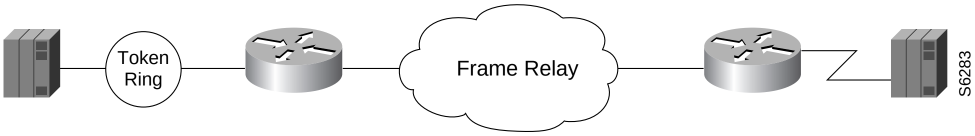
In the following example, all devices are type PU 2.1 (Method 2):

```
interface serial 2
 mtu 4400
 no ip address
 encapsulation sdlc
 no keepalive
 clockrate 19200
 sdlc role prim-xid-poll
 sdlc vmac 4000.1234.5600
 sdlc address C1
 sdlc partner 4001.3745.1088 C1
 sdlc address C2
 sdlc partner 4001.3745.1088 C2
 sdlc dlsw C1 C2
```

DLSw+ with LLC2-to-SDLC Conversion Between PU 4-to-PU 4 Communication Example

The following example is a sample configuration for LLC2-to-SDLC conversion for PU 4-to-PU 4 communication as shown in Figure 134:

Figure 134 LLC2-to-SDLC Conversion for PU 4-to-PU 4 Communication



Router A

```
source-bridge ring-group 1111
dlsw local-peer peer-id 10.2.2.2
dlsw remote-peer 0 tcp 10.1.1.1
interface loopback 0
ip address 10.2.2.2 255.255.255.0
interface TokenRing 0
 no ip address
 ring-speed 16
source-bridge 2 1111
source-bridge spanning
```

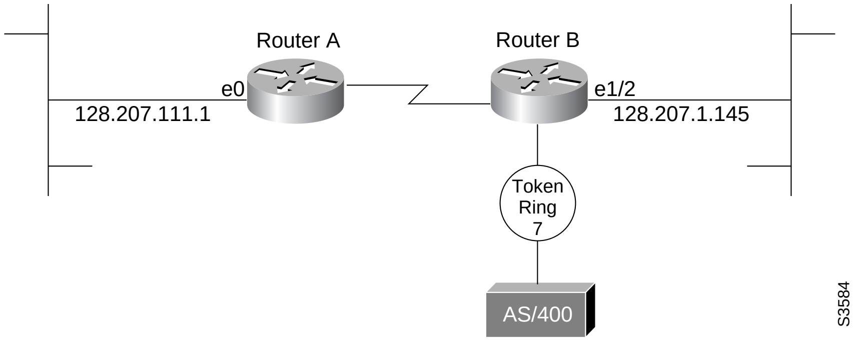
Router B

```
dlsw local-peer peer-id 10.1.1.1
dlsw remote-peer 0 tcp 10.2.2.2
interface loopback 0
ip address 10.1.1.1 255.255.255.0
interface serial 0
 mtu 4096
 no ip address
 encapsulation sdlc
 no keepalive
 nzri-encoding
 clockrate 9600
 sdlc vmac 4000.3745.0000
 sdlc N1 48016
 sdlc address 04 echo
 sdlc partner 4000.1111.0020 04
 sdlc dlsw 4
```

DLSw+ Translation Between Ethernet and Token Ring Configuration Example

DLSw+ also supports Ethernet media. The configuration is similar to other DLSw+ configurations, except for configuring for a specific media. The following example shows Ethernet media (see Figure 135).

Figure 135 DLSw+ Translation Between Ethernet and Token Ring



Router A

```
hostname Router A
!
dlsw local-peer peer-id 128.207.111.1
dlsw remote-peer 0 tcp 128.207.1.145
dlsw bridge-group 5
!
interface loopback 0
ip address 128.207.111.1 255.255.255.0
interface Ethernet 0
no ip address
 bridge-group 5
!
bridge 5 protocol ieee
```

Router B

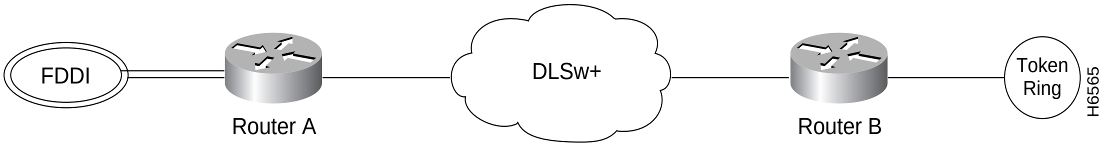
```
hostname Router B
!
source-bridge transparent 500 1000 1 5
dlsw local-peer peer-id 128.207.1.145
dlsw remote-peer 0 tcp 128.207.111.1
dlsw bridge-group 5
!
interface loopback 0
ip address 128.207.1.145 255.255.255.0
interface ethernet 1/2
no ip address
 bridge-group 5
!
interface tokenring 2/0
 no ip address
 ring-speed 16
 source-bridge 7 1 500
 source-bridge spanning
!
bridge 5 protocol ieee
```

Because DLSw+ does not do local translation between different LAN types, Router B must be configured for SR/TLB by issuing the **source-bridge transparent** command. Also, note that the bridge groups are configured on the ethernet interfaces.

DLSw+ Translation Between FDDI and Token Ring Configuration Example

DLSw+ also supports FDDI media. The configuration is similar to other DLSw+ configurations except for configuring for a specific media type. The following example shows FDDI media (see Figure 136).

Figure 136 DLSw+ Translation Between FDDI and Token Ring



In the following configuration, an FDDI ring on Router A is connected to a Token Ring on Router B across a DLSw+ link.

Router A

```
source-bridge ring-group 10
dlsw local-peer peer-id 132.11.11.2
dlsw remote-peer 0 tcp 132.11.11.3
interface loopback 0
ip address 132.11.11.2 255.255.255.0
```

```
interface fddi 0
 no ip address
 source-bridge 26 1 10
 source-bridge spanning
```

Router B

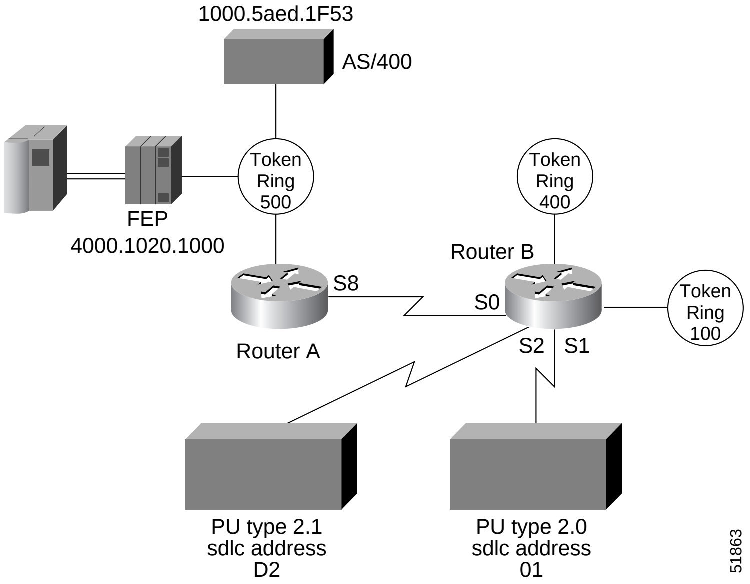
```
source-bridge ring-group 10
dlsw local peer peer-id 132.11.11.3
dlsw remote-peer 0 tcp 132.11.11.2
interface loopback 0
ip address 132.11.11.3 255.255.255.0
interface tokenring 0
 no ip address
 source-bridge 25 1 10
 source-bridge spanning
```

DLSw+ Translation Between SDLC and Token Ring Media Example

DLSw+ provides media conversion between local or remote LANs and SDLC. For additional information about configuring SDLC parameters, refer to the chapter “Configuring LLC2 and SDLC Parameters.”

Figure 137 illustrates DLSw+ with SDLC encapsulation. For this example, 4000.1020.1000 is the MAC address of the FEP host (PU 4.0). The MAC address of the AS/400 host is 1000.5aed.1f53, which is defined as Node Type 2.1. Router B serves as the primary station for the remote secondary station 01. Router B can serve as either primary station or secondary station to remote station D2.

Figure 137 DLSw+ Translation Between SDLC and Token Ring Media



Router A

```
hostname Router A
!
source-bridge ring-group 2000
dlsw local-peer peer-id 150.150.10.2
dlsw remote-peer 0 tcp 150.150.10.1
```

```
!
interface loopback 0
ip address 150.150.10.2 255.255.255.0
interface serial 8
 ip address 150.150.11.2 255.255.255.192
 clockrate 56000

!
interface tokenring 0
 no ip address
 ring-speed 16
 source-bridge 500 1 2000
 source-bridge spanning
!
router eigrp 202
 network 150.150.0.0
```

Router B

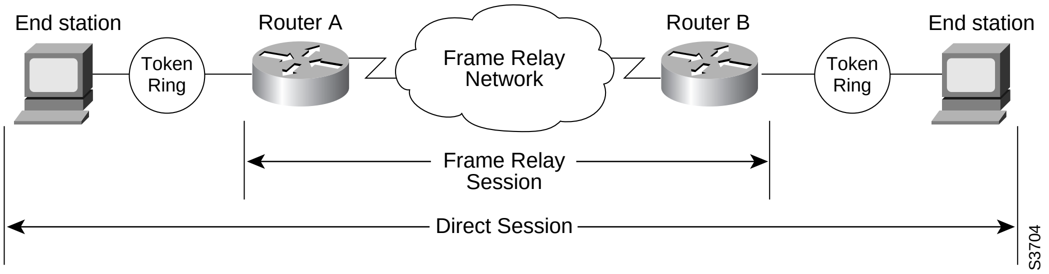
```
hostname Router B
!
source-bridge ring-group 2000
dlsw local-peer peer-id 150.150.10.1
dlsw remote-peer 0 tcp 150.150.10.2
!
interface loopback 0
ip address 150.150.10.1 255.255.255.0
interface serial 0
 ip address 150.150.11.1 255.255.255.192
!
interface serial 1
 description PU2 with SDLC station role set to secondary
 no ip address
 encapsulation sdlc
 no keepalive
 clockrate 9600
 sdlc role primary
 sdlc vmac 4000.9999.0100
 sdlc address 01
 sdlc xid 01 05d20006
 sdlc partner 4000.1020.1000 01
 sdlc dlsw 1
!
interface serial 2
 description Node Type 2.1 with SDLC station role set to negotiable or primary
 encapsulation sdlc
 sdlc role prim-xid-poll
 sdlc vmac 1234.3174.0000
 sdlc address d2
 sdlc partner 1000.5aed.1f53 d2
 sdlc dlsw d2


!
interface tokenring 0
 no ip address
 ring-speed 16
 source-bridge 100 1 2000
 source-bridge spanning
!
interface tokenring 1
 no ip address
 ring-speed 16
 source-bridge 400 1 2000
 source-bridge spanning
!
router eigrp 202
 network 150.150.0.0
```

DLSw+ over Frame Relay Configuration Example

Frame Relay support extends the DLSw+ capabilities to include Frame Relay in direct mode. Frame Relay support includes permanent virtual circuit capability. DLSw+ runs over Frame Relay with or without local acknowledgement. It supports the Token Ring-to-Token Ring connections similar to FST and other direct data link controls. Figure 138 illustrates a DLSw+ configuration over Frame Relay with RIF Passthrough.

Figure 138 DLSw+ over Frame Relay



The following configuration examples are based on Figure 139. The Token Rings in the illustration are in Ring 2.

Router A

```
source-bridge ring-group 100
dlsw local-peer 10.2.23.1
dlsw remote-peer 0 frame-relay interface serial 0 30 passthru
interface loopback 0
ip address 10.2.23.1 255.255.255.0

interface tokenring 0
 ring-speed 16
 source-bridge spanning 1 1 100
!
interface serial 0
 mtu 3000
 no ip address
 encapsulation frame-relay
 frame-relay lmi-type ansi
 frame-relay map dlsw 30
```

Router B

```
source-bridge ring-group 100
dlsw local-peer 10.2.23.2
dlsw remote-peer 0 frame-relay interface serial 0 30 passthru
interface loopback 0
ip address 10.2.23.2 255.255.255.0

interface tokenring 0
 ring-speed 16
 source-bridge spanning 2 1 100
!
```

```
interface serial 0
 mtu 3000
 no ip address
 encapsulation frame-relay
 frame-relay lmi-type ansi
 frame-relay map dlsw 30
```

DLSw+ over QLLC Configuration Examples

The following three examples describe QLLC support for DLSw+.

Example 1

In this configuration, DLSw+ is used to allow remote devices to connect to a DLSw+ network over an X.25 public packet-switched network.

In this example, all QLLC traffic is addressed to destination address 4000.1161.1234, which is the MAC address of the FEP.

The remote X.25-attached IBM 3174 cluster controller is given a virtual MAC address of 1000.0000.0001. This virtual MAC address is mapped to the X.121 address of the 3174 (31104150101) in the X.25 attached router.

```
interface serial 0
 encapsulation x25
 x25 address 3110212011
 x25 map qllc 1000.0000.0001 31104150101
 qllc dlsw partner 4000.1611.1234
```

Example 2

In this configuration, a single IBM 3174 cluster controller needs to communicate with both an AS/400 and a FEP. The FEP is associated with subaddress 150101 and the AS/400 is associated with subaddress 151102.

If an X.25 call comes in for 33204150101, the call is mapped to the FEP and forwarded to MAC address 4000.1161.1234. The IBM 3174 appears to the FEP as a Token Ring-attached resource with MAC address 1000.0000.0001. The IBM 3174 uses a source SAP of 04 when communicating with the FEP, and a source SAP of 08 when communicating with the AS/400.

```
interface serial 0
 encapsulation x25
 x25 address 31102
 x25 map qllc 1000.0000.0001 33204
 qllc dlsw subaddress 150101 partner 4000.1161.1234
 qllc dlsw subaddress 150102 partner 4000.2034.5678 sap 04 08
```

Example 3

In this example, two different X.25 resources want to communicate over X.25 to the same FEP.

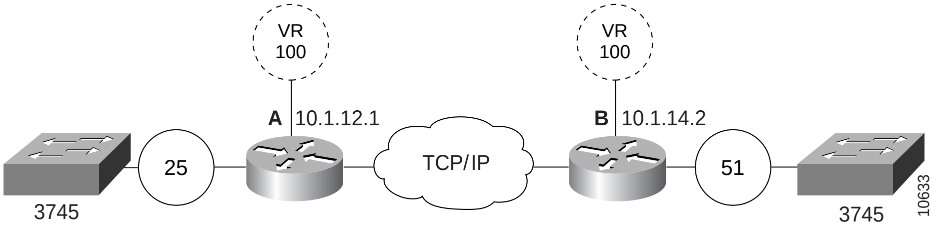
In the router attached to the X.25 network, every X.25 connection request for X.121 address 31102150101 is directed to DLSw+. The first SVC to be established will be mapped to virtual MAC address 1000.0000.0001. The second SVC to be established will be mapped to virtual MAC address 1000.0000.0002.

```
interface serial 0
 encapsulation x25
 x25 address 31102
 x25 map qllc 33204
 x25 map qllc 35765
 qllc dlsw subaddress 150101 vmacaddr 1000.0000.0001 2 partner 4000.1611.1234
```

DLSw+ with RIF Passthrough Configuration Example

Figure 139 is a sample configuration for DLSw+ using the RIF Passthrough feature.

Figure 139 Network Configuration with RIF Passthrough



Router A

```
source-bridge ring-group 100
dlsw local-peer peer id 10.1.12.1
dlsw remote-peer 0 tcp 10.1.14.2 rif-passthru 100
interface loopback 0
ip address 10.1.12.1 255.255.255.0

interface tokenring 0
  ring-speed 16
  source-bridge 25 1 100
  source-bridge spanning
```

Router B

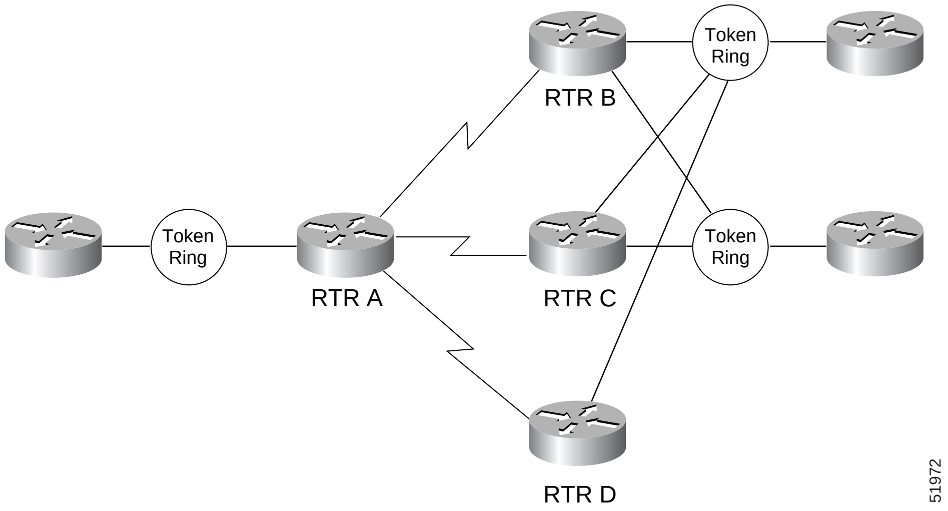
```
source-bridge ring-group 100
dlsw local-peer peer id 10.1.14.2
dlsw remote-peer 0 tcp 10.1.12.1 rif-passthru 100
interface loopback 0
ip address 10.1.14.2 255.255.255.0

interface tokenring 0
  ring-speed 16
  source-bridge 51 1 100
  source-bridge spanning
```

DLSw+ with Enhanced Load Balancing Configuration Example

Figure 140 shows DLSw+ with the Enhanced Load Balancing feature.

Figure 140 DLSw+ with Enhanced Load Balancing



Router A is configured for the DLSw+ Enhanced Load Balancing feature to load balance traffic among the DLSw+ remote peers B, C, and D.

Router A

```
dlsw local-peer 10.2.19.1
dlsw remote-peer 0 tcp 10.2 24.2 circuit-weight 10
dlsw remote-peer 0 tcp 10.2.19.5 circuit-weight 6
dlsw remote-peer 0 tcp 10.2.20.1 circuit-weight 20
dlsw load-balance circuit-count
dlsw timer explorer-wait-time 100
```

Router B

```
dlsw local-peer 10.2.24.2 cost 1 promiscuous
```

Router C

```
dlsw local-peer 10.2.19.5 cost 1 promiscuous
```

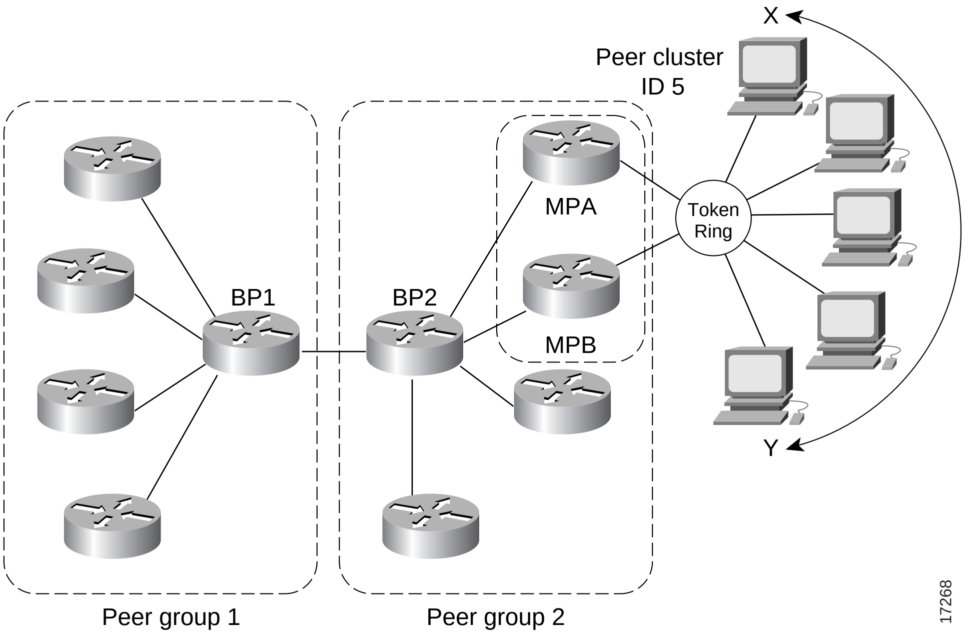
Router D

```
dlsw local-peer 10.2.20.1 cost 1 promiscuous
```

DLSw+ Peer Cluster Feature Configuration Example

Figure 141 shows a DLSw+ network configured with the DLSw+ Peer Clusters feature.

Figure 141 DLSw+ Peer Cluster Feature



Because BP2 is configured as the border peer with the DLSw+ Peer Clusters feature, it does not forward explorers to both MPA and MPB since they are part of the same peer cluster.

BP2

```
source-bridge ring-group 310
dlsw local-peer 10.1.1.3 border group 2 promiscuous
```

MPA

```
source-bridge ring-group 310
dlsw local-peer 10.1.1.1 group 2 promiscuous cluster 5
dlsw remote-peer 0 tcp 10.1.1.3
```

MPB

```
source-bridge ring-group 310
dlsw local-peer 10.1.1.2 group 2 promiscuous cluster 5
dlsw remote-peer tcp 0 10.1.1.3
```

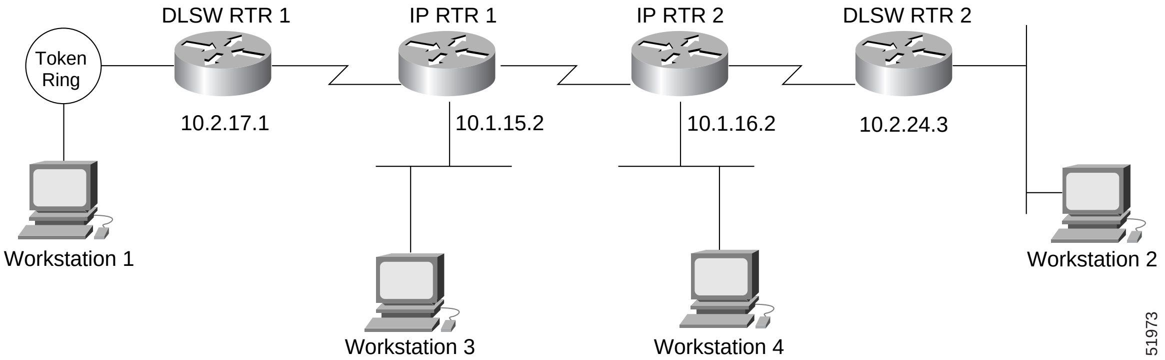
MPC

```
dlsw local-peer 10.1.1.4 group 2 promiscuous
dlsw remote-peer tcp 0 10.1.1.3
```

DLSW+ RSVP Bandwidth Reservation Feature Configuration Example

Figure 142 shows a DLSw+ network with the DLSw+ RSVP Bandwidth Reservation feature configured.

Figure 142 DLSw+ RSVP Bandwidth Reservation Feature Configured



DLSWRTR 1 and DLSWRTR 2 are configured for the DLSw+ RSVP Bandwidth Reservation feature with an average bit rate of 40 and a maximum-burst rate of 10.

DLSWRTR 1

```
dlsw local-peer peer id 10.2.17.1
dlsw remote-peer 0 tcp 10.2.24.3
dlsw rsvp 40 10
```

DLSWRTR2

```
dlsw local-peer peer id 10.2.24.3
dlsw remote-peer 0 tcp 10.2.17.1
dlsw rsvp 40 10
```

The following output of the **show ip rsvp sender** command on the DLSWRTR2 verifies that PATH messages are being sent from DLSWRTR2:

```
DLSWRTR2#show ip rsvp sender
To        From      Pro DPort Sport Prev Hop I/F  BPS     Bytes
10.2.17.1 10.2.24.3 TCP 2065  11003                10K    28K
10.2.24.3 10.2.17.1 TCP 11003 2065 10.2.17.1 Et1/1 10K    28K
```

The following output of the **show ip rsvp req** command on the DLSWRTR2 verifies that RESV messages are being sent from DLSWRTR2:

```
DLSWRTR2#show ip rsvp req
To            From          Pro DPort Sport Next Hop      I/F   Fi Serv BPS Bytes
10.2.24.3   10.2.17.1       TCP 11003 2065 10.2.17.1     Et1/1 FF RATE 10K   28K
```

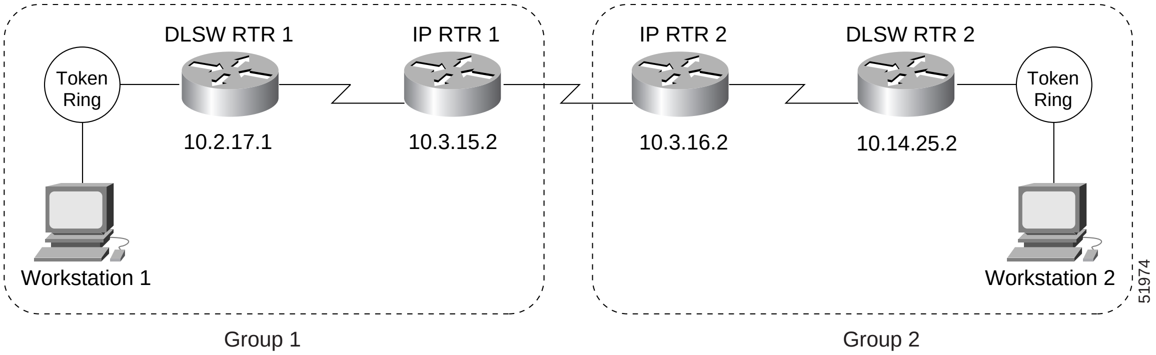
If the IP cloud is able to guarantee the bandwidth requested and the **show ip rsvp sender** and **show ip rsvp req** commands are successful, issue the **show ip rsvp res** command to verify that a reservation was made from DLSWRTR1 to DLSWRTR2:

```
DLSWRTR2#show ip rsvp rese
To            From     Pro DPort Sport Next Hop      I/F   Fi Serv BPS Bytes
10.2.17.1    10.2.24.3 TCP 2065  11003 10.2.17.1 Et1/1 FF RATE     10K   28K
10.2.24.3    10.2.17.1 TCP 11003 2065                  FF RATE     10K   28K
```

DLSw+ RSVP Bandwidth Reservation Feature with Border Peers Configuration Example

Figure 143 shows a DLSw+ border peer network configured with DLSw+ RSVP.

Figure 143 DLSw+ RSVP Bandwidth Reservation Feature in a Border Peer Network



The following example configures DLSWRTR1 to send PATH messages at rates of 40 kbps and 10 kbps and DLSWRTR2 to send PATH messages at rates of 10.

DLSWRTR1

```
dlsw local-peer peer-id 10.2.17.1 group 1 promiscuous
dlsw rsvp default
dlsw remote-peer 0 tcp 10.3.15.2
dlsw peer-on-demand-defaults rsvp 40 10
```

IPRTR1

```
dlsw local-peer peer-id 10.3.15.2 group 1 border promiscuous
dlsw remote-peer 0 tcp 10.3.16.2
```

IPRTR2

```
dlsw local-peer peer-id 10.3.16.2 group 2 border promiscuous
dlsw remote-peer 0 tcp 10.3.15.2
```

DLSWRTR2

```
dlsw local-peer peer-id 10.14.25.2 group 2 promiscuous
dlsw rsvp default
dlsw remote-peer 0 tcp 10.3.16.2
```

The following output of the **show ip rsvp sender** command on DLSWRTR2 verifies that PATH messages are being sent from DLSWRTR2:

```
DLSWRT2#show ip rsvp sender
To              From            Pro DPort Sport Prev Hop        I/F  BPS  Bytes
10.2.17.1      10.14.25.2       TCP 2065  11003                      10K    28K
10.14.25.2     10.2.17.1        TCP 11003 2065 10.2.17.1        Et1/1 10K    28K
```

The following output of the **show ip rsvp request** command on DLSWRTR2 verifies that RESV messages are being sent from DLSWRTR 2:

```
DLSWRT2#show ip rsvp req
To             From           Pro DPort Sport Next Hop      I/F   Fi Serv BPS Bytes
10.14.25.2     10.2.17.1      TCP 11003 2065 10.2.17.1      Et1/1 FF RATE 10K   28K
```

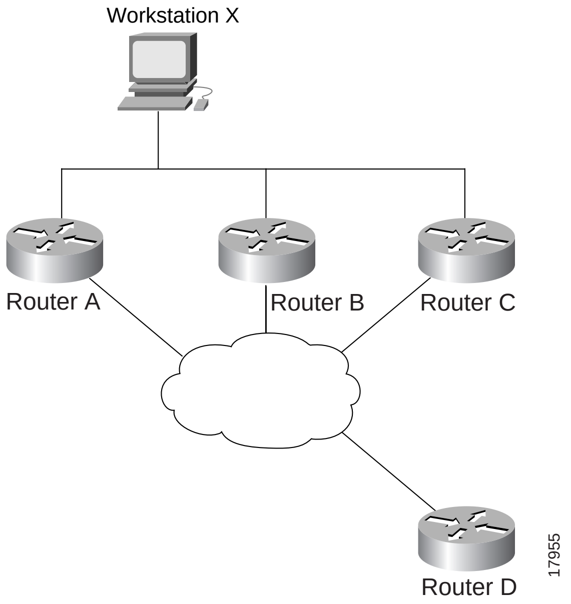
The following output of the **show ip rsvp res** command on the DLSWRTR1 verifies that the RSVP reservation was successful:

```
DLSWRTR1#show ip rsvp rese
To             From           Pro DPort Sport Next Hop      I/F    Fi Serv BPS Bytes
10.2.17.1     10.14.25.2      TCP 2065  11003 10.14.25.2    Et1/1 FF RATE 10K   28K
10.14.25.2    10.2.17.1       TCP 11003 2065                       FF RATE 10K   28K
```

DLSw+ with Ethernet Redundancy Configuration Example

Figure 144 shows that Router A, Router B, and Router C advertise their presence on the Ethernet via their Ethernet interfaces to the multicast MAC address 9999.9999.9999. Because Router B is the master router, it keeps a database of all circuits handled within the domain and grants or denies permission for new circuit requests for Router A and Router C. There is no special configuration required for the end stations or for the remote peer. Only the DLSw+ devices on the LAN need the extra configuration. Master Router B waits 1.5 seconds after it receives the first IWANTIT primitive before assigning the new SNA circuit to one of its ethernet redundancy peers because of the **dlsw transparent timers sna** *1500* command.

Figure 144 DLSw+ with Ethernet Redundancy



Router A

```
dlsw local-peer peer id 10.2.24.2
dlsw remote-peer 0 tcp 10.2.17.1
interface loopback 0
ip address 10.2.24.2 255.255.255.0

int e1
 ip address 150.150.2.1 255.255.255.0
 dlsw transparent redundancy-enable 9999.9999.9999
```

Router B

```
dlsw local-peer peer-id 10.2.24.3
dlsw remote-peer 0 tcp 10.1.17.1
interface loopback 0
ip address 10.2.24.3 255.255.255.0

int e1
 ip address 150.150.2.2 255.255.255.0
 dlsw transparent redundancy-enable 9999.9999.9999 master priority 1
 dlsw transparent timers sna 1500
```

Router C

```
dlsw local-peer peer-id 10.2.24.4
dlsw remote-peer 0 tcp 10.2.17.1
interface loopback 0
ip address 10.2.24.4 255.255.255.0

int e1
 ip address 150.150.2.3 255.255.255.0
 dlsw transparent redundancy-enable 9999.9999.9999
```

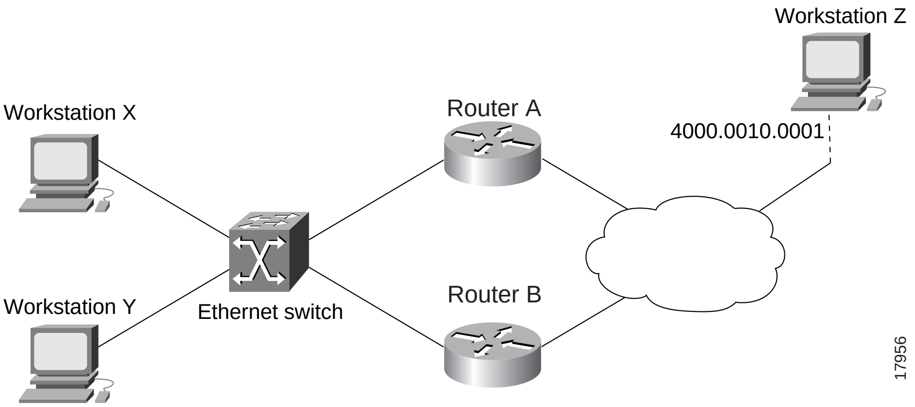
Router D

```
dlsw local-peer peer-id 10.2.17.1 promiscuous
```

DLSw+ with Ethernet Redundancy Enabled for Switch Support Configuration Example

Figure 145 is a sample configuration of the DLSw+ Ethernet Redundancy feature in a switched environment. The ethernet switch sees the device with MAC address 4000.0010.0001 one port at a time because Router A and Router B have mapped different MAC addresses to it. This configuration is known as MAC-address mapping. Router A is configured so that MAC address 4000.0001.0000 maps to the actual device with MAC address 4000.0010.0001. Router B is configured so that MAC address 4000.0201.0001 maps to the actual device with MAC address 4000.0010.0001. Router A and B backup one another. Router A is configured as the master with a default priority of 100. Master Router A waits 1.5 seconds after it receives the first IWANTIT primitive before assigning the new SNA circuit to one of its ethernet redundancy peers because of the **dlsw transparent timers sna** *1500* command.

Figure 145 DLSw+ with Ethernet Redundancy in a Switched Environment



Router A

```
dlsw local peer peer-id 10.2.17.1
dlsw remote-peer 0 tcp 10.3.2.1
dlsw transparent switch-support
interface loopback 0
ip address 10.2.17.1 255.255.255.0

int e 0
 mac-address 4000.0000.0001
 ip address 150.150.2.1 255.255.255.0
 dlsw transparent redundancy-enable 9999.9999.9999 master-priority
 dlsw transparent map local-mac 4000.0001.0000 remote-mac 4000.0010.0001
 neighbor 4000.0000.0011
 dlsw transparent timers sna 1500
```

Router B

```
dlsw local peer peer-id 10.2.17.2
dlsw remote-peer 0 tcp 10.3.2.1
dlsw transport switch-support
interface loopback 0
ip address 10.2.17.2 255.255.255.0

int e 1
 mac-address 4000.0000.0011
 ip address 150.150.3.1 255.255.255.0
 dlsw transparent redundancy-enable 9999.9999.9999
 dlsw transparent map local-mac 4000.0201.0001 remote-mac 4000.0010.0001
 neighbor 4000.0000.0001
```