BayRS Version 15.1

Part No. 308635-15.1 Rev 00
October 2001

600 Technology Park Drive
Billerica, MA 01821-4130

Configuring LLC Services

NORTEL NETWORKS™

Nortel Networks Inc. Software License Agreement

This Software License Agreement ("License Agreement") is between you, the end-user ("Customer") and Nortel Networks Corporation and its subsidiaries and affiliates ("Nortel Networks"). PLEASE READ THE FOLLOWING CAREFULLY. YOU MUST ACCEPT THESE LICENSE TERMS IN ORDER TO DOWNLOAD AND/OR USE THE SOFTWARE. USE OF THE SOFTWARE CONSTITUTES YOUR ACCEPTANCE OF THIS LICENSE AGREEMENT. If you do not accept these terms and conditions, return the Software, unused and in the original shipping container, within 30 days of purchase to obtain a credit for the full purchase price.

"Software" is owned or licensed by Nortel Networks, its parent or one of its subsidiaries or affiliates, and is copyrighted and licensed, not sold. Software consists of machine-readable instructions, its components, data, audio-visual content (such as images, text, recordings or pictures) and related licensed materials including all whole or partial copies. Nortel Networks grants you a license to use the Software only in the country where you acquired the Software. You obtain no rights other than those granted to you under this License Agreement. You are responsible for the selection of the Software and for the installation of, use of, and results obtained from the Software.

1. Licensed Use of Software. Nortel Networks grants Customer a nonexclusive license to use a copy of the Software on only one machine at any one time or to the extent of the activation or authorized usage level, whichever is applicable. To the extent Software is furnished for use with designated hardware or Customer furnished equipment ("CFE"), Customer is granted a nonexclusive license to use Software only on such hardware or CFE, as applicable. Software contains trade secrets and Customer agrees to treat Software as confidential information using the same care and discretion Customer uses with its own similar information that it does not wish to disclose, publish or disseminate. Customer will ensure that anyone who uses the Software does so only in compliance with the terms of this Agreement. Customer shall not a) use, copy, modify, transfer or distribute the Software except as expressly authorized; b) reverse assemble, reverse compile, reverse engineer or otherwise translate the Software; c) create derivative works or modifications unless expressly authorized; or d) sublicense, rent or lease the Software. Licensors of intellectual property to Nortel Networks are beneficiaries of this provision. Upon termination or breach of the license by Customer or in the event designated hardware or CFE is no longer in use, Customer will promptly return the Software to Nortel Networks or certify its destruction. Nortel Networks may audit by remote polling or other reasonable means to determine Customer's Software activation or usage levels. If suppliers of third party software included in Software require Nortel Networks to include additional or different terms, Customer agrees to abide by such terms provided by Nortel Networks with respect to such third party software.

2. Warranty. Except as may be otherwise expressly agreed to in writing between Nortel Networks and Customer, Software is provided "AS IS" without any warranties (conditions) of any kind. NORTEL NETWORKS DISCLAIMS ALL WARRANTIES (CONDITIONS) FOR THE SOFTWARE, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE AND ANY WARRANTY OF NON-INFRINGEMENT. Nortel Networks is not obligated to provide support of any kind for the Software. Some jurisdictions do not allow exclusion of implied warranties, and, in such event, the above exclusions may not apply.

3. Limitation of Remedies. IN NO EVENT SHALL NORTEL NETWORKS OR ITS AGENTS OR SUPPLIERS BE LIABLE FOR ANY OF THE FOLLOWING: a) DAMAGES BASED ON ANY THIRD PARTY CLAIM; b) LOSS OF, OR DAMAGE TO, CUSTOMER'S RECORDS, FILES OR DATA; OR c) DIRECT, INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE, OR CONSEQUENTIAL DAMAGES (INCLUDING LOST PROFITS OR SAVINGS), WHETHER IN CONTRACT, TORT OR OTHERWISE (INCLUDING NEGLIGENCE) ARISING OUT OF YOUR USE OF THE SOFTWARE, EVEN IF NORTEL NETWORKS, ITS AGENTS OR SUPPLIERS HAVE BEEN ADVISED OF THEIR POSSIBILITY. The forgoing limitations of remedies also apply to any developer and/or supplier of the Software. Such developer and/or supplier is an intended beneficiary of this Section. Some jurisdictions do not allow these limitations or exclusions and, in such event, they may not apply.

4. General

a. If Customer is the United States Government, the following paragraph shall apply: All Nortel Networks Software available under this License Agreement is commercial computer software and commercial computer software documentation and, in the event Software is licensed for or on behalf of the United States Government, the respective rights to the software and software documentation are governed by Nortel Networks standard commercial license in accordance with U.S. Federal Regulations at 48 C.F.R. Sections 12.212 (for non-DoD entities) and 48 C.F.R. 227.7202 (for DoD entities).

b. Customer may terminate the license at any time. Nortel Networks may terminate the license if Customer fails to comply with the terms and conditions of this license. In either event, upon termination, Customer must either return the Software to Nortel Networks or certify its destruction.

c. Customer is responsible for payment of any taxes, including personal property taxes, resulting from Customer's use of the Software. Customer agrees to comply with all applicable laws including all applicable export and import laws and regulations.

d. Neither party may bring an action, regardless of form, more than two years after the cause of the action arose.

e. The terms and conditions of this License Agreement form the complete and exclusive agreement between Customer and Nortel Networks.

f. This License Agreement is governed by the laws of the country in which Customer acquires the Software. If the Software is acquired in the United States, then this License Agreement is governed by the laws of the state of New York.

Contents

Chapter 4
Customizing LLC Services

Appendix A
Site Manager Parameters

Figures

Tables

Preface

This guide describes Logical Link Control (LLC) services and what you do to start and customize LLC services on a Nortel Networks* router. By customizing your router for LLC services, you open your network to LAN Network Manager (LNM) servers, data link switching (DLSw) services, and Advanced Peer-to-Peer Networking (APPN).

You can use the Bay Command Console (BCC) or Site Manager to configure LLC on a router. In this guide, you will find instructions for using both the BCC and Site Manager.

Before You Begin

Before using this guide, you must complete the following procedures. For a new router:

- Install the router (see the installation guide that came with your router).
- Connect the router to the network and create a pilot configuration file (see *Quick-Starting Routers*, *Configuring Remote Access for AN and Passport ARN Routers*, or *Connecting ASN Routers to a Network)*.

Make sure that you are running the latest version of Nortel Networks BayRS and Site Manager software. For information about upgrading BayRS and Site Manager, see the upgrading guide for your version of BayRS.

Text Conventions

This guide uses the following text conventions:

angle brackets (< >)	Indicate that you choose the text to enter based on the description inside the brackets. Do not type the brackets when entering the command. Example: If the command syntax is: **ping** <*ip_address*>, you enter: **ping 192.32.10.12**
bold text	Indicates command names and options and text that you need to enter. Example: Enter **show ip** {**alerts** | **routes**}. Example: Use the **dinfo** command.
braces ({ })	Indicate required elements in syntax descriptions where there is more than one option. You must choose only one of the options. Do not type the braces when entering the command. Example: If the command syntax is: **show ip** {**alerts** | **routes**}, you must enter either: **show ip alerts** or **show ip routes**, but not both.
italic text	Indicates new terms, book titles, and variables in command syntax descriptions. Where a variable is two or more words, the words are connected by an underscore. Example: If the command syntax is: **show at** <*valid_route*> *valid_route* is one variable and you substitute one value for it.
`screen text`	Indicates system output, for example, prompts and system messages. Example: `Set Trap Monitor Filters`

separator (>)	Shows menu paths. Example: Protocols > IP identifies the IP option on the Protocols menu.
vertical line (|)	Separates choices for command keywords and arguments. Enter only one of the choices. Do not type the vertical line when entering the command. Example: If the command syntax is: **show ip** {**alerts** | **routes**}, you enter either: **show ip alerts** or **show ip routes**, but not both.

Acronyms

This guide uses the following acronyms:

ANSI	American National Standards Institute
APPN	Advanced Peer-to-Peer Networking
ATM	asynchronous transfer mode
BAN	Boundary Access Node
BNI	Boundary Node Identifier
BNN	Boundary Network Node
DLCI	data link connection identifier
DLSw	data link switching
DM	disconnected mode
DNA	data network address
DSAP	destination service access point
DSPU	downstream physical unit
FDDI	Fiber Distributed Data Interface
FEP	front-end processor
FR	frame relay
FRAD	Frame Relay Access Device
FRMR	frame reject

IEEE	Institute of Electrical and Electronic Engineers
IP	Internet Protocol
ISO	International Organization for Standardization
ITU-T	International Telecommunication Union-Telecommunication Standardization sector [formerly CCITT]
LAN	local area network
LANE	LAN emulation
LEC	LAN emulation client
LLC	Logical Link Control
LNM	LAN Network Manager
LSAP	link service access point
LSDU	link service data unit
MAC	media access control
MSB	most significant byte
NCP	Network Communications Program
NetBIOS	Network Basic Input/Output System
OSI	Open Systems Interconnection
PDU	protocol data unit
PPP	Point-to-Point Protocol
PVC	permanent virtual circuit
RFC	Request for Comments
RNR	receiver not ready
RR	receiver ready
SABME	set asynchronous balanced mode extended
SAP	service access point
SDLC	Synchronous Data Link Control
SNA	Systems Network Architecture
SR	source routing
SRB	source route bridging

SSAP	source service access point
SVC	switched virtual circuit
UA	unnumbered acknowledgment
UI	unnumbered information
WAN	wide area network
XID	exchange identification

Hard-Copy Technical Manuals

You can print selected technical manuals and release notes free, directly from the Internet. Go to the www.nortelnetworks.com/documentation URL. Find the product for which you need documentation. Then locate the specific category and model or version for your hardware or software product. Use Adobe* Acrobat Reader* to open the manuals and release notes, search for the sections you need, and print them on most standard printers. Go to Adobe Systems at the www.adobe.com URL to download a free copy of the Adobe Acrobat Reader.

You can purchase selected documentation sets, CDs, and technical publications through the Internet at the www1.fatbrain.com/documentation/nortel/ URL.

How to Get Help

If you purchased a service contract for your Nortel Networks product from a distributor or authorized reseller, contact the technical support staff for that distributor or reseller for assistance.

If you purchased a Nortel Networks service program, contact one of the following Nortel Networks Technical Solutions Centers:

Technical Solutions Center	Telephone
Europe, Middle East, and Africa	(33) (4) 92-966-968
North America	(800) 4NORTEL or (800) 466-7835
Asia Pacific	(61) (2) 9927-8800
China	(800) 810-5000

Additional information about the Nortel Networks Technical Solutions Centers is available from the www.nortelnetworks.com/help/contact/global URL.

An Express Routing Code (ERC) is available for many Nortel Networks products and services. When you use an ERC, your call is routed to a technical support person who specializes in supporting that product or service. To locate an ERC for your product or service, go to the http://www130.nortelnetworks.com/cgi-bin/eserv/common/essContactUs.jsp URL.

Chapter 1
Logical Link Control Overview

LLC is a standard protocol within the ITU-T (formerly CCITT) 8802.2 and IEEE 802.*x* family of LAN standards. Connection-oriented protocols, including IBM* Systems Network Architecture (SNA) and NetBIOS, use LLC services.

Connection-oriented protocols do not have a network layer address (such as an IP subnet) to route information. Instead, before any information transfer occurs, a device on the network sends a "broadcast" or "explorer" frame to locate the session partner. From this broadcast, the network establishes a path for the data transfer.

LLC2 traffic is generally sensitive to excessive network delays, causing problems with SNA and NetBIOS sessions. Data link switching (DLSw) and Advanced Peer-to-Peer Networking* (APPN*) resolve these problems by locally terminating the LLC2 session at the router and by providing a local acknowledgment to SNA/NetBIOS workstations. The LLC2 subsystem provides these services.

The Nortel Networks implementation of the LLC protocol consists of LLC Class 1 (LLC1), a connectionless service, and LLC Class 2 (LLC2), a connection-oriented service. The subsystems that require LLC2 services are as follows:

- DLSw
- APPN
- LAN Network Manager (LNM)

Most other protocols use LLC1, or connectionless, delivery services.

In general, there is no need to change the LLC2 default settings. You can, however, tune the network by changing these default settings. In Site Manager, you should not add LLC2 to an interface without also adding the DLSw, APPN, or LNM protocol.

Using LLC2 with SNA and NetBIOS

SNA requires a connection-oriented data link layer for end-to-end packet sequencing and error control. Over wide area networks (WANs), the Synchronous Data Link Control (SDLC) protocol has traditionally met this need. However, in a LAN environment, front-end processors (FEPs), controllers, and NetBIOS client/server stations commonly use an LLC2 layer for this purpose. To support communication among these devices, you can add LLC2 interfaces to a router configuration.

SNA devices and NetBIOS PCs use LLC when they establish sessions through a LAN topology. SNA and NetBIOS need LLC2 connection-oriented circuits to provide higher-layer sequencing and error control in bridged LAN environments.

LLC2 works much like SDLC for packet sequencing and acknowledgment. Unlike SDLC, it does not impose unbalanced, primary/secondary relationships between communicating nodes. Any LLC station can initiate a peer-to-peer conversation with any other LLC station.

Supported Connections

You configure LLC2 on any interface requiring local termination, including:

- APPN interfaces
- DLSw interfaces
  - -- When you connect over an IP backbone in dual-switch DLSw configurations, the interface attached to the IP backbone does not use LLC2.
  - -- When you connect over an LLC2 backbone in DLSw single-switch configurations, the interface attached to the backbone uses LLC2.
- Token ring interfaces running LNM

You can enable LLC2 on any LAN or WAN interface that supports APPN, DLSw, and LNM, including:

- LAN interfaces
  - -- Token ring
  - -- Ethernet
  - -- Other LAN media supporting source route bridging (SRB), including Fiber Distributed Data Interface (FDDI)
- WAN interfaces
  - -- Frame relay Boundary Network Node (BNN) and Boundary Access Node (BAN) interfaces
  - -- Any other WAN media supporting source route bridging traffic, including Point-to-Point Protocol (PPP)

Frame Relay Support

Figure 1-1 illustrates the connection of a host through a frame relay network in a configuration with multiprotocol traffic to other locations.

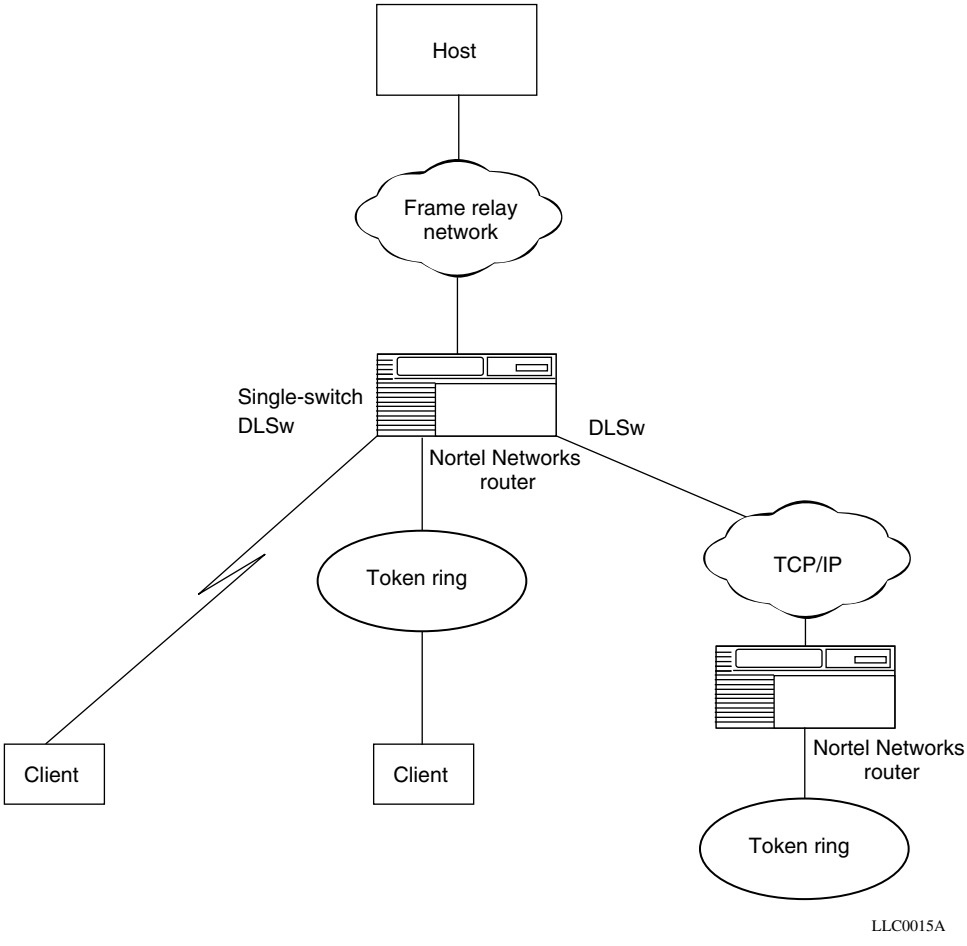


Figure 1-1. Sample Frame Relay Network

Nortel Networks provides two ways to communicate directly with an SNA processor (such as an IBM 3745 or AS/400) over frame relay:

- Boundary Network Node (BNN)
- Boundary Access Node (BAN)

Boundary Network Node

The Boundary Network Node refers to the RFC 1490 specification for routed SNA over frame relay. This implementation of LLC2 also complies with the Frame Relay Forum “Frame Relay Multiprotocol Encapsulation Implementation Agreement” (FRF.3.2), which defines how SNA traffic traverses a frame relay network.

BNN allows native SNA traffic (originating from SDLC LAN- or WAN-attached devices) to communicate over public or private frame relay networks directly with an SNA processor. Devices can communicate with intermediate routing nodes or, in a single-switch configuration, function as a Frame Relay Access Device (FRAD).

Because BNN does not carry the destination and source MAC addresses in the network packets, the BNN format carries the fewest number of bits per packet and yields low network overhead. Therefore, you must explicitly define a permanent virtual circuit (PVC) or a switched virtual circuit (SVC) to carry a packet to its destination.

PVC Support

To configure PVCs for LLC2, you create the LLC2 frame relay mapping table. The mapping table consists of three fields:

- DLCI: frame relay PVC
- Remote MAC: destination MAC address
- Local MAC: source MAC address

For each entry in the table, you must specify the remote MAC, the local MAC, or both. A packet that matches this entry is then forwarded to the specified data link connection identifier (DLCI).

SVC Support

The use of a switched virtual circuit (SVC) is very similar to the BNN PVC over frame relay implementation. However, rather than requiring PVCs to always be available, you use an SVC to connect only when there is data to transfer.

The following features are supported with the BNN SVC implementation:

- Providing a connection only after a client requests a session (for example, through sending a test poll).
- Disconnecting when an SVC is not in use.
- Mapping remote and local MAC addresses to E.164 or X.121 addresses.
- Directing multiple client connection requests to a single destination MAC address over a single SVC by modifying the source (local) service access point (SAP). SAPs are created at the receiving side, and source MAC addresses are automatically created.

Boundary Access Node

The Boundary Access Node (BAN) is an IBM router enhancement. BAN refers to the RFC 1490 specification for bridged SNA over frame relay. The associated IBM NCP 7.3 enhancement is called the Boundary Node Identifier (BNI).

Because BAN carries the destination and source MAC addresses in the network packets, this format carries more bits per packet than BNN and requires less configuration.

Standard BAN uses the source route bridging frame format with local termination. Nortel Networks routers select BAN when you configure the frame relay network with source route encapsulation.

LLC 8802/802.2 Standards

The LLC protocols comply with the ITU-T 8802.2 standard and operate within the IEEE Project 802.*x* protocol stack. Figure 1-2 compares LLC's location in the 802.*x* protocol stack to its equivalent position in the ISO/OSI model.

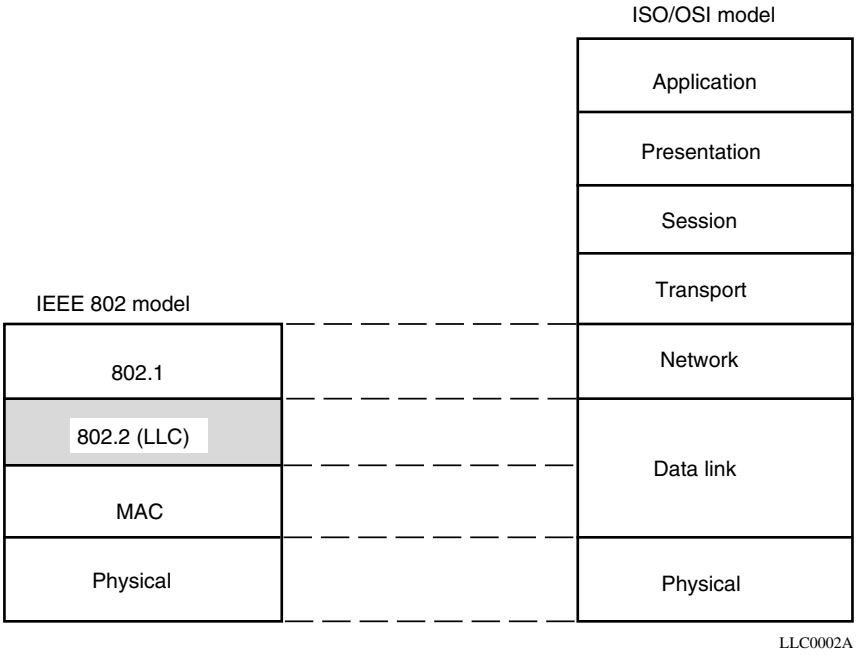


Figure 1-2. LLC Sublayer in the IEEE 802.*x* and OSI Models

You can add an IEEE 802.2-compliant LLC interface to any physical circuit attached directly to an 8802.*x*/802.*x* LAN segment. Each interface services higher-level clients (networking protocols and applications) and is serviced by lower-level protocols (MAC and physical layers) operating within the router.

LLC Service Classes

The 802.2/LLC recommendations support three *service classes:*

- Connectionless unacknowledged (Class 1 or LLC1)
- Connection-oriented (Class 2 or LLC2)
- Connectionless acknowledged (Class 3 or LLC3)

Note: The Nortel Networks implementation of LLC does not support the LLC3 service class.

LLC1 (Connectionless Service)

LLC1 is a datagram service that sends and receives LLC frames called link service data units (LSDUs) without requiring acknowledgment from the peer to assure delivery.

LLC1 supports all forms of communication (point-to-point, multipoint/multicast, and broadcast).

LLC1 service is appropriate for protocols that provide addressing, routing, recovery, and sequencing services at a higher layer.

LLC2 (Connection-Oriented Service)

LLC2 secures point-to-point virtual circuit connections between link service access points (LSAPs) by acting as follows:

- Responds to a higher-level protocol's request to open a connection through the data link layer
- Notifies a higher-level protocol that a connection through the data link layer has been established successfully
- Enables a higher-level protocol to govern LSDU activity by:
  - -- Sending or receiving LSDUs over an established data link layer connection
  - -- Sequencing LSDUs sent over a data link layer connection
  - -- Controlling the flow of LSDUs over a data link layer connection

LLC2 also performs the following services:

- Responds to a request from a higher-level protocol to reset a connection to its initially connected state
- Responds to a request from a higher-level protocol to close an established connection
- Notifies a higher-level protocol that a connection previously established has been closed successfully

Because the connection occurs in the data link layer rather than in higher layers, LLC2 performs frame sequencing, flow control, and error recovery services for the data link layer.

LLC Operation Types

LLC supports two *operation types*:

- Unnumbered, unacknowledged (type 1)
- Numbered, acknowledged (type 2)

LLC1 supports only type 1 operations; LLC2 supports both type 1 and type 2 operations.

Type 1 Operations

Type 1 operations have the following characteristics:

- LLCs exchange protocol data units (PDUs) without establishing a data link connection.
- The peer does not acknowledge the PDUs it receives.
- There are no mechanisms for PDU sequencing, flow control, or error recovery, because higher-level protocols perform these services.

Type 2 Operations

Type 2 operations have the following characteristics:

- The LLC and its peer must establish a data link layer, virtual circuit/connection prior to any exchange of data.
- The source and destination are peer LLCs in an asynchronous, balanced data link connection.
- The source and destination LLCs control traffic by means of a numbering scheme for the sequential transfer of PDUs. The PDUs for each virtual circuit/connection have independent sequence-numbering schemes.
- The destination LLC acknowledges data PDUs that the source LLC sends by informing the source LLC of the next sequence number expected.

LLC Functionality

The LLC protocols generate and interpret command packets or frames called protocol data units (PDUs). The LLC sublayer, which can support multiple logical links concurrently, uses the following types of PDUs:

- Initiates and terminates control signal interchange with XID, TEST, SABME, and DISC PDUs.
- Organizes data flow with UI, I, and UA PDUs. The level of organization differs between type 1 and type 2 operations.
- Interprets command PDUs that it receives and generates appropriate response PDUs, which differ between type 1 and type 2 operations and between LLC1 and LLC2 service.
- Manages error control and recovery with the REJ, RR, RNR, and FRMR PDUs.

Table 1-1 lists type 1 and type 2 command PDUs and their counterpart response PDUs.

Table 1-1. LLC Command PDUs

Operation Type	Command	Response
Type 1	Unnumbered information (UI)	No response
	Exchange identification (XID)	Exchange identification (XID)
	Test (TEST)	Test (TEST)
Type 2	Information (I)	Information (I)
	Receiver ready (RR)	Receiver ready (RR)
	Receiver not ready (RNR)	Receiver not ready (RNR)
	Reject (REJ)	Reject (REJ)
	Set asynchronous balanced mode extended (SABME)	Unnumbered acknowledgment (UA)
	Disconnect (DISC)	Disconnected mode (DM)
	No command	Frame reject (FRMR)

Type 1 operations do not include definition of an acknowledgment PDU.

Type 2 operations do not include a command PDU counterpart for the FRMR response PDU.

LLC Protocol Data Unit Formats

The LLC PDU contains fields for addressing, control, and data, as shown in Figure 1-3. This section describes each field of the LLC PDU.

DSAP	SSAP	Control	Information field
8 bits	8 bits	8 or 16 bits	Variable; 8 bits each packet

Figure 1-3. LLC PDU Structure

Destination SAP (DSAP)

The DSAP address field identifies one or more service access points (SAPs) for which the LLC PDU is intended. The DSAP field contains 7 bits of actual address and 1 address designation bit to indicate an individual (I) destination address or a group (G) destination address, as shown in Figure 1-4.

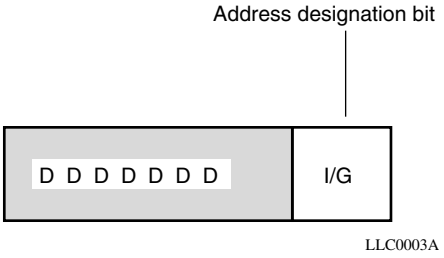


Figure 1-4. DSAP Address Field

A value of 0 for the address designation bit indicates that the PDU is destined for an individual SAP.

A value of 1 for the address designation bit indicates that the PDU is destined for a group-level SAP.

Source SAP (SSAP)

The SSAP address field identifies the specific service access point that initiated the PDU. The SSAP field contains 7 bits of actual address and 1 command/response identifier bit to indicate that the LLC PDU is a command (C) PDU or a response (R) PDU, as shown in Figure 1-5.

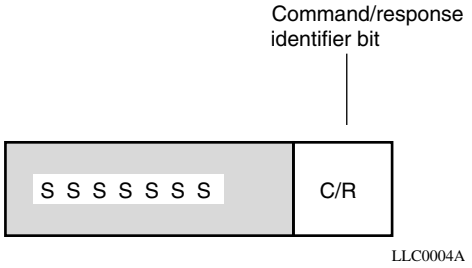


Figure 1-5. SSAP Address Field

A value of 0 for the command/response identifier bit indicates that the PDU is a command PDU.

A value of 1 for the command/response identifier bit indicates that the PDU is a response PDU.

SAP Addressing Scheme

All 802.2/LLC protocols provide a SAP addressing scheme that lets multiple applications and protocol entities in a single machine share a MAC address. Popular network protocols such as LAN Network Manager, NetBIOS, and SNA all have published SAP addresses, but any application can use a SAP to send or receive data via the LLC sublayer. The LLC SAP function sorts frames coming up from the MAC layer and directs them to the appropriate application or protocol software entity.

Figure 1-6 illustrates some SAPs published for NetBIOS and SNA. The “xx” in the last column denotes all other published and unpublished SAPs.

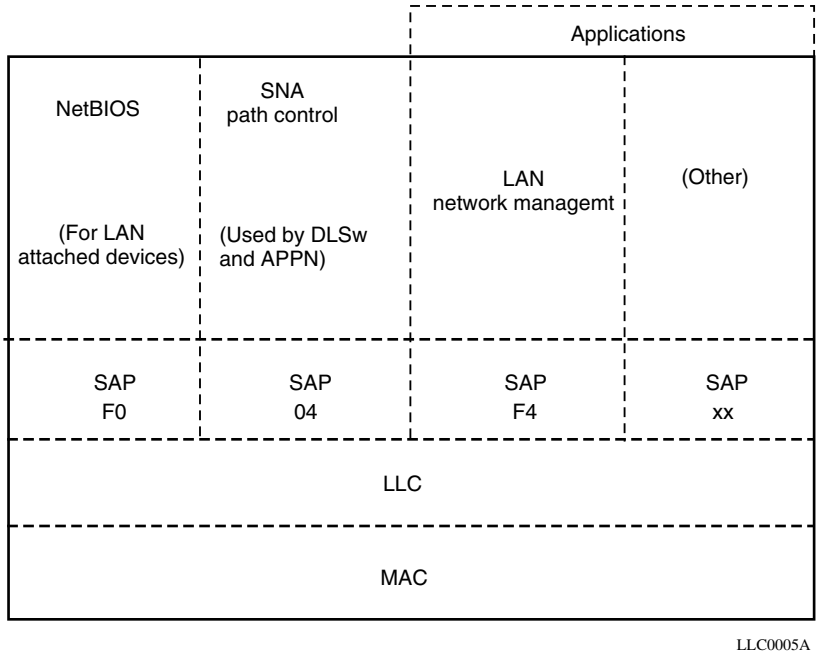


Figure 1-6. SAPs for LLC Clients

SAP addresses are as follows:

- *Individual* — Designates a single SAP. The individual address is usable as both an SSAP and a DSAP. The individual SAP has an address designation bit value of 0.
- *Group* — Designates a group of DSAPs. The group DSAP has an address designation bit value of 1.
- *Global* — Designates a group consisting of all DSAPs that the underlying MAC SAP addresses actively service. The global DSAP has a value of all 1s.
- *Null* — Designates the SAP of the underlying MAC sublayer and does not identify any SAP to either the network layer or to an associated layer management function. The null address is usable as both an SSAP and a DSAP. The null SAP has a value of all 0s.

Control Field

The control field consists of one or two octets that designate command and response functions. It also contains sequence numbers when required.

The format of the control field of the LLC PDU defines the type of operation (type 1 versus type 2):

- Information (an I format PDU)
- Supervisory (an S format PDU)
- Unnumbered (a U format PDU)

Figure 1-7 shows the three control field formats.

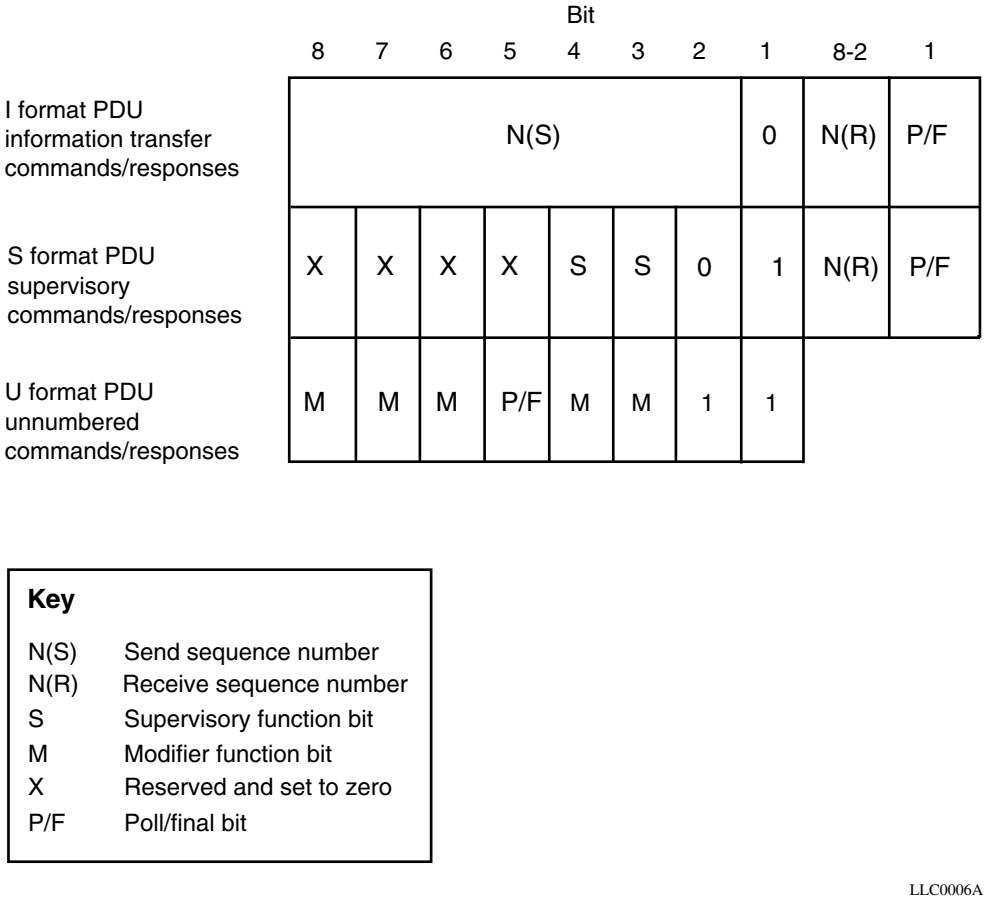


Figure 1-7. LLC PDU Control Field Format

Control Field Formats

Table 1-2 further defines the purpose of the three PDU types, where the specific format in the PDU control field determines the type.

Table 1-2. PDU Format and Function

Format	Function
Information transfer format (I)	The I format PDU performs a numbered information transfer in type 2 operation. Except for the UI, TEST, FRMR, and XID command/ response PDUs, the I format PDU is the only LLC PDU that can contain an information field. (See "Information Field" on page 1-20 for more details.)
Supervisory format (S)	The S format PDU performs data link supervisory control functions in type 2 operation, such as acknowledging I format PDUs, requesting retransmission of I format PDUs, and requesting temporary suspension of I format PDU transmission.
Unnumbered format (U)	The U format PDU is available for type 1 or type 2 operations, and provides additional data link control functions and unsequenced information transfer.

Table 1-3 further defines the purpose of parameter bits in the PDU control field.

Table 1-3. Control Field Bits and Functions

Bit	Function
Send sequence number (N [S]) bit	Only I PDUs contain N(S), which is the sequence number of the PDU being transmitted.
Receive sequence number (N [R]) bit	I PDUs contain N(R), which is the sequence number of the PDU an LLC expects to receive next on the specified data link connection.
Poll/final (P/F) bit	The P/F bit solicits (polls) a response from the addressed LLC. The final (F) bit indicates the response PDU sent as a result of a soliciting (poll) command.

Table 1-4 further defines the purpose of each command and response PDU.

Table 1-4. Command and Response PDU Names and Definitions

Command/ Response PDU	Control Field Value	Definition
Unnumbered information (UI)	0x13 or 0x03	The UI command PDU transports information to one or more LLCs. Because this is a type 1 operation, there is no corresponding response/reply PDU.
Exchange identification (XID)	0xBF or 0xAF	The XID command PDU conveys the following information to the destination LLC: • Types of LLC services that the source LLC supports • Receive window size that the source LLC supports per data link connection (per virtual circuit) The XID response PDU identifies the responding LLC and conveys to the source LLC: • Types of LLC services that the destination LLC supports • Receive window size that the destination LLC supports per data link connection (per virtual circuit)
Test (TEST)	0xF3 or 0xE3	The TEST command PDU causes the destination LLC to respond with the TEST response PDU; it performs a loopback test of the LLC-to-LLC transmission paths. The TEST command PDU also initiates the establishment of an LLC1 logical link across a network to another LLC entity. The TEST response PDU confirms the establishment of an LLC1 link.

(continued)

Table 1-4. Command and Response PDU Names and Definitions *(continued)*

Command/ Response PDU	Control Field Value	Definition
Information (I)	6xxx0 or xx even	The I command PDU indicates to the destination LLC: • Sequence number for each I command PDU • I PDU sequence number that the destination LLC expects next The I command PDU also serves as an I response PDU by indicating to the destination LLC that the source LLC received I PDUs up to a designated number from that destination LLC.
Receiver ready (RR)	01xx	The RR command PDU indicates that the source LLC is ready to receive an I PDU. The sending LLC then considers I PDUs sent prior to the RR condition as acknowledged.
Receiver not ready (RNR)	05xx	The RNR command PDU notifies the destination LLC that the originating LLC is busy and temporarily unable to receive I PDUs. RNRs, combined with RRs, control flow between source and destination LLC interfaces.
Reject (REJ)	09xx	The REJ command PDU conveys a request to the peer LLC to retransmit I PDUs, starting with the I PDU that the REJ command designates.
Set asynchronous balanced mode extended (SABME)	7F or 6F	The SABME command PDU establishes an LLC2 connection to the destination LLC. The connection operates in asynchronous balanced mode. If the destination LLC receives from its network layer a data link connect request, the destination LLC responds to the SABME PDU with a UA PDU. If the destination LLC receives from its network layer a data link disconnect request, it does not send a UA PDU.

(continued)

Table 1-4. Command and Response PDU Names and Definitions *(continued)*

Command/ Response PDU	Control Field Value	Definition
Disconnect (DISC)	53 or 43	The DISC response PDU closes an open connection by initiating a SABME command. The DISC PDU informs the destination LLC that the source LLC is suspending the data link connection, and the destination LLC should assume the disconnected mode. Prior to acting on the DISC command, the destination LLC must confirm the acceptance of the DISC command PDU by sending a UA response PDU. I PDUs sent previously but not acknowledged remain unacknowledged.
Unnumbered acknowledgment (UA)	73 or 63	The UA response PDU acknowledges the receipt and acceptance of a SABME or DISC command PDU relating to a specific data link connection to be opened or closed, as appropriate for the type of command PDU it received.
Disconnected mode (DM)	1F or 0F	The DM response PDU indicates that the LLC sending the response is logically disconnected from the data link connection.
Frame reject (FRMR)	97 or 87	The FRMR command PDU reports to the sending LLC that an uncorrectable condition was detected in a received frame. The FRMR PDU includes an information field that indicates the reason for the PDU rejection. The LLC receiving the FRMR PDU responds as follows: • Initiates the appropriate mode setting • Initiates corrective action by reinitializing transmission in both directions on the data link connection, using the SABME and DISC command PDUs, as appropriate

Information Field

The contents of the information field depend on the type of PDU it appears in, as follows:

- The information field of an I format PDU contains only user data.
- The information field of a UI command/response PDU also contains only user data.
- The information field of a TEST command/response PDU is optional and contains a test pattern used for LLC loopback testing.
- The information field of an XID command/response PDU contains:
  - -- An 8-bit XID format identifier field
  - -- A 16-bit parameter field encoded to identify the LLC services supported, plus the maximum receive window size
- The information field of an FRMR PDU contains the reason for PDU rejection by an LLC. For more details on the FRMR PDU, refer to *ISO 8802/IEEE Std 802.2 1989*.

Chapter 2
LLC2 Routed over Frame Relay

LLC2 (connection-oriented service) in a Nortel Networks router supports frame relay with both data link switching (DLSw) and Advanced Peer-to-Peer Networking (APPN), based on RFC 1490.

This chapter includes the following topics:

Compatibility with RFC 1490

RFC 1490 describes an encapsulation method for carrying internetworking traffic over a frame relay backbone. The description covers both bridging and routing standards.

The Nortel Networks router implementation of LLC exceeds RFC 1490 (SNA encapsulation in frame relay only) by complying with the Frame Relay Forum "Frame Relay Multiprotocol Encapsulation Implementation Agreement" (FRF.3.2). The latter description not only defines how routed SNA traffic traverses a frame relay network, but also adds RFC 1490 support for frame relay to DLSw and APPN.

This feature allows native SNA traffic originating from SDLC-, token ring-, or Ethernet-attached devices to communicate over public or private frame relay networks directly with IBM 3745 or 3746 communications controllers. It operates on all Nortel Networks routers that include a frame relay interface. Devices can communicate with intermediate routing nodes or in a single-switch configuration similar to a standalone Frame Relay Access Device (FRAD).

Compatibility with IBM NCP 7.1 and Later

LLC2 routed over a frame relay (BNN) network is fully compatible with IBM NCP 7.1 and later, and with existing or new IBM equipment. The service has passed IBM interoperability testing. You can use it without upgrading your LAN-based downstream physical units (DSPUs) or network type, such as APPN or IP.

DSPUs attached to the router retain full visibility for IBM NetView* management. The router passes through all NetView commands for the DSPUs and any alerts generated by the DSPUs.

You can configure a network without a router at the host, if the communications controller is directly attached to a frame relay network. Some terminals can also connect directly to the frame relay network without a router. Frame relay networks eliminate the expense of leased lines. Additional savings accrue because one port on a communications controller can support hundreds of data link connection identifiers (DLCIs).

Nortel Networks interoperates with NCP 7.1 and later with software only, eliminating the need for any new hardware or upgrades to existing SNA terminals or router equipment.

Figure 2-1 illustrates the connection of an SNA host through a frame relay network in a configuration with multiprotocol traffic to other locations. In addition to APPN, token ring, and IP traffic, LLC can also route SDLC and Ethernet traffic.

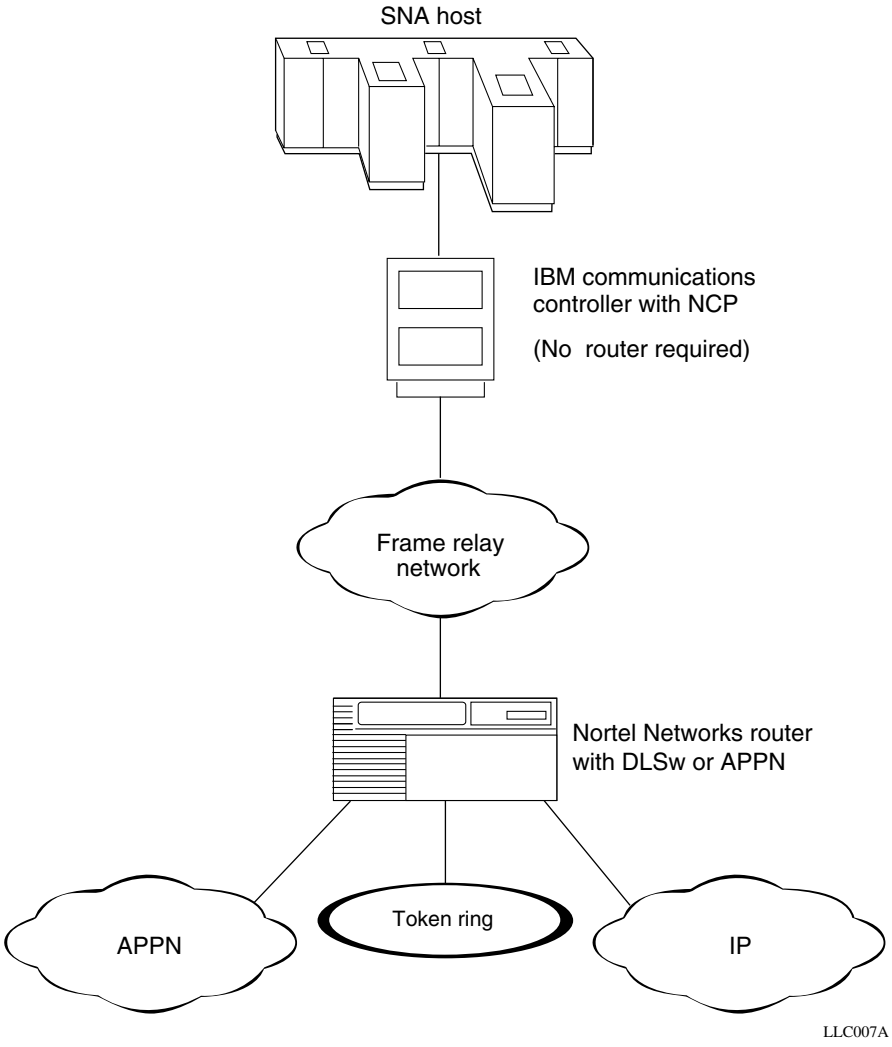


Figure 2-1. Sample Frame Relay Network Using LLC2

FRAD-like Functionality

Token ring, Ethernet, and SDLC end stations communicate with a frame relay-attached host via Frame Relay Access Devices (FRADs). The Nortel Networks router with DLSw operating in single-switch mode has FRAD-like capability, supporting token ring, Ethernet, and SDLC end stations. The router performs the following actions:

- Terminates the data link control level sessions
- Strips the link-level header off the SNA packet
- Puts an RFC 1490 LLC header on the SNA packet
- Sends packets into the frame relay network

Mapping DLCIs to MAC Addresses

The frame relay network provides a number of permanent virtual circuits (PVCs) that connect devices attached to the same frame relay network. Each virtual circuit is uniquely identified at each frame relay interface by a DLCI. The frame relay interface allows either group or direct (single) assignment of DLCIs. Group assignment allows many DLCIs per circuit; direct assignment allows only one.

The system administrator or frame relay provider assigns DLCIs. To communicate with an IBM host, you must associate the MAC address of your DSPU with a DLCI. You can accomplish this task in one of two ways:

- Create a virtual MAC address, formed by preceding the DLCI address, such as 100 (decimal), with a unique mask, such as 0x400000FF, to make a valid MAC address, for example, 400000FF0064. (Decimal 100 is 64 hexadecimal.)

  When the router receives an LLC frame from the DLSw network with a destination MAC (dmac) starting with the virtual MAC mask, it can automatically translate it into a DLCI, so no mapping table is needed at the frame relay interface.

- Use the end station's physical or locally configured MAC address. In this case, be aware that if you change your hardware or end station configuration, you must reconfigure the DLCI mapping table.

  When the router receives an LLC frame from the DLSw network with a dmac that does not start with the virtual MAC mask, the mapping table at the frame relay interface translates the dmac into a DLCI.

SDLC single switched over LLC does not require address mapping if a virtual MAC address is used to access the host. But you still must define DLCIs.

In general, you configure only the remote MAC address in the mapping table, setting it equal to the remote host MAC address. (A host may be an IBM mainframe.)

You must configure the local MAC address in the mapping table only if the frame relay interface receives connection requests. Usually only local (workstation) nodes will request a connection, so you configure only the remote MAC address.

Router Mapping Examples

Some sample network configurations with associated mapping tables follow, including:

- Virtual MAC to frame relay
- Frame relay to virtual MAC
- Physical MAC to frame relay
- Frame relay to physical MAC
- Frame relay to frame relay

Although these network configurations illustrate topologies with two routers, the same principles apply to DLSw operating in single-switch mode. Instead of configuring a single interface on each router, you configure two interfaces on a single router.

Virtual MAC Address to Frame Relay DLCI

Figure 2-2 illustrates a sample virtual MAC address to frame relay DLCI mapping. In this network, the PC makes connection requests to hosts 1 and 2. The workstation administrator has control over the PC configuration and has configured the remote host addresses as virtual MAC addresses corresponding to the DLCIs assigned to the hosts.

Configuring the PC in this way simplifies the router configuration, because a mapping table is not necessary in the frame relay-attached router B. The connection request received at router A will have a source MAC address equal to the PC MAC address and a destination MAC address equal to remote host 1 or 2.

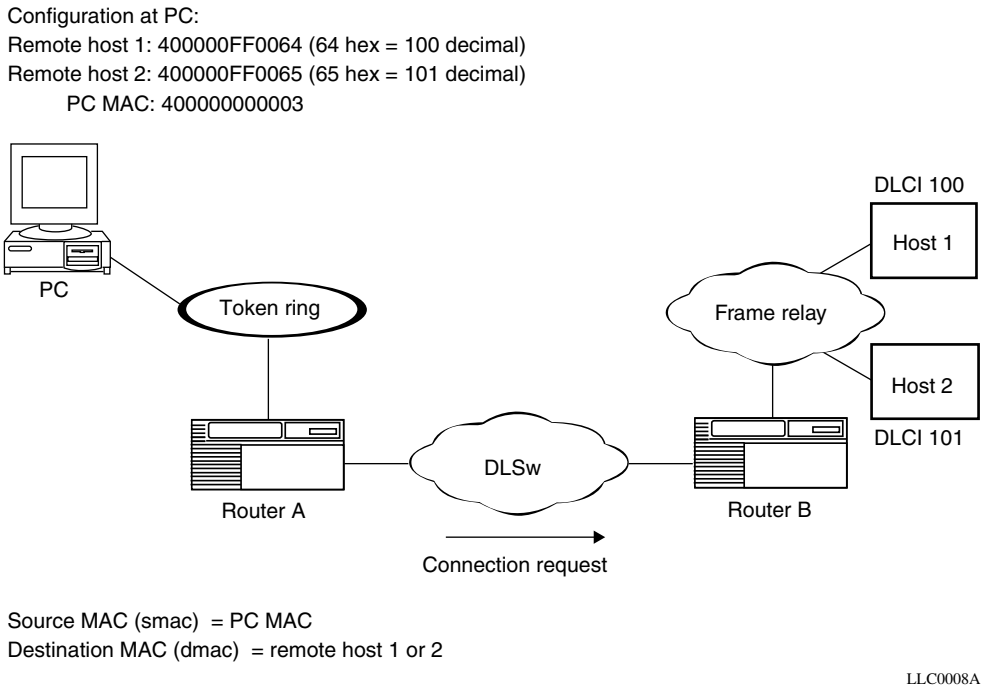


Figure 2-2. Virtual MAC to Frame Relay Topology

Frame Relay DLCI to Virtual MAC Address

Figure 2-3 illustrates a sample frame relay DLCI to virtual MAC address mapping. In this network, hosts 1 and 2 can make connection requests to the PC. The workstation administrator has control over the PC configuration and has configured the remote host addresses as virtual MAC addresses corresponding to the DLCIs assigned to the hosts.

At router B, a mapping table maps the DLCIs for hosts 1 and 2 to the PC MAC address. Router B first creates a connection request with the source MAC addresses equal to the virtual MAC address corresponding to the DLCIs for hosts 1 and 2. Router B then creates a connection request with the destination MAC equal to the local MAC address from the mapping table.

Router B always sets the source MAC address equal to the virtual MAC address, even when a remote MAC address is configured in the mapping table.

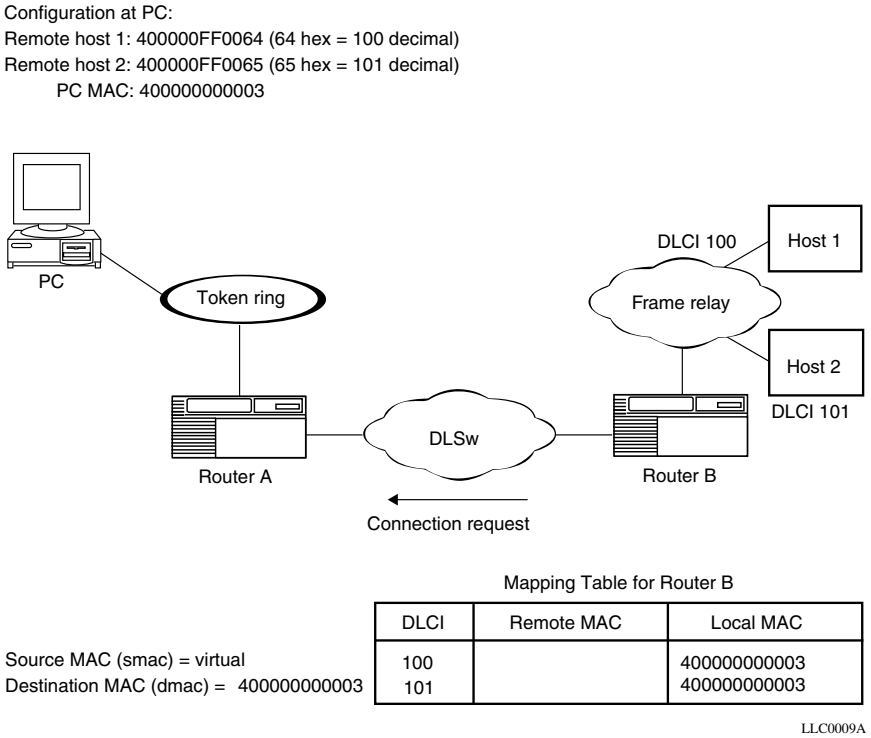
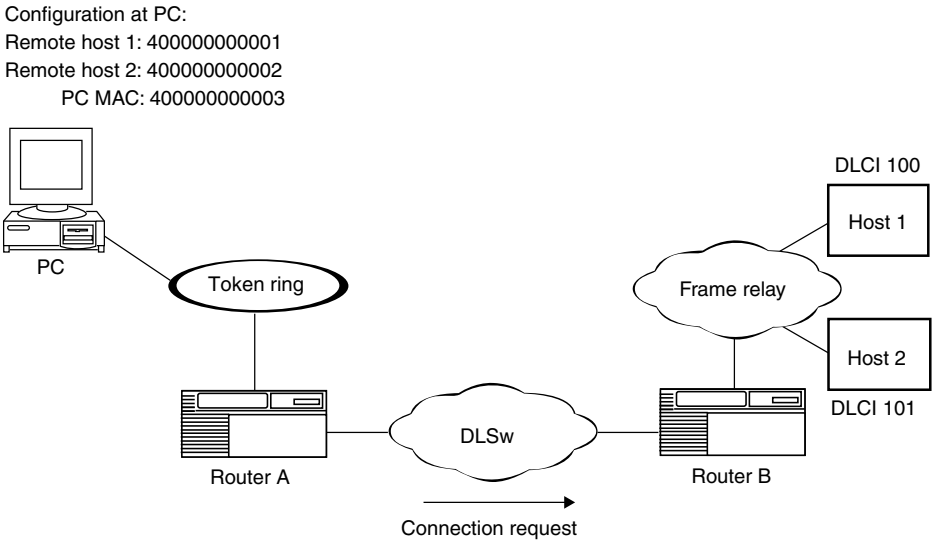


Figure 2-3. Frame Relay to Virtual MAC Topology

Physical MAC Address to Frame Relay DLCI

Figure 2-4 illustrates a sample physical MAC address to frame relay DLCI mapping. In this network, the PC makes connection requests to hosts 1 and 2. The workstation administrator does not have control over the PC configuration and must use a configuration with real, physical MAC addresses for the remote hosts.

At router B, a mapping table maps hosts 1 and 2 to the DLCIs assigned to the hosts. The connection request received at router A will have the source MAC address of the PC MAC and a destination MAC address of remote host 1 or 2.



Mapping Table for Router B

Remote MAC	Local MAC	DLCI
400000000001		100
400000000002		101

Source MAC (smac) = PC MAC
Destination MAC (dmac) = remote host 1 or 2

LLC0010A

Figure 2-4. Physical MAC to Frame Relay Topology

Frame Relay DLCI to Physical MAC Address

Figure 2-5 illustrates a sample frame relay DLCI to physical MAC mapping. In this network, hosts 1 and 2 can make connection requests to the PC. The workstation administrator does not have control over the PC configuration and must use a configuration with real, physical MAC addresses for the remote hosts.

Router B requires a mapping table to map the DLCIs for hosts 1 and 2 to the PC MAC address. Router B creates a connection request with the source MAC address equal to the virtual MAC address corresponding to the host 1 and 2 DLCIs. Router B also creates a connection request with the destination MAC address equal to the local MAC address from the mapping table.

Router B always sets the source MAC address equal to the virtual MAC address, even when a remote MAC address is configured in the mapping table.

Note: This mapping does not work with applications that check the source MAC address against configured remote host addresses.

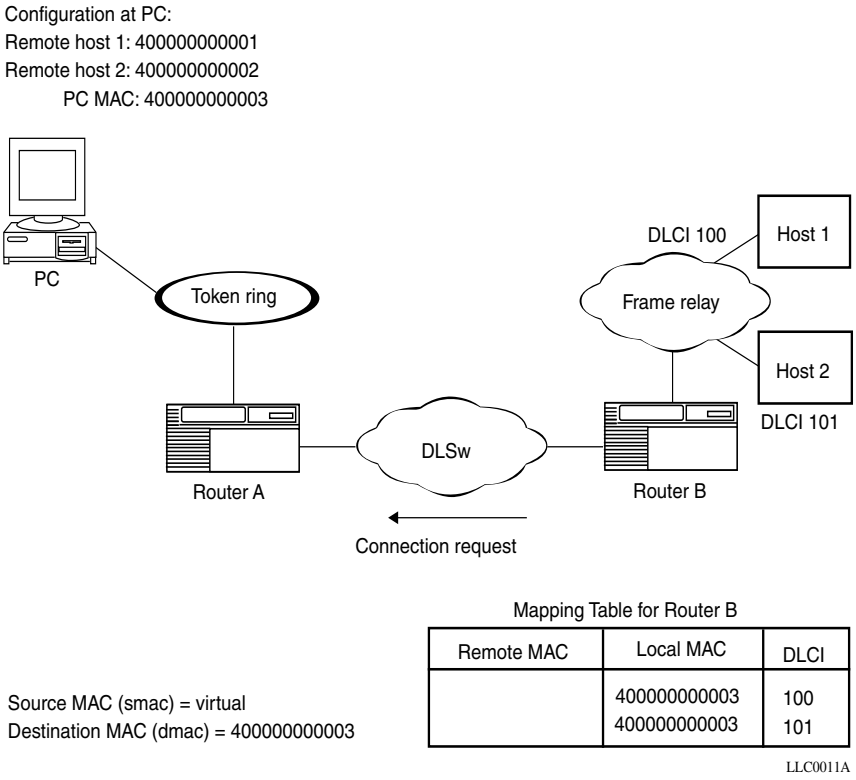


Figure 2-5. Frame Relay to Physical MAC Topology

Frame Relay DLCI to Frame Relay DLCI

Figure 2-6 illustrates a sample frame relay DLCI to frame relay DLCI mapping. In this network, the PC makes connection requests to both hosts 1 and 2. The workstation administrator has configured the PC with remote hosts 1 and 2 equal to the assigned DLCIs. Router A requires a mapping table to map the remote host 1 and 2 DLCIs to a virtual MAC address corresponding to the host 1 or 2 DLCI.

Router A creates a connection request with the source MAC address equal to the virtual MAC address corresponding to the remote host 1 or 2 DLCI. Router B creates a connection request with the destination MAC address equal to the local MAC address from the mapping table.

Router A always sets the source MAC address equal to the virtual MAC address, even if there is a remote MAC address configured in the mapping table.

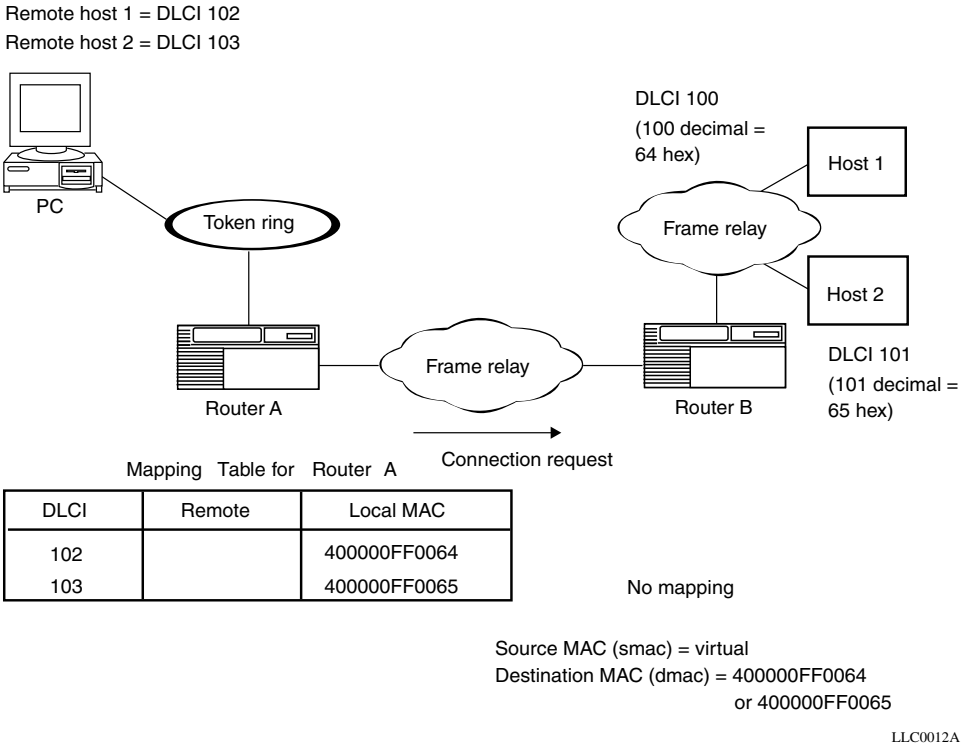


Figure 2-6. Frame Relay to Frame Relay Topology

LLC2 over Frame Relay: Routed versus Bridged

Figure 2-7 illustrates (a) SNA over frame relay with source route bridging and (b) SNA over frame relay in native mode, including routing through SDLC and Ethernet. The frame relay link can be part of an alternate route to the token ring or other link. Dotted lines indicate the path of LLC, which passes through bridging but terminates at the router for more flexible routing.

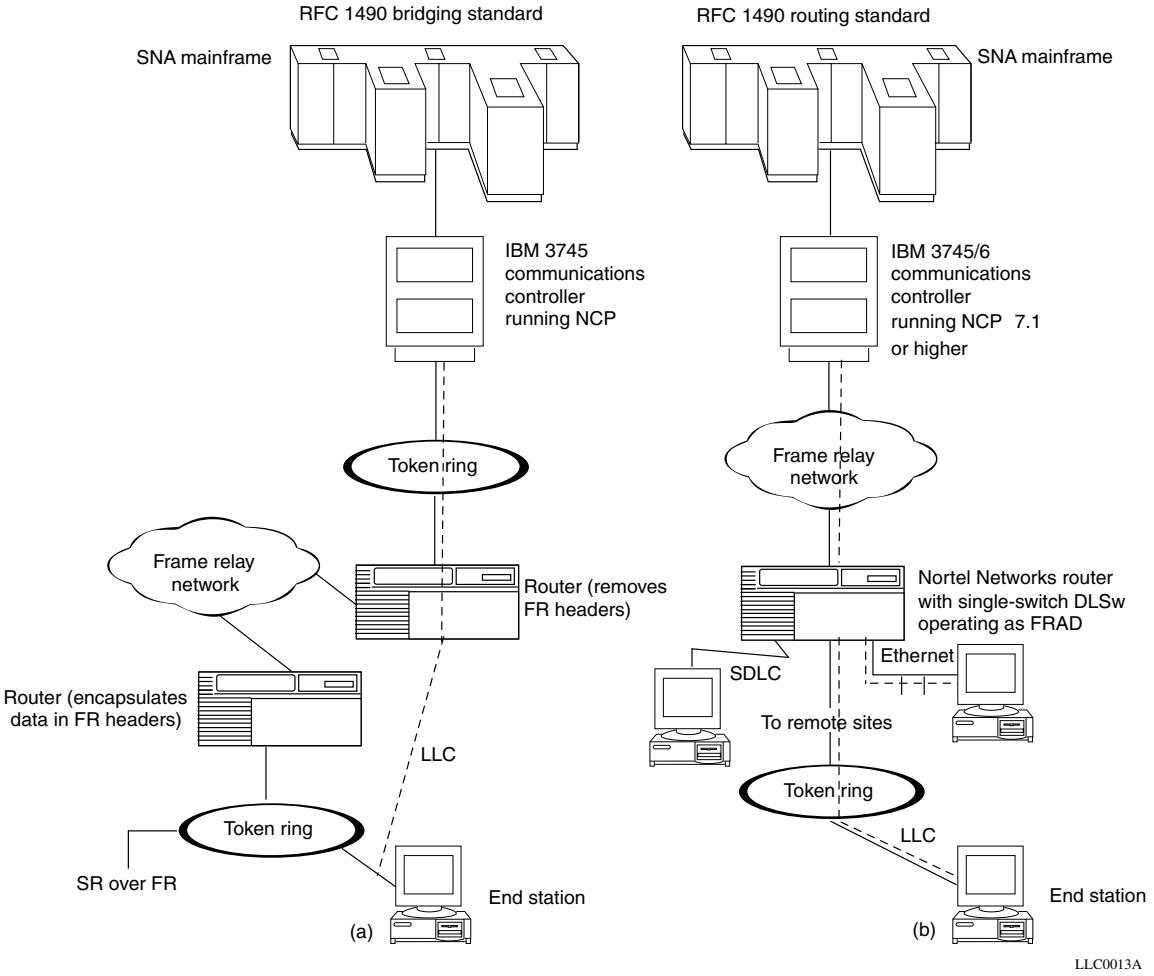


Figure 2-7. RFC 1490 Bridging and Routing Standards for SNA

Chapter 3
Starting LLC Services

This chapter describes how to create a basic LLC configuration by specifying values for required parameters only and accepting default values for all other parameters.

When you start LLC2 over frame relay with APPN and DLSw, you must specify the frame relay mapping parameters; the Configuration Manager sets default values for all other parameters.

For background information about LLC, see Chapter 1, "Logical Link Control Overview" and Chapter 2, "LLC2 Routed over Frame Relay." After you create an initial configuration, you can customize LLC parameters as described in Chapter 4, "Customizing LLC Services."

Starting Configuration Tools

Before you configure LLC services, refer to the following user guides for instructions on how to start and use the Nortel Networks configuration tool of your choice.

Configuration Tool	User Guide
Bay Command Console (BCC)	*Using the Bay Command Console (BCC)*
Site Manager	*Configuring and Managing Routers with Site Manager*

These guides also describe generically how to create and modify a device configuration.

LLC2 Configuration Hierarchy

Figure 3-1 shows the hierarchy of LLC objects and the relationship between objects. The atm, frame relay, ethernet, token ring, and fddi objects are the interfaces on which you can configure LLC.

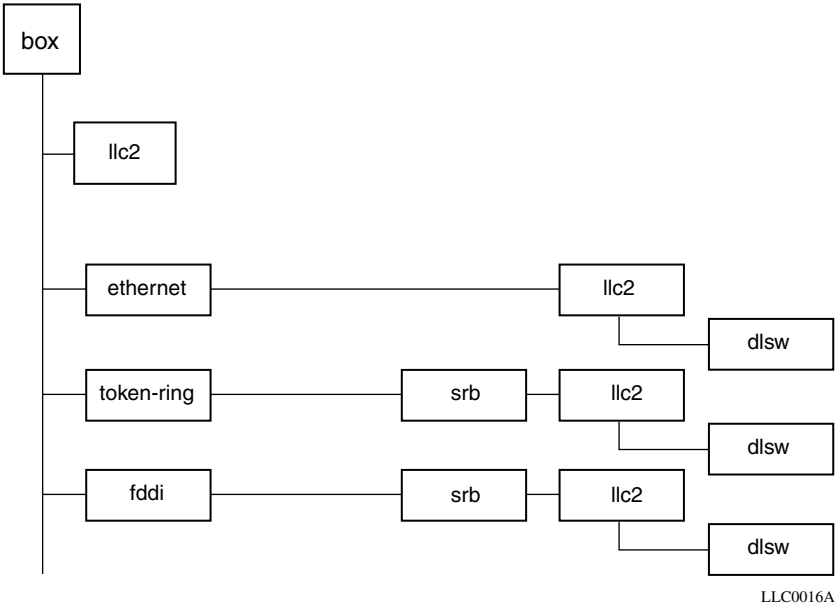


Figure 3-1. LLC2 Configuration Hierarchy *(continued next page)*

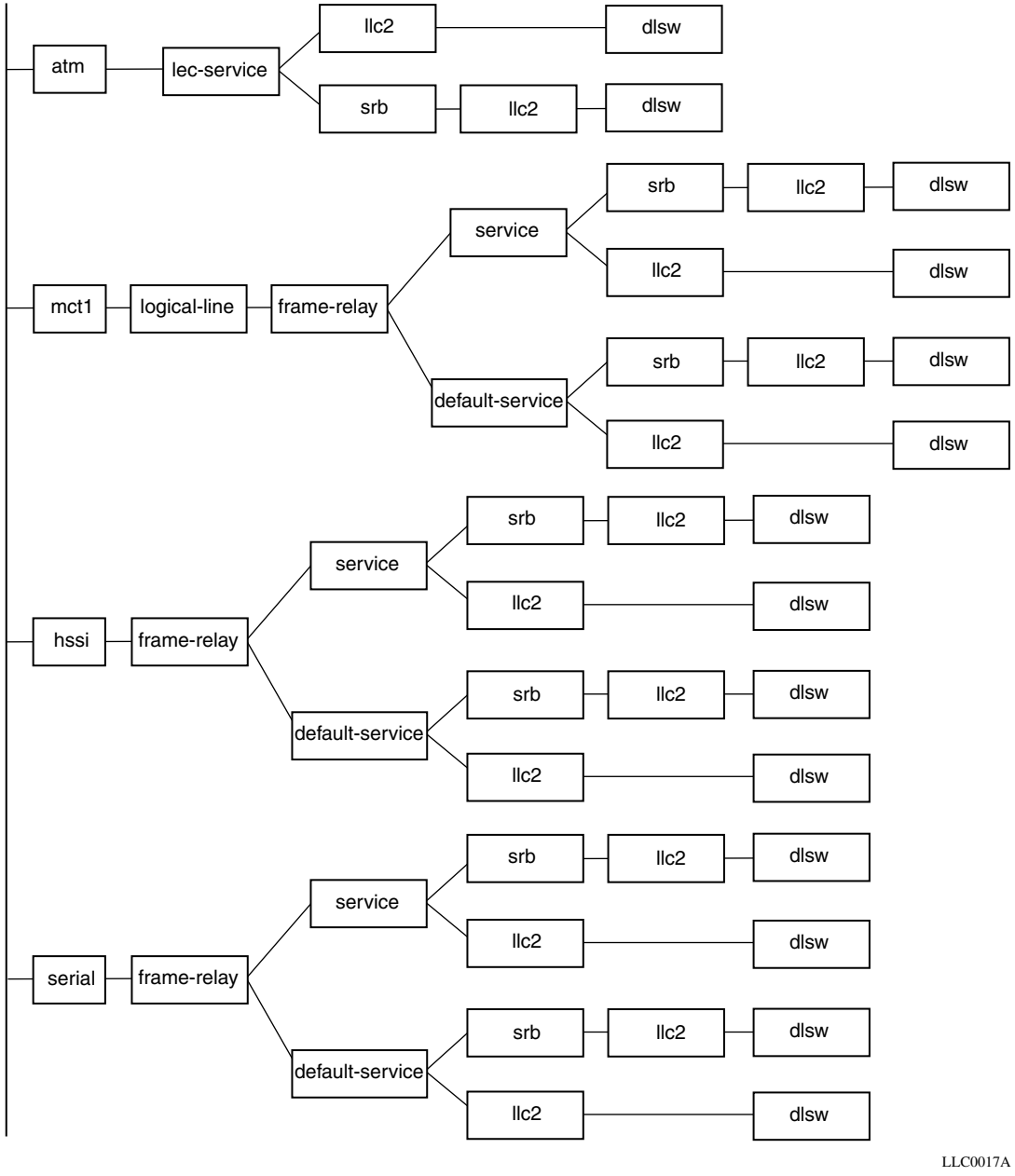


Figure 3-1. LLC2 Configuration Hierarchy *(continued)*

Starting LLC2 on a LAN Interface

When you configure an LLC2 interface on an 802.*x* LAN physical (LAN-attachment) circuit, you supply information required by the MAC and LLC sublayers.

You can use the BCC or Site Manager to start LLC2 on a LAN interface using default values for all parameters.

Using the BCC

The following sections describe how to use the BCC to configure LLC2 on Ethernet, token ring, and FDDI interfaces. When you add LLC2 to one interface, LLC2 is automatically configured on the router.

Configuring LLC2 on an Ethernet Interface

To configure LLC2 on an Ethernet interface with default values:

1. **In configuration mode, navigate to the** `box#` **or** `stack#` **prompt.**
2. **Configure an Ethernet interface. For example, enter:**

   ```
   box# ethernet slot 2 connector 1
   ethernet/2/1#
   ```

3. **Add LLC2 to the interface.**

   ```
   ethernet/2/1# llc2
   llc2/ethernet/2/1#
   ```

4. **Display the default settings for LLC2 interface parameters:**

   ```
   llc2/ethernet/2/1# info
      ack-xmt-timer 1
      busy-timer 60
      dup-addr-check disabled
      dynamic-window enabled
      encapsulation default
      fr-virtual-mask <not_set>
      high-water-reset normal
      idle-timer 120
      local-response-acktimer 10
      max-info-size 5128
      max-links 255
      max-retries 2
      max-saps 255
      max-ui-size 5128
      n2 10
      n3 1
      poll-cycle-timer 30
   ```

```
   receive-window 7
   reject-timer 1
   srb-ring-id 0x0
   state enabled
   transmit-window 7
   ui-ackwait-timer 30
llc2/ethernet/2/1#
```

Configuring LLC2 on a Token Ring Interface

To configure LLC2 on a token ring interface with default values:

1. **In configuration mode, navigate to the** `box#` **or** `stack#` **prompt.**
2. **If source route bridging is not yet configured on the router, you must configure it globally before you can add LLC2 to a token ring interface.**

   For example, the following command enables source routing services on the router, with a bridge ID value of 0x10 and a LAN ID value of 0x100:

   ```
   box# srb bridge-id 0x10 internal-lan-id 0x100
   srb#
   ```

Note: For complete information about how to configure source route bridging, see *Configuring Bridging Services*.

3. **Navigate to the** `box#` **or** `stack#` **prompt and configure a token ring interface. For example, enter:**

   ```
   srb# box
   box# token-ring slot 3 connector 1
   token-ring/3/1#
   ```

4. **Add source route bridging (SRB) to the interface. For example, enter:**

   ```
   token-ring/3/1# srb interface-ring-id 0x1
   srb/token-ring/3/1#
   ```

5. **Add LLC2 to the interface.**

   ```
   srb/token-ring/3/1# llc2
   llc2/token-ring/3/1#
   ```

Configuring LLC2 on an FDDI Interface

To configure LLC2 on an FDDI interface with default values:

1. **In configuration mode, navigate to the** `box#` **or** `stack#` **prompt.**
2. **If source route bridging is not yet configured on the router, you must configure it globally before you can add LLC2 to an FDDI interface.**

   For example, the following command enables source routing services on the router, with a bridge ID value of 0x10 and a LAN ID value of 0x100:

   ```
   stack# srb bridge-id 0x10 internal-lan-id 0x100
   srb#
   ```

Note: For complete information about how to configure source route bridging, see *Configuring Bridging Services*.

3. **Navigate to the** `box#` **or** `stack#` **prompt and configure an FDDI interface. For example, enter:**

   ```
   stack# fddi slot 4 connector 1
   fddi/4/1#
   ```

4. **Add SRB to the interface. For example, enter:**

   ```
   fddi/4/1# srb interface-ring-id 0x1
   srb/fddi/4/1#
   ```

5. **Add LLC2 to the interface.**

   ```
   srb/fddi/4/1# llc2
   llc2/fddi/4/1#
   ```

Using Site Manager

In Site Manager, you should not add LLC2 to an interface without also adding the DLSw, APPN, or LNM protocol. To start LLC2 on a LAN interface, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, click on the Ethernet, token ring, or FDDI connector on which you want to enable LLC2 services.	The Add Circuit window opens.
2. Click on **OK** to accept the default circuit name.	The Select Protocols window opens.
3. In the Select Protocols window, choose **DLSw**, **APPN**, or **LNM Servers** and click on **OK**. When you select one of these items, LLC2 is selected automatically. On FDDI and token ring interfaces, source routing is also selected automatically.	Depending on the protocol that you selected (DLSw, APPN, or LNM), a configuration window opens.
4. Enter the required information in the configuration windows. Click on **Help** or see the configuration guide for DLSw, APPN, source route bridging, or LNM.	

Starting LLC2 over ATM LANE

The following sections describe how to configure LLC2 and DLSw over ATM LAN emulation (LANE) using the BCC or Site Manager.

Using the BCC

To configure LLC2 and DLSw on an ATM LANE interface with default settings:

1. **In configuration mode, navigate to the `box#` or `stack#` prompt.**
2. **Configure an ATM interface.**

   ```
   box# atm 3/1
   atm/3/1#
   ```

3. **Enable signaling on the ATM interface.**

   ```
   atm/3/1# signaling
   signaling/3/1#
   ```

4. **Return to the ATM interface prompt.**

   ```
   signaling/3/1# back
   atm/3/1#
   ```

5. **Create a LAN emulation client (LEC) service record for the interface. For example, to create a service record with the name service1, enter:**

   ```
   atm/3/1# lec-service service1
   lec-service/service1#
   ```

6. **Add LLC2 to the LEC service record.**

   ```
   lec-service/service1# llc2
   llc2/service1#
   ```

7. **Add DLSw to the service record.**

   ```
   llc2/service1# dlsw
   dlsw/service1#
   ```

For complete information about configuring DLSw, see *Configuring DLSw Services*.

Using Site Manager

To enable LLC2 and DLSw over ATM LANE, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, click on the ATM connector on which you are enabling LLC2 and DLSw services.	The Add Circuit window opens.
2. Click on **OK** to accept the default circuit name.	The Select Connection Type window opens.
3. Click on **ATM**.	The Initial ATM Signaling Config window opens.
4. Click on **OK**.	The Edit ATM Connector window opens.
5. Click on **Service Attributes**.	The ATM Service Records List window opens.
6. Click on **Add**.	The ATM Service Record Parameters window opens.
7. Click on **OK**.	The Select Protocols window opens.
8. In the Select Protocols window, choose **DLSw**. When you choose DLSw, LLC2 is selected automatically.	The DLSw Basic Global Parameters window opens.
9. Set the following parameters: • **DLSw RFC Version** • **DLSw Virtual Ring ID (hex)** • **DLSw Peer IP Address** (dual-switch networks only) Click on **Help** or see *Configuring DLSw Services* for parameter descriptions.	
10. Click on **OK**.	The DLSw Basic Interface Parameters window opens.
11. Set the **DLSw Slot IP Address** parameter. Click on **Help** or see *Configuring DLSw Services* for parameter descriptions.	
12. Click on **OK**.	You return to the ATM Service Records List window.
13. Click on **Done** until you return to the Configuration Manager window.	

Starting DLSw and LLC2 over Frame Relay

For the configuration of DLSw over frame relay, IBM provides two types of frame relay support:

- Boundary Access Node (BAN)—bridged format
- Boundary Network Node (BNN)—RFC 1490 or Routed SNA

When you configure a frame relay interface for DLSw using Site Manager, a message prompts you to select BAN PVC, BNN PVC, or BNN SVC.

Starting DLSw and LLC2 over Frame Relay BAN

BAN frames use a standard RFC 1490 Bridged 802.5 over frame relay format. Because this frame is source routed, you must enable SRB on a frame relay BAN interface.

The following sections describe how to configure DLSw and LLC2 over frame relay BAN using the BCC or Site Manager.

Note: If you configure two token ring interfaces or a token ring interface and a frame relay BAN interface on a DLSw single switch, the traffic between the two interfaces uses SRB, not DLSw.

Using the BCC

To configure DLSw and LLC2 on a frame relay BAN interface, you first configure SRB and DLSw global attributes. Then you configure frame relay, SRB, LLC2, and DLSw on that interface.

For example, to configure DLSw and LLC2 on a frame relay BAN interface over a serial line with default settings:

1. **In configuration mode, navigate to the `box#` or `stack#` prompt.**
2. **Configure DLSw global attributes.**

   ```
   box# dlsw
   dlsw#
   ```

3. **Specify a slot for the IP interface and the IP address to use for TCP connections based on this slot.**

For example, to configure slot 3 with an IP address of 1.1.1.3, enter:

```
dlsw# slot-ip 3 ip-addr 1.1.1.3
slot-ip/3#
```

4. **Return to the** `box#` **or** `stack#` **prompt.**

```
slot-ip/3# box
box#
```

5. **If source route bridging is not yet configured on the router, you must configure it globally before you can add DLSw and LLC2 to a frame relay BAN interface.**

   For example, the following command enables source routing services on the router, with a bridge ID value of 0x10 and a LAN ID value of 0x100:

```
box# srb bridge-id 0x10 internal-lan-id 0x100
srb#
```

Note: For complete information about how to configure source route bridging, see *Configuring Bridging Services*.

6. **Return to the** `box#` **or** `stack#` **prompt.**

```
srb# box
box#
```

7. **Add a serial interface on which you want to configure frame relay, SRB, LLC2, and DLSw.**

```
box# serial 3/1
serial/3/1#
```

8. **Configure frame relay on the serial interface.**

```
serial/3/1# frame-relay
frame-relay/3/1#
```

9. **Configure a service name for the frame relay interface.**

```
frame-relay/3/1# service service1
service/service1#
```

10. **Configure SRB on the frame relay service.**

```
service/service1# srb interface-ring-id 0x30
srb/service1#
```

11. Add LLC2 to the frame relay service.

```
srb/service1# llc2
llc2/service1#
```

12. Configure DLSw on the serial interface.

```
llc2/service1# dlsw
dlsw/service1#
```

For complete information about configuring DLSw, see *Configuring DLSw Services*.

Using Site Manager

To enable DLSw and LLC2 over frame relay BAN, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, click on the synchronous connector on which you are enabling DLSw services.	The Add Circuit window opens.
2. Click on **OK** to accept the default circuit name.	The WAN Protocols window opens.
3. Choose **Frame Relay** and click on **OK**.	The Select Protocols window opens.
4. Choose **DLSw**. When you choose DLSw, you automatically choose LLC2.	
5. Click on **OK**.	The Frame Relay/SNA Connection window opens.
6. Click on **BAN PVC**.	The DLSw Basic Global Parameters window opens.
7. Set the following parameters: • **DLSw RFC Version** • **SR Internal LAN ID** • **DLSw Virtual Ring ID (hex)** • **DLSw Peer IP Address** (dual-switch networks only) Click on **Help** or see *Configuring DLSw Services* for parameter descriptions.	

(continued)

Site Manager Procedure *(continued)*	
You do this	**System responds**
8. Click on **OK**.	The DLSw Basic Interface Parameters window opens.
9. Set the following parameters: • **SR Interface Ring ID** • **DLSw Slot IP Address** Click on **Help** or see *Configuring DLSw Services* for parameter descriptions.	
10. Click on **OK**.	You return to the Configuration Manager window.

Starting DLSw and LLC2 over Frame Relay BNN

Because the BNN format does not carry the destination MAC address, incoming LAN frames are delivered to the host in one of two ways:

- Using permanent virtual circuits (PVCs)
- Using switched virtual circuits (SVCs)

Starting DLSw and LLC2 on a Frame Relay BNN PVC Interface

If you use PVCs to connect two devices over the network, the router retrieves the destination MAC address from a frame relay mapping table. The table has these fields:

- DLCI—Represents a frame relay PVC
- Remote MAC—Represents the destination MAC address
- Local MAC—Represents a source MAC address

Each physical frame relay interface has one frame relay PVC mapping table. Each table entry must have a value specified for the local MAC address, the remote MAC address, or both.

Incoming LLC2 packets (such as LAN packets) are checked against the entries in this table. If a match occurs, the router forwards the frame only to the DLCI specified. If no entry is found, then the information is not forwarded out this interface as a BNN packet.

Using the BCC

To configure DLSw and LLC2 on a frame relay BNN interface using PVCs, you first configure DLSw global attributes. Then, you configure frame relay, LLC2, and DLSw on that interface.

For example, to configure DLSw and LLC2 on a frame relay BNN PVC interface over a serial line with default settings:

1. **In configuration mode, navigate to the** `box#` **or** `stack#` **prompt.**

2. **Configure DLSw global attributes.**

   ```
   box# dlsw
   dlsw#
   ```

3. **Specify a slot for the IP interface and the IP address to use for TCP connections based on this slot.**

   For example, to configure slot 3 with an IP address of 1.1.1.3, enter:

   ```
   dlsw# slot-ip 3 ip-addr 1.1.1.3
   slot-ip/3#
   ```

4. **Return to the** `box#` **or** `stack#` **prompt.**

   ```
   slot-ip/3# box
   box#
   ```

5. **Add a serial interface on which you want to configure frame relay, LLC2, and DLSw.**

   ```
   box# serial 3/1
   serial/3/1#
   ```

6. **Configure frame relay on the serial interface.**

   ```
   serial/3/1# frame-relay
   frame-relay/3/1#
   ```

7. **Configure a service name on the frame relay interface.**

   ```
   frame-relay/3/1# service service1
   service/service1#
   ```

8. **Add LLC2 to the frame relay service.**

   ```
   service/service1# llc2
   llc2/service1#
   ```

9. **Configure the frame relay DLCI to which you are mapping the local or remote MAC address. For example, enter:**

```
llc2/service1# dlci 101
dlci/101#
```

10. **Configure a remote MAC address, a local MAC address, or both.**

    - If you configure a MAC address for a local end station, incoming requests on this DLCI are mapped to the specified local MAC address.
    - If you configure a MAC address for a remote MAC address, outgoing requests specifying this MAC address are mapped to the DLCI.

    For example, to specify both a local and remote MAC address, enter:

```
dlci/101# local-mac 111111111111 remote-mac 222222222222
dlci/101#
```

11. **Return to the llc2 prompt.**

```
dlci/101# back
llc2/service1#
```

12. **Configure DLSw on the serial interface.**

```
llc2/service1# dlsw
dlsw/service1#
```

For complete information about configuring DLSw, see *Configuring DLSw Services*.

Using Site Manager

To enable DLSw and LLC2 over a frame relay BNN interface using PVCs, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, click on the synchronous connector on which you are enabling DLSw services.	The Add Circuit window opens.
2. Click on **OK** to accept the default circuit name.	The WAN Protocols window opens.
3. Choose **Frame Relay** and click on **OK**.	The Select Protocols window opens.

(continued)

Site Manager Procedure *(continued)*	
You do this	**System responds**
4. Choose **DLSw**. When you choose DLSw, you automatically choose LLC2.	
5. Click on **OK**.	The Frame Relay/SNA Connection window opens.
6. Click on **BNN PVC**.	The DLSw Basic Global Parameters window opens.
7. Set the following parameters: • **DLSw RFC Version** • **DLSw Virtual Ring ID (hex)** • **DLSw Peer IP Address** (dual-switch networks only) Click on **Help** or see *Configuring DLSw Services* for parameter descriptions.	
8. Click on **OK**.	The DLSw Basic Interface Parameters window opens.
9. Set the **DLSw Slot IP Address** parameter. Click on **Help** or see *Configuring DLSw Services* for parameter descriptions.	
10. Click on **OK**.	The LLC2 Frame Relay PVC Mappings window opens.
11. Click on **Add**.	The LLC2 Frame Relay PVC Mapping Add window opens.
12. Set the following parameters: • **DLCI** • **Remote MAC** • **Local MAC** Click on **Help** or see the parameter descriptions beginning on page A-7.	
13. Click on **OK**.	You return to the LLC2 Frame Relay PVC Mappings window.
14. Click on **Done**.	You return to the Configuration Manager window.

Starting DLSw and LLC2 on a Frame Relay BNN SVC Interface

If you use SVCs to connect two devices over the network, you do not configure virtual circuits. An SVC is created only when there is data to transfer. For SVCs, the frame relay switch assigns the DLCI number on a per-call basis.

The destination MAC address is mapped to a data network address X.121 or E.164 number (address, subaddress, numbering plan, and type of number). You configure the numbering plan numbers (for example, X.121 or E.164). Each record contains one mapping and mapping type (either local or remote).

Remote Mapping

Use remote mapping to map a remote MAC address to a remote data network address (DNA) for outgoing calls. If you configure only remote mappings, the router can initiate an SVC setup, but it cannot accept incoming calls. The router accepts incoming calls from any MAC address to the destination MAC address configured in the mapping and establishes the SVC.

Local Mapping

Local mapping maps the called DNA in the incoming setup message to the local MAC address. The router accepts the local DNA from the frame relay SVC configured in the mapping and establishes the SVC. The local DNA from the frame relay SVC configuration serves as the source DNA. If you configure only local mappings, the router can accept incoming calls, but it cannot initiate calls.

Using the BCC

To configure DLSw and LLC2 on a frame relay BNN interface using SVCs, you first configure DLSw global attributes. Then, you configure frame relay, LLC2, and DLSw on that interface.

For example, to configure DLSw and LLC2 on a frame relay BNN SVC interface over a serial line with default settings:

1. **In configuration mode, navigate to the** `box#` **or** `stack#` **prompt.**
2. **Configure DLSw global attributes.**

```
box# dlsw
dlsw#
```

3. **Specify a slot for the IP interface and the IP address to use for TCP connections based on this slot. For example, to configure slot 3 with an IP address of 1.1.1.3, enter:**

```
dlsw# slot-ip 3 ip-addr 1.1.1.3
slot-ip/3#
```

4. **Return to the `box#` or `stack#` prompt.**

```
slot-ip/3# box
box#
```

5. **Specify a serial interface on which you want to configure frame relay, LLC2, and DLSw.**

```
box# serial 3/1
serial/3/1#
```

6. **Configure frame relay on the serial interface.**

```
serial/3/1# frame-relay
frame-relay/3/1#
```

7. **Configure a service name for the frame relay interface.**

```
frame-relay/3/1# service service1
service/service1#
```

8. **Configure an SVC on the frame relay service.**

```
service/service1# svc-options svc-name svc1
svc-options/svc1#
```

9. **Add LLC2 to the frame relay service.**

```
svc-options/svc1# llc2
llc2/service1#
```

10. **Configure the local or remote MAC address of the end station to be mapped to the SVC.**

```
llc2/service1# fr-svc 111111111111
fr-svc/111111111111#
```

11. **Configure the WAN address that will accept an incoming call (if the mapping is local) or initiate the call (if the mapping is remote).**

    For example, to configure a phone number that will map to the SVC, enter the following command:

```
fr-svc/111111111111# x121-addr 9195551212
fr-svc/111111111111#
```

12. **By default, the SVC mapping type is set to local. If you want to map the SVC to a remote MAC address, enter the following command:**

```
fr-svc/111111111111# mapping-type remote
fr-svc/111111111111#
```

For information about editing other parameters for LLC2 frame relay SVCs, see "Editing Frame Relay SVC Mappings" on page 4-17.

13. **Return to the llc2 prompt.**

```
fr-svc/111111111111# back
llc2/service1#
```

14. **Configure DLSw on the serial interface.**

```
llc2/service1# dlsw
dlsw/service1
```

For complete information about configuring DLSw, see *Configuring DLSw Services*.

Using Site Manager

To enable DLSw and LLC2 over frame relay BNN using SVCs, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, click on the synchronous connector on which you are enabling DLSw services.	The Add Circuit window opens.
2. Click on **OK** to accept the default circuit name.	The WAN Protocols window opens.
3. Choose **Frame Relay** and click on **OK**.	The Select Protocols window opens.
4. Choose **DLSw**. When you choose DLSw, you automatically choose LLC2.	
5. Click on **OK**.	The Frame Relay/SNA Connection window opens.
6. Click on **BNN SVC**.	The DLSw Basic Global Parameters window opens.

(continued)

Site Manager Procedure *(continued)*	
You do this	**System responds**
7. Set the following parameters: • **DLSw RFC Version** • **DLSw Virtual Ring ID (hex)** • **DLSw Peer IP Address** (dual-switch networks only) Click on **Help** or see *Configuring DLSw Services* for parameter descriptions.	
8. Click on **OK**.	The DLSw Basic Interface Parameters window opens.
9. Set the **DLSw Slot IP Address** parameter. Click on **Help** or see *Configuring DLSw Services* for parameter descriptions.	
10. Click on **OK**.	The LLC2 Frame Relay SVC Mappings window opens.
11. Click on **Add**.	The LLC2 Frame Relay SVC Mapping Add window opens.
12. Set the following parameters: • **MAC Address** • **Mapping Type** • **X121 Addr** • **Sub Addr** • **Numbering Plan** • **Type of Number** Click on **Help** or see the parameter descriptions beginning on page A-2.	
13. Click on **OK**.	You return to the LLC2 Frame Relay SVC Mappings window.
14. Click on **Done**.	You return to the Configuration Manager window.

Starting APPN and LLC2 over Frame Relay

To start APPN and LLC2 over frame relay, complete the following steps:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, click on the synchronous connector on which you are enabling APPN.	The Add Circuit window opens.
2. Click on **OK** to accept the default circuit name.	The WAN Protocols window opens.
3. Choose **Frame Relay** and click on **OK**.	The Select Protocols window opens.
4. Choose **APPN**. When you choose APPN, you automatically choose LLC2.	
5. Click on **OK**.	A window opens asking whether you want to use source route encapsulation.
6. Click on **No** to select native (routed) frame relay for LLC2.	The APPN Local Node Name Configuration window opens.
7. Set the **Local Node Name (NETID.NAME)** parameter. Click on **Help** or see *Configuring APPN Services* for a parameter description.	
8. Click on **OK**.	The APPN/FR Configuration window opens.
9. Set the following parameters: • **DLCI Address** • **SAP (hex)** Click on **Help** or see *Configuring APPN Services* for parameter descriptions.	
10. Click on **OK**.	You return to the Configuration Manager window.

Chapter 4
Customizing LLC Services

When you start LLC on the router as described in Chapter 3, "Starting LLC Services," default values are in effect for all parameters. Depending on the requirements of your network, you may want to change some of these values. This chapter includes the following information:

Disabling and Reenabling LLC2 on the Router

When you configure LLC2, LLC2 is automatically enabled on the router. If you disable LLC2, it is no longer available on the router.

Using the BCC

To disable LLC2 on the router, navigate to the global LLC2 prompt and enter:

disable

To reenable LLC2, navigate to the global LLC2 prompt and enter:

enable

For example, the following command sequence disables and reenables LLC2 on the router:

```
box# llc2
llc2# disable
llc2# info
   state disabled
llc2# enable
llc2# info
   state enabled
llc2#
```

Using Site Manager

To disable or reenable LLC2 on the router, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Global**.	The Edit LLC2 Global Parameters window opens.
4. Set the **Enable** parameter. Click on **Help** or see the parameter description on page A-10.	
5. Click on **OK**.	You return to the Configuration Manager window.

Customizing an LLC2 Interface

You customize LLC2 interface parameters for specific clients such as DLSw and LAN Network Manager (LNM). You can configure these and other LLC2 clients on the same physical circuits and, therefore, they can share the same LLC interfaces. In such cases, you can devise a profile of LLC2 parameter settings that satisfy the combined recommendations of the LLC2 clients.

Disabling and Reenabling an LLC2 Interface

The following sections describe how to disable and enable LLC2 on an interface using the BCC or Site Manager.

Using the BCC

To disable or reenable LLC2 on an interface, navigate to the LLC2 interface prompt (for example, **box**; **ethernet 2/1**; **llc2**) and enter the following command:

{**disable** | **enable**}

For example, the following command sequence disables LLC2 on an Ethernet interface:

```
ethernet/2/1# llc2
llc2/ethernet/2/1# disable
llc2/ethernet/2/1#
```

Using Site Manager

To disable or reenable LLC2 on a router interface, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Select the interface that you want to disable or enable.	
5. Set the **Enable** parameter. Click on **Help** or see the parameter description on page A-11.	
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Configuring the Window Size

In LLC, a window controls how many frames a link station sends before receiving an acknowledgment. The window size depends on which modulo your network's implementation of LLC uses. Modulo 8 operation allows a maximum window size of 7; Modulo 128 operation allows a maximum window size of 127.

For example, with a window size of 7, a link station can transmit frames 0 through 6 before requiring acknowledgment from the receiving station. The sending station will not send more frames until it receives an acknowledgment.

Specifying the Maximum Number of Received Information PDUs

The following sections describe how to specify the maximum number of unacknowledged information PDUs that LLC can receive using the BCC or Site Manager.

Using the BCC

To specify the maximum number of unacknowledged information PDUs that LLC can receive, navigate to the LLC2 interface prompt (for example, **box**; **ethernet 2/1**; **llc2**) and enter:

receive-window <*PDUs*>

PDUs is the maximum number of unacknowledged information PDUs that LLC can receive. You can enter a value from 1 through 127.

For example, the following command changes the maximum number of unacknowledged information PDUs to 10:

```
llc2/ethernet/2/1# receive-window 10
llc2/ethernet/2/1#
```

Using Site Manager

To specify the maximum number of unacknowledged information PDUs that LLC can receive, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Click on the interface that you want to customize.	
5. Set the **Receive Window** parameter. Click on **Help** or see the parameter description on page A-13.	
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Specifying the Maximum Number of Outstanding Information PDUs

The following sections describe how to specify the maximum number of information PDUs that can be outstanding at any given time using the BCC or Site Manager.

Using the BCC

To specify the maximum number of information PDUs that can be outstanding (sent) at any given time, navigate to the LLC2 interface prompt (for example, **box**; **ethernet 2/1**; **llc2**) and enter:

transmit-window <*PDUs*>

PDUs is the maximum number of information PDUs that can be outstanding at any given time. The value serves as a default send window size when no other size has been set by an XID information-exchange procedure. You can enter a value from 1 through 127.

For example, the following command changes the maximum number of outstanding information PDUs to 10:

```
llc2/ethernet/2/1# transmit-window 10
```

Using Site Manager

To specify the maximum number of information PDUs that can be outstanding at any given time, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Click on the interface that you want to customize.	
5. Set the **Send Window** parameter. Click on **Help** or see the parameter description on page A-14.	
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Specifying the Unnumbered Information and Information PDU Sizes

The following sections describe how to specify the UI and I PDU sizes using the BCC or Site Manager.

Using the BCC

To specify the UI and I PDU sizes, navigate to the LLC2 interface prompt (for example, **box**; **ethernet 2/1**; **llc2**) and enter the following commands:

max-ui-size <*ui_size*> **max-info-size** <*info_size*>

ui_size is the maximum size, in octets, of an unnumbered information PDU this LLC2 interface sends or receives. You can enter a value from 1 through 5128.

info_size is the maximum size, in octets, of an information PDU that this LLC2 interface sends or receives. You can enter a value from 1 through 5128.

For example, the following command changes the maximum size of the UI PDUs and I PDUs to 4000 and 3000, respectively:

```
llc2/ethernet/2/1# max-ui-size 4000 max-info-size 3000
```

Using Site Manager

To specify the UI PDU and I PDU size, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Click on the interface that you want to customize.	
5. Set the following parameters: • **Max Octets in UI** • **Max Octets in I** Click on **Help** or see the parameter descriptions beginning on page A-12.	
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Configuring Timers

Four timers control how many seconds the local LLC waits to receive the following data:

- Acknowledgment for an outstanding PDU
- Reply to a frame-reject response PDU
- Indication from a remote LLC that it is ready to receive PDUs
- PDU soliciting the status of the remote LLC

Using the BCC

To configure LLC2 timers, navigate to the LLC2 interface prompt (for example, **box**; **ethernet 2/1**; **llc2**) and enter one or more of the following commands:

ack-xmt-timer <*seconds*> **reject-timer** <*seconds*> **busy-timer** <*seconds*> **poll-cycle-timer** <*seconds*>

For ack-xmt-timer, *seconds* is 1 through 15; for reject-timer and poll-cycle-timer, *seconds* is 1 through 30; for busy-timer, *seconds* is 1 through 60.

For example, the following command changes the values for the ack-xmt-timer and reject-timer parameters to 5, and the values for the busy-timer and the poll-cycle-timer parameters to 25:

`llc2/ethernet/2/1#` **ack-xmt-timer 5 reject-timer 5 busy-timer 25 poll-cycle-timer 25**

Using Site Manager

To configure LLC2 timers, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Click on the interface that you want to customize.	
5. Set the following parameters: • **Ack Timer for Xmt** • **Reject Timer** • **Busy Timer** • **Inactivity Timer** Click on **Help** or see the parameter descriptions beginning on page A-15.	
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Specifying the Maximum Number of PDU Retries After Timeout

The following sections describe how to specify the maximum number of times that a PDU can be sent following expiration of a transmit acknowledgment or reject timer. You can complete these tasks using the BCC or Site Manager.

Using the BCC

To specify the maximum number of times that a PDU can be sent following expiration of the transmit acknowledgment timer or the reject timer, navigate to the LLC2 interface prompt (for example, **box**; **ethernet 2/1**; **llc2**) and enter:

n2 <*number_of_retransmissions*>

number_of_retransmissions is the maximum number of times that a PDU can be sent following expiration of the ack-xmt-timer or the reject-timer. You can enter a value from 1 through 10.

For example, the following command changes the maximum number of PDU retries to 5:

```
llc2/ethernet/2/1# n2 5
llc2/ethernet/2/1#
```

Using Site Manager

To specify the maximum number of times that a PDU can be sent following the expiration of the Ack Timer for Xmt or the Reject Timer, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Click on the interface that you want to customize.	

(continued)

Site Manager Procedure *(continued)*	
You do this	**System responds**
5. Set the **Max Retry After TimeOut** parameter. Click on **Help** or see the parameter description on page A-14.	
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Setting the Maximum Number of LLC2 Interface Connections

The following sections describe how to set the maximum number of LLC2 interface connections using the BCC or Site Manager.

Using the BCC

To specify the maximum number of logically independent, end-to-end connections that the local LLC2 interface can allocate, navigate to the LLC2 interface prompt (for example, **box**; **ethernet 2/1**; **llc2**) and enter:

max-links <*max_links*>

max_links is the number of end-to-end connections, from 4 through 5000.

For example, the following command changes the number of end-to-end connections to 1000:

```
llc2/ethernet/2/1# max-links 1000
llc2/ethernet/2/1#
```

Using Site Manager

To specify the maximum number of logically independent, end-to-end connections that the local LLC2 interface can allocate, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Click on the interface that you want to customize.	
5. Set the **Max Links** parameter. Click on **Help** or see the parameter description on page A-17.	
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Fine-Tuning LLC2 Interface Parameters

Using the BCC, you can further fine-tune the LLC2 configuration of an interface. Table 4-1 describes these parameters. In general, you can accept the default values for these parameters.

Table 4-1. BCC Fine-Tuning Parameters for LLC2 Interfaces

Parameter	Values	Function
dup-addr-check	enabled or disabled (default)	Enables or disables a flag to force checking for duplicate addresses
dynamic-window	enabled (default) or disabled	Enables or disables the dynamic window
encapsulation	default, tring, csmacd, srb, fr	Indicates the encapsulation method that LLC uses. When you configure LLC2 over frame relay, the default value is “fr”; for other interfaces, it is “default.”
high-water-reset	normal (default) or reset	Setting this parameter to “reset” sets HiWaterLinks to CurrentLinks
idle-timer	integer 1 through 120 (default 120)	Specifies the idle time in seconds
local-response-acktimer	integer 1 through 10 (default 10)	Specifies the local response timer for remote transmit window rotation response in seconds
max-retries	integer 1 or 2 (default)	Specifies the maximum number of times that an XID or TEST command PDU is sent after the response timer runs out
max-saps	integer 4 through 255 (default 255)	Specifies the maximum number of SAPs per LLC service
n3	integer 1 (default) or 2	Specifies the maximum number of information PDUs that this LLC2 interface can receive before sending a local acknowledgment to the transmitter
ui-ackwait-timer	integer 1 through 30 (default 30)	Specifies the amount of time in seconds that LLC waits to receive an acknowledgment to a sent unnumbered XID or TEST command PDU

For example, the following command changes the maximum number of SAPs allowed on the LLC2 interface to 100:

```
llc2/ethernet/2/1# max-saps 100
```

Customizing LLC2 over Frame Relay

The following section describes how to customize LLC2 over frame relay using the BCC or Site Manager.

Configuring the Frame Relay Virtual MAC Address Mask

The frame relay virtual MAC address mask specifies the upper 2 to 4 bytes of a virtual destination MAC address. The lower remaining bytes specify the DLCI to be used.

Using the BCC

To configure the frame relay virtual MAC address mask, navigate to the LLC2 interface prompt (for example, **box; serial/3/1; frame-relay; service/service1; llc2**) and enter:

fr-virtual-mask *<mask>*

mask specifies the upper 2 to 4 bytes of a virtual destination MAC address. The lower remaining bytes specify the DLCI to be used. Select a mask that is unique within your network. The mask should be the upper 2 to 4 bytes of a standard MSB token ring MAC address.

For example, to set a mask of 0x400000FF, enter:

```
llc2/service1# fr-virtual-mask 0x400000FF
llc2/service1#
```

Using Site Manager

To configure the frame relay virtual MAC address mask, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Click on the interface that you want to customize.	
5. Set the **Frame Relay Virtual MAC Address Mask** parameter. Click on **Help** or see the parameter description on page A-18.	
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Enabling Frame Relay MAC Address Translation to a Virtual SAP

If you configure frame relay BNN SVC and DLSw on an interface, you can enable the translation of multiple source MAC addresses and SAPs that are addressed to the same destination MAC to one virtual SAP. When you enable this feature, multiple clients with different source MAC addresses can use the same frame relay SVC configured on this interface to send information to a specific destination MAC address. By default, this feature is disabled.

To direct multiple client connection requests to a single destination MAC address over a single SVC, frame relay maps the source MAC and source SAP to a unique virtual SAP. Each SVC can support up to 63 connections (SAPs). If this maximum number of SAPs is reached, a new SVC is created. At the receiving side, the virtual SAPs are converted, and the source MAC address is automatically created.

Using the BCC

To direct multiple client connection requests for a single destination MAC address to a single SVC configured on this interface, navigate to the LLC2 interface prompt (for example, **box; serial/3/1; frame-relay; service/service1; llc2**) and enter:

fr-sap-translation {**enabled** | **disabled**}

For example, the following command enables translation of multiple source MAC addresses and SAPs to a virtual SAP:

```
llc2/service1# fr-sap-translation enabled
llc2/service1#
```

Using Site Manager

To enable or disable translation of multiple source MAC addresses and SAPs to a virtual SAP, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Click on the interface that you want to customize.	
5. Set the **FR Sap Translation** parameter. Click on **Help** or see the parameter description on page A-19.	
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Editing Frame Relay PVC Mappings

After you create a DLCI for the frame relay BNN PVC implementation, you can change the remote and local addresses associated with the DLCI. However, you cannot change the DLCI number itself; you must delete the existing DLCI and create a new one.

For instructions on creating a DLCI for use with frame relay BNN PVC, see "Starting DLSw and LLC2 on a Frame Relay BNN PVC Interface" on page 3-13.

Using the BCC

To edit frame relay PVC mappings that you previously configured, navigate to the LLC2 DLCI prompt (for example, **box; serial/3/1; frame-relay; service/service1; llc2; dlci/101**) and enter:

local-mac *<local_mac>* **remote-mac** *<remote_mac>*

local_mac is a standard MSB token ring MAC address that maps incoming requests on this DLCI to that address. The local MAC address must be unique, with only DLCI mapping for a specific MAC address.

remote_mac is a standard MSB token ring MAC address that maps outgoing requests to the DLCI. The remote MAC address must be unique, with only DLCI mapping for a specific MAC address.

For example, the following command changes the local and remote MAC addresses associated with DLCI 101 to 111111111111 and 222222222222:

```
dlci/101# local-mac 111111111111 remote-mac 222222222222
dlci/101#
```

Using Site Manager

To edit and delete frame relay PVC mappings that you previously configured, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Frame Relay PVC Mapping**.	The LLC2 Frame Relay PVC Mappings window opens.
4. Click on the DLCI that you want to edit.	
5. Set one or both of the following parameters: • **Remote MAC** • **Local MAC** Click on **Help** or see the parameter descriptions beginning on page A-8.	
6. Click on **Apply** and then click on **Done**.	You return to the Configuration Manager window.

Editing Frame Relay SVC Mappings

After you create an SVC for the frame relay BNN SVC implementation, you can change the parameters associated with the SVC. However, you cannot change the MAC address associated with the SVC; you must delete the SVC and create a new one for the new MAC address.

For instructions on creating an SVC for use with frame relay BNN SVC, see "Starting DLSw and LLC2 on a Frame Relay BNN SVC Interface" on page 3-17.

Using the BCC

To edit frame relay SVC mappings for LLC2, navigate to the LLC2 SVC prompt (for example, **box; serial/3/1; frame-relay; service/service1; llc2; fr-svc/111111111111**) and set one or more of the following parameters:

mapping-type {**local** | **remote**}

Specifies whether this is a remote or local mapping. The default value is local.

sub-addr <*sub_addr*>

sub_addr specifies the outbound calling or called party subaddress, which is also the inbound calling or called party subaddress.

svc-plan {**e164** | **x121**}

Specifies whether this SVC uses the E.164 or X.121 number plan for addresses. You can enter e164 or x121 (the default value).

type-of-number {**international** | **unknown**}

Specifies the type of number that the remote or local caller uses. You can enter international (the default value) or unknown.

x121-addr <*x121_addr*>

x121_addr specifies a WAN address that is registered with frame relay to accept an incoming call if the mapping is local, or to establish an SVC to the configured number if the mapping is remote.

For example, the following command sequence changes the mapping type from local to remote and configures a number used to initiate the call and establish an SVC with the remote MAC address:

```
fr-svc/123456789012# mapping-type remote
fr-svc/123456789012# x121-addr 9785551212
fr-svc/123456789012#
```

Using Site Manager

To edit and delete frame relay SVC mappings, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Frame Relay SVC Mapping**.	The LLC2 Frame Relay SVC Mappings window opens.
4. Click on the SVC for the MAC address that you want to edit.	
5. Set one or more of the following parameters: • **Mapping Type** • **X121 Addr** • **Sub Addr** • **Numbering Plan** • **Type of Number** Click on **Help** or see the parameter descriptions beginning on page A-4.	
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Configuring the LLC Virtual Ring Number for APPN with SRB

If an LLC interface is configured for APPN with source route bridging, you may need to specify the virtual ring number for LLC to use. The ring number must be unique in the SRB network.

Using the BCC

To specify a ring number for LLC to use if you configure APPN with source route bridging, navigate to the LLC2 interface prompt (for example, **box**; **ethernet 2/1**; **llc2**) and enter:

srb-ring-id <*ring_ID*>

ring_ID is the ring number, from 0x1 through 0xfff.

For example, the following command sets the ring number for this LLC2 interface to 0x10:

```
llc2/ethernet/2/1# srb-ring-id 0x10
llc2/ethernet/2/1#
```

Using Site Manager

To specify a ring number for LLC to use if you configure APPN with source route bridging, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Click on the interface that you want to customize.	
5. Set the **Virtual Ring Number (hex)** parameter. Click on **Help** or see the parameter description on page A-18.	

(continued)

Site Manager Procedure *(continued)*	
You do this	**System responds**
6. Click on **Apply**.	
7. Click on **Done**.	You return to the Configuration Manager window.

Configuring LLC2 Inbound Traffic Filters

For descriptive and procedural information about inbound traffic filters for LLC and any other protocols that support this capability, refer to *Configuring Traffic Filters and Protocol Prioritization*.

Deleting LLC2 from an Interface

The following sections describe how to remove LLC2 from an interface using the BCC or Site Manager.

Using the BCC

To delete LLC2 from a router interface, navigate to the LLC2 interface prompt (for example, **box**; **ethernet 2/1**; **llc2**) and enter:

delete

For example, the following command removes LLC2 from a router interface:

```
llc2/ethernet/2/1# delete
ethernet/2/1#
```

Using Site Manager

To delete an LLC2 interface from its associated physical circuit, complete the following tasks:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Interfaces**.	The LLC2 Interface Configuration window opens.
4. Select the LLC2 interface that you want to delete.	
5. Click on **Delete**.	Site Manager deletes the LLC2 entry that you selected.
6. Click on **Done**.	You return to the Configuration Manager window.

Deleting LLC2 from the Router

The following sections describe how to remove LLC2 from a router entirely using the BCC or Site Manager.

Using the BCC

To delete LLC2 services from the router entirely, navigate to the LLC2 global prompt and enter:

delete

For example, the following command removes LLC2 from the router:

```
llc2# delete
box#
```

Using Site Manager

To delete LLC2 from a router entirely:

Site Manager Procedure	
You do this	**System responds**
1. In the Configuration Manager window, choose **Protocols**.	The Protocols menu opens.
2. Choose **LLC2**.	The LLC2 menu opens.
3. Choose **Delete LLC2**.	A confirmation window opens.
4. Click on **OK**.	You return to the Configuration Manager window.

Appendix A
Site Manager Parameters

This appendix contains the Site Manager parameter descriptions for LLC services. You can display the same information using Site Manager online Help.

This appendix contains the following information:

For each parameter, this appendix provides the following information:

- Parameter name
- Configuration Manager menu path
- Default setting
- Valid parameter options
- Parameter function
- Instructions for setting the parameter
- Management information base (MIB) object ID

The Technician Interface allows you to modify parameters by issuing **set** and **commit** commands with the MIB object ID. This process is equivalent to modifying parameters using Site Manager. For more information about using the Technician Interface to access the MIB, see *Using Technician Interface Software*.

Caution: The Technician Interface does not verify that the value you enter for a parameter is valid. Entering an invalid value can corrupt your configuration.

Accessing LLC Parameters

After you enable LLC services on one or more interfaces, you can access and edit LLC parameters. To display LLC parameter windows, begin at the Configuration Manager window and select Protocols > LLC2. The LLC2 menu opens.

You can access and edit the parameters for a specific LLC2 interface by clicking on the circuit and choosing Edit Circuit from the Edit Connector window. If you are editing a frame relay interface, click on Services. Then open the Protocols menu and choose Edit LLC2 to display the LLC2 menu.

Add LLC2 Frame Relay SVC Mapping Parameters

The LLC2 Frame Relay SVC Mapping Add window (Figure A-1) contains the following parameters:

- MAC Address—address of the end station to be mapped
- Mapping Type—specifies whether this is a remote or local mapping
- X121 Addr—address that is registered with frame relay to accept an incoming call if the mapping is local, or to establish an SVC to the configured number if the mapping is remote
- Sub Addr—outbound or inbound calling or called party subaddress
- Numbering Plan—specifies whether this SVC uses the E.164 or X.121 number plan for address
- Type of Number—specifies the type of number the remote or local caller uses

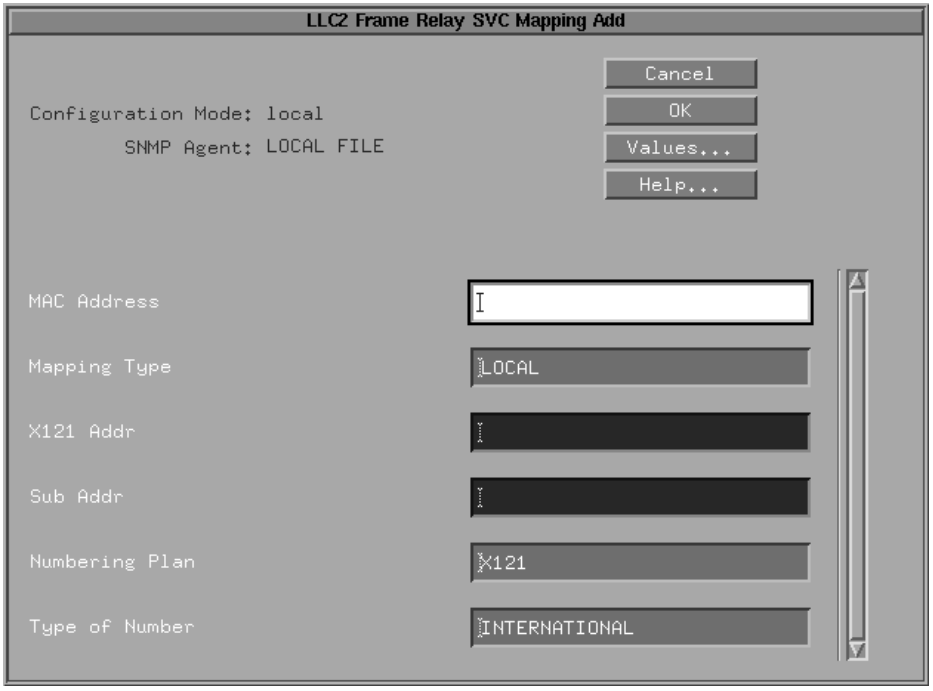


Figure A-1. LLC2 Frame Relay SVC Mapping Add Window

Parameter: MAC Address

Path: Configuration Manager > Edit Circuit > Services > Protocols > Edit LLC2 > Frame Relay SVC Mapping > Add

Default: None

Options: Standard MSB token ring MAC address

Function: Specifies the local or remote MAC address of the end station to be mapped.

Instructions: Enter the MAC address that you want to use.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.10.1.3

Parameter: Mapping Type

Path: Configuration Manager > Protocols > LLC2 > Frame Relay SVC Mapping
Default: Local
Options: Local | Remote
Function: Specifies whether this is a remote or local mapping.
Instructions: Accept the default, Local, or choose Remote.
MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.10.1.4

Parameter: X121 Addr

Path: Configuration Manager > Protocols > LLC2 > Frame Relay SVC Mapping
Default: None
Options: Any display string
Function: Specifies a WAN address (for example, X.121 or E.164) that is registered with frame relay to accept an incoming call if the mapping is local, or to establish an SVC (initiate the call) to the configured number if the mapping is remote.
Instructions: Enter the X.121 or E.164 address that you want.
MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.10.1.5

Parameter: Sub Addr

Path: Configuration Manager > Protocols > LLC2 > Frame Relay SVC Mapping
Default: None
Options: Any display string
Function: Specifies the outbound calling or called party subaddress, which is also the inbound calling or called party subaddress.
Instructions: Enter the number.
MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.10.1.6

Parameter:	**Numbering Plan**
Path:	Configuration Manager > Protocols > LLC2 > Frame Relay SVC Mapping
Default:	X.121
Options:	E.164 | X.121
Function:	Specifies whether this SVC uses the E.164 or X.121 number plan for addresses.
Instructions:	Choose the numbering plan that applies to your network.
MIB Object ID:	1.3.6.1.4.1.18.3.5.1.6.10.1.7

Parameter:	**Type of Number**
Path:	Configuration Manager > Protocols > LLC2 > Frame Relay SVC Mapping
Default:	International
Options:	Unknown | International
Function:	Specifies the type of number that the remote or local caller uses.
Instructions:	To allow the caller to use an international type, accept the default, International. Otherwise, choose Unknown.
MIB Object ID:	1.3.6.1.4.1.18.3.5.1.6.10.1.8

LLC2 Frame Relay SVC Mapping Parameters

The LLC2 Frame Relay SVC Mappings window (Figure A-2) allows you to edit and delete frame relay SVC mappings that you previously configured.

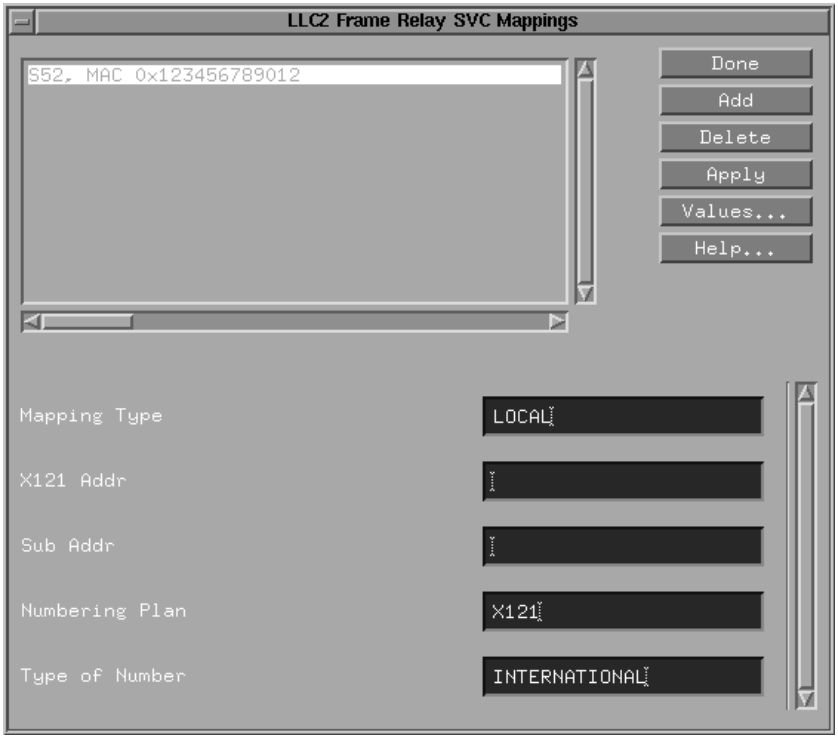


Figure A-2. LLC2 Frame Relay SVC Mappings Window

Add LLC2 Frame Relay PVC Mapping Parameters

The LLC2 Frame Relay PVC Mapping Add window (Figure A-3) contains the following parameters:

- DLCI—number of the virtual circuit to which you map the local or remote MAC address
- Remote MAC—address that maps outgoing requests to the DLCI value
- Local MAC—address that maps incoming requests on this DLCI to this address

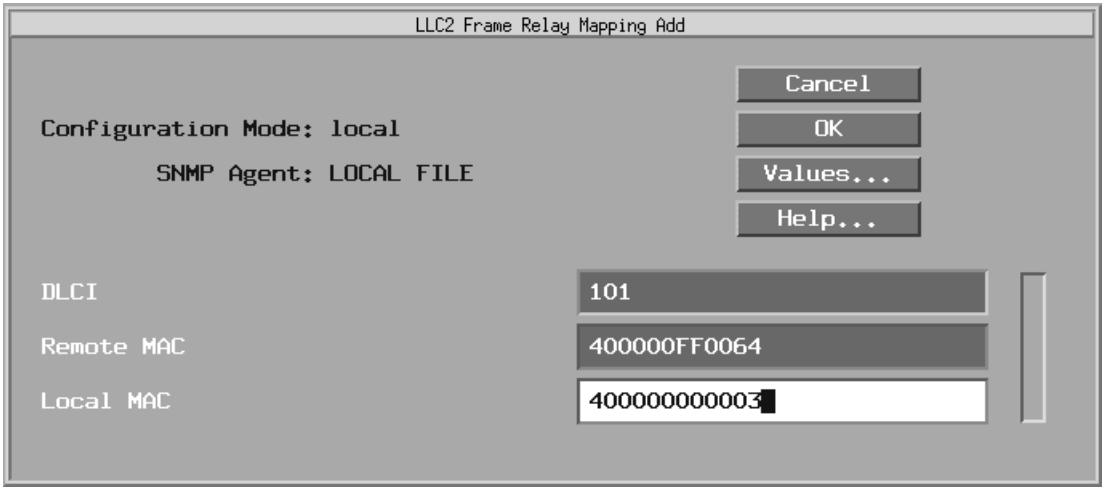


Figure A-3. LLC2 Frame Relay PVC Mapping Add Window

Parameter: DLCI

Path: Configuration Manager > Edit Circuit > Services > Protocols > Edit LLC2 > Frame Relay PVC Mapping > Add

Default: None

Options: Standard data link connection identifier number

Function: Provides the number of the virtual circuit to which you are mapping the local or remote MAC address.

Instructions: Enter a decimal DLCI number assigned by your system administrator or frame relay provider.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.9.1.3

Parameter: **Remote MAC**

Path: Configuration Manager > Protocols > LLC2 > Frame Relay PVC Mapping

Default: None

Options: Standard MSB token ring MAC addresses

Function: Provides the remote MAC address, mapping outgoing requests to the DLCI value. The remote MAC address must be unique, with only DLCI mapping for a specific MAC address.

Instructions: If you need to specify the real hardware address of the host, enter it as an octal string.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.9.1.5

Parameter: **Local MAC**

Path: Configuration Manager > Protocols > LLC2 > Frame Relay PVC Mapping

Default: None

Options: Standard MSB token ring MAC addresses

Function: Provides the local MAC address, mapping incoming requests on this DLCI to that address. The local MAC address must be unique, with only DLCI mapping for a specific MAC address.

Instructions: If the incoming connections are valid, enter the MAC address of the recipient.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.9.1.4

LLC2 Frame Relay PVC Mapping Parameters

The LLC2 Frame Relay PVC Mappings window (Figure A-4) allows you to edit and delete frame relay mappings that you previously configured.

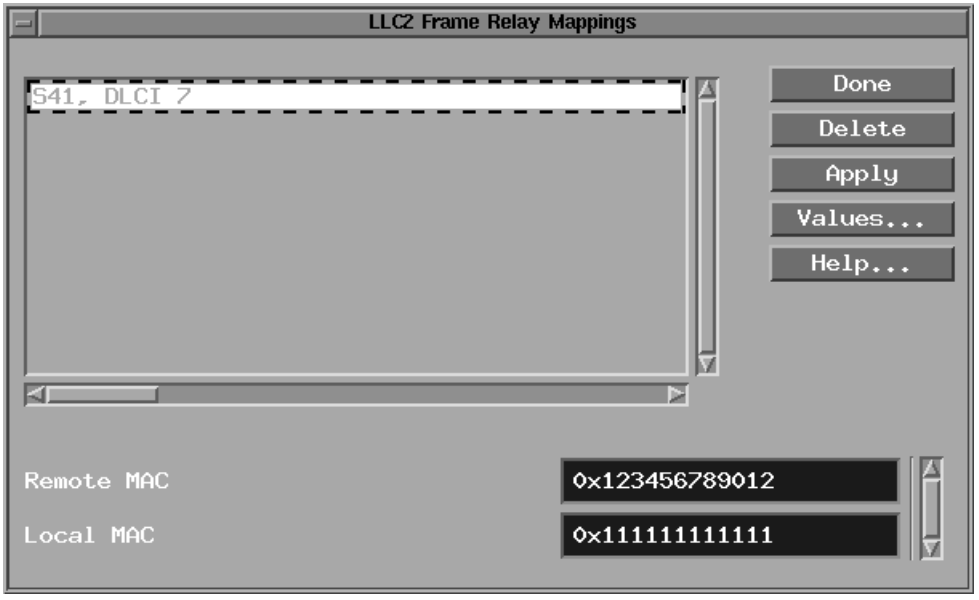


Figure A-4. LLC2 Frame Relay PVC Mappings Window

LLC2 Global Parameters

The Edit LLC2 Global Parameters window (Figure A-5) lets you enable or disable LLC2 on the router.

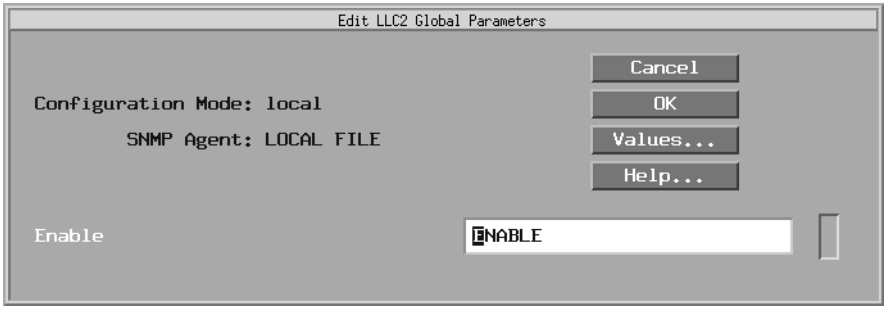


Figure A-5. Edit LLC2 Global Parameters Window

Parameter:	**Enable**
Path:	Configuration Manager > Protocols > LLC2 > Global
Default:	Enable
Options:	Enable | Disable
Function:	Globally enables or disables the system software mechanisms that, in turn, allow (or do not allow) users to add an LLC2 interface to a physical circuit. You can configure only one LLC2 interface per physical circuit. Other significant actions that the system software performs when you choose a setting for the LLC Enable parameter include: Disable—Forces every LLC2 interface on this node into the inoperative (down) state. Enable—Reinitializes every LLC2 interface on this node, with each interface maintaining the most recent setting of its own interface Enable parameter. The actual operating state of each interface further depends on the current (up/down) state of the associated physical circuit.
Instructions:	Select Disable to force every LLC2 interface existing on this node into the inoperative (down) state. Select Enable only when an existing LLC2 interface is in the Disabled state.
MIB Object ID:	1.3.6.1.4.1.18.3.5.1.6.1.2

LLC2 Interface Parameters

The LLC2 Interface Configuration window (Figure A-6) lets you customize LLC2 interface parameters for specific clients such as DLSw and LAN Network Manager. These and other LLC2 clients can be configured on the same physical circuits and, therefore, share the same LLC interfaces. In such cases, you can determine a compromise profile of LLC2 parameter settings that satisfy the combined recommendations of the LLC2 clients.

Note: The Edit LLC2 Interface window has the same parameters as the LLC Interface Configuration window. The Edit LLC2 Interface window shows only the circuit that you highlighted in the Circuit Definition window. Refer to *Configuring and Managing Routers with Site Manager* for information about editing circuits.

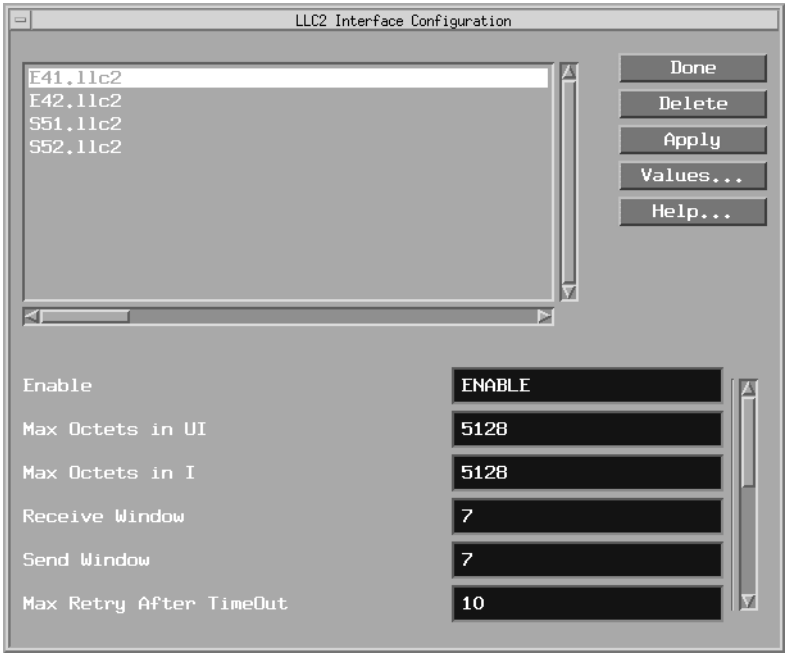


Figure A-6. LLC2 Interface Configuration Window

Parameter: Enable

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: Enable

Options: Enable | Disable

Function: Enables or disables the LLC2 interface added previously to this physical circuit.

Instructions: Select Enable if you disabled this LLC2 interface previously and now want to reenable the interface on its associated physical circuit.

Select Disable if you want to disable this LLC2 interface on its associated physical circuit.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.2

Parameter: Max Octets in UI

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: 5128 (octets)

Options: 1 to 5128

Function: Specifies, in octets, the maximum size of an unnumbered information (UI) PDU that this LLC2 interface sends or receives.

Instructions: Enter a valid value from 1 octet (8 bits) to 5128 octets. Choose a value that is appropriate for the applications that LLC2 supports.

The LLC sublayer imposes no restrictions. However, all MAC sublayers must be capable of accommodating UI PDUs with information fields up to 128 octets in length.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.6

Parameter: Max Octets in I

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: 5128 (octets)

Options: 1 to 5128

Function: Specifies, in octets, the size of an information (I) PDU that this LLC2 interface sends or receives.

Instructions: Enter any valid value from 1 octet (8 bits) to 5128 octets. Choose a value that is appropriate for the applications that LLC2 supports.

Refer to the various MAC descriptions to determine the precise value that you should specify for the given medium. All MACs must be capable of accommodating I format PDUs with information fields up to 5128 octets in length.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.9

Parameter: Receive Window

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: 7 (PDUs)

Options: 1 to 127

Function: Specifies the maximum number of unacknowledged information PDUs that LLC can receive. LLC drops frames it receives outside this window and recovers them via timers.

Instructions: Enter any valid value from 1 through 127 LLC PDUs.

For sessions that do not negotiate XIDs (SNA PU 2.0 and NetBIOS), set the router receive window to the largest end station's send window. If the receive window is too small, the router discards frames it receives outside this window. Timers recover these frames, and dropping these frames degrades performance. On a mainframe's front-end processor, the Max Out parameter in the NCP controls the front-end's transmit window. Therefore, if the Max Out parameter in the NCP is set to 127, you should set the router Receive Window parameter to 127.

For sessions that negotiate XIDs (SNA PU 2.1), the receive window is set dynamically during connection establishment. The router uses the value specified here as an upper limit and negotiates downward.

Choose a value that is appropriate for the applications that LLC2 supports.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.22

Parameter: Send Window

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: 7 (PDUs)

Options: 1 to 127

Function: Specifies the maximum number of information PDUs that can be outstanding (sent or transmitted) at any given time. This value serves as a default send window size when no other size has been set by an XID information-exchange procedure.

Instructions: Enter any valid value from 1 through 127 LLC PDUs.

For sessions that do not negotiate XIDs (SNA PU 2.0 and NetBIOS), set the router send window to the minimum end station's receive window. If the send window is too large, end stations discard frames that they receive outside their receive window. Timers recover these frames, and dropping these frames degrades performance.

For sessions that negotiate XIDs (SNA PU 2.1), the send window is set dynamically during connection establishment. The router uses the value specified here as an upper limit and negotiates downward.

Choose a value that is appropriate for the requirements of the applications that LLC2 supports.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.23

Parameter: Max Retry After TimeOut

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: 10 (retransmissions)

Options: 1 to 10

Function: Specifies the maximum number of times that a PDU can be sent following expiration of the acknowledgment timer, the inactivity timer, or the reject timer.

Instructions: Enter a valid value, from 1 through 10 retransmissions. Choose a value that is appropriate for the applications that LLC2 supports.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.11

Parameter: Ack Timer for Xmt

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: 1 (s)

Options: 1 to 15

Function: Specifies the amount of time, in seconds, that the local LLC waits to receive:

- An acknowledgment for one or more outstanding I PDUs sent during the timer window
- A response PDU for an unnumbered command PDU sent during the timer window
- A response PDU with the F bit set

Instructions: Enter a valid value from 1 through 15.

The default value (1 second) works in most environments, but may be too small if the LLC connection is over frame relay, a source route network with multiple hops, or if the end station responds slowly to I frames.

Choose a value that is appropriate for the applications that LLC2 supports.

If you increase the value of the Ack Timer for Xmt parameter, then you should consider decreasing the value of the Inactivity Timer parameter.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.13

Parameter: Reject Timer

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: 1 (s)

Options: 1 to 30

Function: Specifies the amount of time, in seconds, that the local LLC waits to receive a reply to a REJ PDU (frame reject response PDU).

If the reject timer expires and no reply has been received for the REJ PDU sent by the local LLC, the local reject timer restarts, and LLC retransmits the REJ PDU. (The total number of times that a specific REJ PDU can be retransmitted depends on the setting of the Max Retry After TimeOut parameter.)

Instructions: Enter any valid value, from 1 through 30.

The default value (1 second) works in most environments, but may be too small if the LLC connection is over frame relay, a source route network with multiple hops, or if the end station responds slowly to I frames.

Choose a value that is appropriate for the applications that LLC2 supports.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.14

Parameter: Busy Timer

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: 60 (s)

Options: 1 to 60

Function: Specifies the amount of time, in seconds, that the local LLC waits for an indication from a remote LLC that it is ready to receive PDUs from the local LLC. (The busy condition at the remote LLC has been cleared.)

If the remote busy timer expires and no indication has been received that the remote busy condition has been cleared, the remote busy timer restarts and LLC waits again, either for the remote busy cleared indication or for expiration of the remote busy timer interval.

Instructions: Enter any valid value from 1 through 60. Choose a value that is appropriate for the applications that LLC2 supports.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.15

Parameter: Inactivity Timer

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: 30 (s)

Options: 1 to 30

Function: Specifies the amount of time, in seconds, that the local LLC waits to receive a PDU soliciting the status of the remote LLC.

If the inactivity timer expires, the local LLC sends an S format PDU with the P bit set to solicit the status of the remote LLC. It initiates the acknowledgment timer to handle retries.

Instructions: Enter any valid value from 1 through 30.

This timer detects when an end station no longer responds. The router uses the following formulas to recognize a nonresponsive LLC end station:

Inactivity Timer + (Ack Timer for Xmt * Max Retry After TimeOut)

Defaults: 30 + (1 * 10) = 40 seconds

If you increase the Ack Timer for Xmt parameter value, then you should consider decreasing the Inactivity Timer parameter value.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.18

Parameter: Max Links

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: 255 (logical connections)

Options: 4 to 5000

Function: Specifies the maximum number of logically independent, end-to-end connections that the local LLC2 interface can allocate.

Instructions: Enter any valid number of end-to-end connections, from 4 through 5000. Choose an appropriate value for the aggregate performance requirements of all the applications that this LLC2 interface supports. Be aware that higher settings reduce the amount of available memory.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.20

Parameter:	**Frame Relay Virtual MAC Address Mask**
Path:	Configuration Manager > Protocols > LLC2 > Interfaces
Default:	0x400000FF
Options:	Octal string
Function:	Specifies the upper 2 to 4 bytes of a virtual destination MAC address. The lower remaining bytes specify the DLCI to be used.
Instructions:	Select a mask that is unique within your network. The mask should be the upper 2 to 4 bytes of a standard MSB token ring MAC address.
MIB Object ID:	1.3.6.1.4.1.18.3.5.1.6.2.1.26

Parameter:	**Virtual Ring Number (hex)**
Path:	Configuration Manager > Protocols > LLC2 > Interfaces
Default:	0x0
Options:	0x0 to 0xfff
Function:	Indicates a ring number for LLC to use if you configure APPN with source route bridging. The ring number must be unique in the SRB network.
Instructions:	Select a hexadecimal number from 0x1 through 0xfff that is unique in your SRB network.
MIB Object ID:	1.3.6.1.4.1.18.3.5.1.6.2.1.25

Parameter: FR Sap Translation

Path: Configuration Manager > Protocols > LLC2 > Interfaces

Default: Disable

Options: Enable | Disable

Function: Enables or disables the translation of multiple source MAC addresses and SAPs that are addressed to the same destination MAC to one virtual SAP. If you configured frame relay BNN and DLSw on this interface and you enable this parameter, multiple clients with different source MAC addresses can use the same frame relay SVC to send information to a specific destination MAC address.

To direct multiple client connection requests to a single destination MAC address over a single SVC, frame relay maps the source MAC and source SAP to a unique virtual SAP. Each SVC can support up to 63 connections (SAPs). If this maximum number of SAPs is reached, a new SVC is created. At the receiving side, the virtual SAPs are converted, and the source MAC address is automatically created.

Instructions: Select Enable if you configured frame relay BNN SVC service and DLSw on this LLC2 interface, and you want to direct multiple client connection requests for a single destination MAC address to a single SVC configured on this interface.

Otherwise, accept the default, Disable.

MIB Object ID: 1.3.6.1.4.1.18.3.5.1.6.2.1.31

Appendix B
Monitoring LLC Using the BCC show Commands

To display configuration and statistical data about LLC2 from the management information base (MIB), use the BCC **show llc2** command.

This appendix includes descriptions of the following **show** commands:

Online Help for show Commands

To display a list of command options, enter **show llc2 ?** at any BCC prompt. To learn more about any **show llc2** command option and its syntax, use the question mark (**?**) command as follows:

Example

```
bcc> show llc2 ?
   all     dlci     fr-svc      interfaces      links      summary

bcc> show llc2 interfaces ?
show llc2 interfaces [-enabled <arg>] [-interface <arg>]

bcc> show llc2 interfaces -interface S21
show llc2 interfaces -interface S21  Oct 12, 2001 04:26:51 [EDT]

LLC2 Interfaces
-----------------------------------------------------------------
                Max         Receive     Transmit
Name   State    Links       Window      Window      Encapsulation
-----  ------   -------     --------    ---------   -------------
S21    down     255          7           7              fr

bcc>
```

show llc2 all

The **show llc2 all** command shows all the information that you can display using the other **show llc2** commands. The output includes the following information:

LLC2 Interfaces	
Name	Circuit name assigned to the interface.
State	State of the LLC service: up, down, init (initializing), disabled, or absent.
Max Links	Maximum number of end-to-end connections per LLC service.
Receive Window	Maximum number of unacknowledged information PDUs that LLC can receive.
Transmit Window	Maximum number of information PDUs that can be outstanding at any given time.
Encapsulation	The encapsulation technique that should be used by LLC: default, fr, token-ring, csmacd, or source-routing.
DLCI Mapping Table	
Name	Name of the frame relay service record on which the DLCI is configured. If the DLCI is configured on the default service record, the circuit name is displayed.
Dlci Num	Configured DLCI number to which you are mapping the local or remote MAC address.
Local MAC	MAC address of the local end station to be mapped to this DLCI. Incoming requests on this DLCI will be mapped to the specified local MAC address.
Remote MAC	MAC address of the remote end station to be mapped to this DLCI. Outgoing requests specifying this MAC address will be mapped to the DLCI.
LLC2 Connections Table	
Circuit Name	Circuit name assigned to the interface.
Dest MAC	MAC address of the remote station.
Src MAC	MAC address of the local station.
Dsap	One or more destination SAPs for which the LLC PDU is intended.
Ssap	Specific source SAP that initiated the PDU.

(continued)

LLC2 FR SVC Mapping Table	
Name	Name of the frame relay service record on which the SVC is configured. If the SVC is configured on the default service record, the circuit name is displayed.
MAC Address	Address of the local or remote end station to be mapped to this SVC.
Mapping Type	Specifies whether this is a remote or local mapping.
Plan	Specifies whether this SVC uses the E.164 or X.121 number plan for address.
X121 Address	WAN address registered with frame relay to accept an incoming call if the mapping is local, or to establish an SVC to the configured number if the mapping is remote.
Sub Address	Outbound or inbound calling or called party subaddress.
Type of Number	Specifies the type of number that the remote or local caller uses: international or unknown.

show llc2 dlci

The **show llc2 dlci** command displays information about the DLCIs configured for LLC2 on frame relay interfaces.

This command allows for the following command filters (flags) and arguments:

-dlci <*dlci_number*>	Displays information for the specified DLCI only.
-interface <*circuit_name*>	Displays information for the specified frame relay service record or interface only.

The output includes the following information:

Name	Name of the frame relay service record on which the DLCI is configured. If the DLCI is configured on the default service record, the circuit name is displayed.
Dlci Num	Configured DLCI number to which you are mapping the local or remote MAC address.
Local MAC	MAC address of the local end station to be mapped to this DLCI. Incoming requests on this DLCI will be mapped to the specified local MAC address.
Remote MAC	MAC address of the remote end station to be mapped to this DLCI. Outgoing requests specifying this MAC address will be mapped to the DLCI.

show llc2 fr-svc

The **show llc2 fr-svc** command displays information about the SVCs configured for LLC2 on frame relay interfaces.

This command allows for the following command filters (flags) and arguments:

-mac-address <*mac_address*>	Displays information for the specified MAC address only.
-interface <*circuit_name*>	Displays information for the specified frame relay service record or interface only.

The output includes the following information:

Name	Name of the frame relay service record on which the SVC is configured. If the SVC is configured on the default service record, the circuit name is displayed.
MAC Address	Address of the local or remote end station to be mapped to this SVC.
Mapping Type	Specifies whether this is a remote or local mapping.
Plan	Specifies whether this SVC uses the E.164 or X.121 number plan for address.
X121 Address	WAN address registered with frame relay to accept an incoming call if the mapping is local, or to establish an SVC to the configured number if the mapping is remote.
Sub Address	Outbound or inbound calling or called party subaddress.
Type of Number	Specifies the type of number that the remote or local caller uses: international or unknown.

show llc2 interfaces

The **show llc2 interfaces** command displays information about LLC2 interfaces, including the current operational status and interface type.

This command allows for the following command filters (flags) and arguments:

-enabled [**enabled** | **disabled**]	Displays information for enabled or disabled interfaces only.
-interface <*circuit_name*>	Displays information for the specified interface only.

The output includes the following information:

Name	Circuit name assigned to the interface.
State	State of the LLC service: up, down, init (initializing), disabled, or absent.
Max Links	Maximum number of end-to-end connections per LLC service.
Receive Window	Maximum number of unacknowledged information PDUs that LLC can receive.
Transmit Window	Maximum number of information PDUs that can be outstanding at any given time.
Encapsulation	Encapsulation technique that LLC should use: default, fr, token-ring, csmacd, source-routing.

show llc2 links

The **show llc2 links** command displays general information about connections on the router.

This command allows for the following command filter (flag) and argument:

-interface <*circuit_name*>	Displays information about connections for the specified interface only.

The output includes the following information:

Name	Circuit name assigned to the interface.
Dest MAC	MAC address of the remote station.
Src MAC	MAC address of the local station.
Dsap	One or more destination SAPs for which the LLC PDU is intended.
Ssap	Specific source SAP that initiated the PDU.

show llc2 summary

The **show llc2 summary** command displays general information about LLC2 interfaces, including current operational status and the maximum number of links configured. This command also shows whether global LLC2 is enabled.

This command allows for the following command filter (flag) and argument:

-interface <*circuit_name*>	Displays information about connections for the specified interface only.

The output includes the following information:

Name	Circuit name assigned to the interface.
State	State of the LLC service: up, down, init (initializing), disabled, or absent.
Max Links	Maximum number of end-to-end connections per LLC service.

Index

E

F

I

L

M

N

O

P

R

S

T

V

X