# Configuring LLC Services

BayRS Version 13.00
Site Manager Software Version 7.00

Part No. 303533-A Rev 00
October 1998

Bay Networks

*Where Information Flows.*™

Bay Networks Where Information Flows.

4401 Great America Parkway
Santa Clara, CA 95054

8 Federal Street
Billerica, MA 01821

## Bay Networks, Inc. Software License Agreement

**NOTICE:** Please carefully read this license agreement before copying or using the accompanying software or installing the hardware unit with pre-enabled software (each of which is referred to as "Software" in this Agreement). BY COPYING OR USING THE SOFTWARE, YOU ACCEPT ALL OF THE TERMS AND CONDITIONS OF THIS LICENSE AGREEMENT. THE TERMS EXPRESSED IN THIS AGREEMENT ARE THE ONLY TERMS UNDER WHICH BAY NETWORKS WILL PERMIT YOU TO USE THE SOFTWARE. If you do not accept these terms and conditions, return the product, unused and in the original shipping container, within 30 days of purchase to obtain a credit for the full purchase price.

**1. License Grant.** Bay Networks, Inc. ("Bay Networks") grants the end user of the Software ("Licensee") a personal, nonexclusive, nontransferable license: a) to use the Software either on a single computer or, if applicable, on a single authorized device identified by host ID, for which it was originally acquired; b) to copy the Software solely for backup purposes in support of authorized use of the Software; and c) to use and copy the associated user manual solely in support of authorized use of the Software by Licensee. This license applies to the Software only and does not extend to Bay Networks Agent software or other Bay Networks software products. Bay Networks Agent software or other Bay Networks software products are licensed for use under the terms of the applicable Bay Networks, Inc. Software License Agreement that accompanies such software and upon payment by the end user of the applicable license fees for such software.

**2. Restrictions on use; reservation of rights.** The Software and user manuals are protected under copyright laws. Bay Networks and/or its licensors retain all title and ownership in both the Software and user manuals, including any revisions made by Bay Networks or its licensors. The copyright notice must be reproduced and included with any copy of any portion of the Software or user manuals. Licensee may not modify, translate, decompile, disassemble, use for any competitive analysis, reverse engineer, distribute, or create derivative works from the Software or user manuals or any copy, in whole or in part. Except as expressly provided in this Agreement, Licensee may not copy or transfer the Software or user manuals, in whole or in part. The Software and user manuals embody Bay Networks' and its licensors' confidential and proprietary intellectual property. Licensee shall not sublicense, assign, or otherwise disclose to any third party the Software, or any information about the operation, design, performance, or implementation of the Software and user manuals that is confidential to Bay Networks and its licensors; however, Licensee may grant permission to its consultants, subcontractors, and agents to use the Software at Licensee's facility, provided they have agreed to use the Software only in accordance with the terms of this license.

**3. Limited warranty.** Bay Networks warrants each item of Software, as delivered by Bay Networks and properly installed and operated on Bay Networks hardware or other equipment it is originally licensed for, to function substantially as described in its accompanying user manual during its warranty period, which begins on the date Software is first shipped to Licensee. If any item of Software fails to so function during its warranty period, as the sole remedy Bay Networks will at its discretion provide a suitable fix, patch, or workaround for the problem that may be included in a future Software release. Bay Networks further warrants to Licensee that the media on which the Software is provided will be free from defects in materials and workmanship under normal use for a period of 90 days from the date Software is first shipped to Licensee. Bay Networks will replace defective media at no charge if it is returned to Bay Networks during the warranty period along with proof of the date of shipment. This warranty does not apply if the media has been damaged as a result of accident, misuse, or abuse. The Licensee assumes all responsibility for selection of the Software to achieve Licensee's intended results and for the installation, use, and results obtained from the Software. Bay Networks does not warrant a) that the functions contained in the software will meet the Licensee's requirements, b) that the Software will operate in the hardware or software combinations that the Licensee may select, c) that the operation of the Software will be uninterrupted or error free, or d) that all defects in the operation of the Software will be corrected. Bay Networks is not obligated to remedy any Software defect that cannot be reproduced with the latest Software release. These warranties do not apply to the Software if it has been (i) altered, except by Bay Networks or in accordance with its instructions; (ii) used in conjunction with another vendor's product, resulting in the defect; or (iii) damaged by improper environment, abuse, misuse, accident, or negligence. THE FOREGOING WARRANTIES AND LIMITATIONS ARE EXCLUSIVE REMEDIES AND ARE IN LIEU OF ALL OTHER WARRANTIES EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Licensee is responsible for the security of

its own data and information and for maintaining adequate procedures apart from the Software to reconstruct lost or altered files, data, or programs.

**4. Limitation of liability.** IN NO EVENT WILL BAY NETWORKS OR ITS LICENSORS BE LIABLE FOR ANY COST OF SUBSTITUTE PROCUREMENT; SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES; OR ANY DAMAGES RESULTING FROM INACCURATE OR LOST DATA OR LOSS OF USE OR PROFITS ARISING OUT OF OR IN CONNECTION WITH THE PERFORMANCE OF THE SOFTWARE, EVEN IF BAY NETWORKS HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. IN NO EVENT SHALL THE LIABILITY OF BAY NETWORKS RELATING TO THE SOFTWARE OR THIS AGREEMENT EXCEED THE PRICE PAID TO BAY NETWORKS FOR THE SOFTWARE LICENSE.

**5. Government Licensees.** This provision applies to all Software and documentation acquired directly or indirectly by or on behalf of the United States Government. The Software and documentation are commercial products, licensed on the open market at market prices, and were developed entirely at private expense and without the use of any U.S. Government funds. The license to the U.S. Government is granted only with restricted rights, and use, duplication, or disclosure by the U.S. Government is subject to the restrictions set forth in subparagraph (c)(1) of the Commercial Computer Software—Restricted Rights clause of FAR 52.227-19 and the limitations set out in this license for civilian agencies, and subparagraph (c)(1)(ii) of the Rights in Technical Data and Computer Software clause of DFARS 252.227-7013, for agencies of the Department of Defense or their successors, whichever is applicable.

**6. Use of Software in the European Community.** This provision applies to all Software acquired for use within the European Community. If Licensee uses the Software within a country in the European Community, the Software Directive enacted by the Council of European Communities Directive dated 14 May, 1991, will apply to the examination of the Software to facilitate interoperability. Licensee agrees to notify Bay Networks of any such intended examination of the Software and may procure support and assistance from Bay Networks.

**7. Term and termination.** This license is effective until terminated; however, all of the restrictions with respect to Bay Networks' copyright in the Software and user manuals will cease being effective at the date of expiration of the Bay Networks copyright; those restrictions relating to use and disclosure of Bay Networks' confidential information shall continue in effect. Licensee may terminate this license at any time. The license will automatically terminate if Licensee fails to comply with any of the terms and conditions of the license. Upon termination for any reason, Licensee will immediately destroy or return to Bay Networks the Software, user manuals, and all copies. Bay Networks is not liable to Licensee for damages in any form solely by reason of the termination of this license.

**8. Export and Re-export.** Licensee agrees not to export, directly or indirectly, the Software or related technical data or information without first obtaining any required export licenses or other governmental approvals. Without limiting the foregoing, Licensee, on behalf of itself and its subsidiaries and affiliates, agrees that it will not, without first obtaining all export licenses and approvals required by the U.S. Government: (i) export, re-export, transfer, or divert any such Software or technical data, or any direct product thereof, to any country to which such exports or re-exports are restricted or embargoed under United States export control laws and regulations, or to any national or resident of such restricted or embargoed countries; or (ii) provide the Software or related technical data or information to any military end user or for any military end use, including the design, development, or production of any chemical, nuclear, or biological weapons.

**9. General.** If any provision of this Agreement is held to be invalid or unenforceable by a court of competent jurisdiction, the remainder of the provisions of this Agreement shall remain in full force and effect. This Agreement will be governed by the laws of the state of California.

Should you have any questions concerning this Agreement, contact Bay Networks, Inc., 4401 Great America Parkway, P.O. Box 58185, Santa Clara, California 95054-8185.

LICENSEE ACKNOWLEDGES THAT LICENSEE HAS READ THIS AGREEMENT, UNDERSTANDS IT, AND AGREES TO BE BOUND BY ITS TERMS AND CONDITIONS. LICENSEE FURTHER AGREES THAT THIS AGREEMENT IS THE ENTIRE AND EXCLUSIVE AGREEMENT BETWEEN BAY NETWORKS AND LICENSEE, WHICH SUPERSEDES ALL PRIOR ORAL AND WRITTEN AGREEMENTS AND COMMUNICATIONS BETWEEN THE PARTIES PERTAINING TO THE SUBJECT MATTER OF THIS AGREEMENT. NO DIFFERENT OR ADDITIONAL TERMS WILL BE ENFORCEABLE AGAINST BAY NETWORKS UNLESS BAY NETWORKS GIVES ITS EXPRESS WRITTEN CONSENT, INCLUDING AN EXPRESS WAIVER OF THE TERMS OF THIS AGREEMENT.

# Contents

**Preface**

Before You Begin ..... xi
Text Conventions ..... xii
Acronyms ..... xiii
Bay Networks Technical Publications ..... xv
How to Get Help ..... xv

**Chapter 1**
**Logical Link Control Overview**

Using LLC2 with SNA and NetBIOS ..... 1-2
Supported Connections ..... 1-2
Frame Relay Support ..... 1-3
Boundary Network Node (RFC 1490) ..... 1-3
Boundary Access Node ..... 1-4
LLC 8802/802.2 Standards ..... 1-6
LLC Service Classes ..... 1-6
LLC1 (Connectionless Service) ..... 1-7
LLC2 (Connection-Oriented Service) ..... 1-7
LLC Operation Types ..... 1-8
Type 1 Operations ..... 1-8
Type 2 Operations ..... 1-8
LLC Functionality ..... 1-9
LLC Protocol Data Unit Formats ..... 1-10
Destination SAP (DSAP) ..... 1-10
Source SAP (SSAP) ..... 1-11
SAP Addressing Scheme ..... 1-12
Control Field ..... 1-13
Control Field Formats ..... 1-14
Information Field ..... 1-18

For More Information about Logical Link Control ..... 1-19

**Chapter 2**
**LLC2 Routed over Frame Relay**

Compatibility with RFC 1490 ..... 2-1
Compatibility with IBM NCP 7.1 and Higher ..... 2-1
FRAD-like Functionality ..... 2-4
Mapping DLCIs to MAC Addresses ..... 2-4
Router Mapping Examples ..... 2-5
Virtual MAC to Frame Relay ..... 2-6
Frame Relay to Virtual MAC ..... 2-7
Physical MAC to Frame Relay ..... 2-8
Frame Relay to Physical MAC ..... 2-9
Frame Relay to Frame Relay ..... 2-10
LLC2 over Frame Relay: Routed versus Bridged ..... 2-12
For More Information about LLC2 over Frame Relay ..... 2-13

**Chapter 3**
**Enabling LLC Services**

Using the Parameter Descriptions ..... 3-1
Enabling LLC2 on an Interface ..... 3-2
Enabling LLC2 Services over Native Frame Relay ..... 3-3
For APPN Networks ..... 3-4
For DLSw Networks ..... 3-5

**Chapter 4**
**Editing LLC Parameters**

Configuring LLC Parameters ..... 4-2
Editing LLC2 Global Parameters ..... 4-3
Editing LLC2 Interface Parameters ..... 4-4
Editing Frame Relay Mappings ..... 4-13
Deleting an LLC2 Interface ..... 4-14
Editing LLC2 Inbound Traffic Filters ..... 4-14
Deleting LLC2 from the Node ..... 4-14

**Appendix A**
**LLC2 Default Settings**

**Index**

# Figures


Figure 1-1. Sample Frame Relay Network ..... 1-5
Figure 1-2. The LLC Sublayer in the IEEE 802.x and OSI Models ..... 1-6
Figure 1-3. LLC PDU Structure ..... 1-10
Figure 1-4. DSAP Address Field ..... 1-11
Figure 1-5. SSAP Address Field ..... 1-11
Figure 1-6. SAPs for LLC Clients ..... 1-12
Figure 1-7. LLC PDU Control Field Format ..... 1-14
Figure 2-1. Sample Frame Relay Network Using LLC2 ..... 2-3
Figure 2-2. Frame Relay to Virtual MAC Topology ..... 2-7
Figure 2-3. Physical MAC to Frame Relay Topology ..... 2-8
Figure 2-4. Frame Relay to Physical MAC Topology ..... 2-10
Figure 2-5. Frame Relay-to-Frame Relay Topology ..... 2-11
Figure 2-6. RFC 1490 Bridging and Routing Standards for SNA ..... 2-12
Figure 3-1. Select Protocols Window (LLC only) ..... 3-2
Figure 3-2. WAN Protocols Window (Frame Relay) ..... 3-3
Figure 3-3. Select Protocols Window ..... 3-4
Figure 3-4. Source Route Encapsulation Dialog Box ..... 3-4
Figure 3-5. LLC2 Frame Relay Mappings Window ..... 3-6
Figure 3-6. LLC2 Frame Relay Mapping Add Window ..... 3-7
Figure 3-7. LLC2 Frame Relay Mappings Window with DLCI Added ..... 3-9
Figure 4-1. Configuration Manager Window ..... 4-2
Figure 4-2. Edit LLC2 Global Parameters Window ..... 4-3
Figure 4-3. LLC2 Interface Configuration Window ..... 4-5
Figure 4-4. LLC2 Interface Configuration Window (Bottom) ..... 4-5

# Tables


Table 1-1. LLC Command PDUs ..... 1-9
Table 1-2. PDU Format and Function ..... 1-15
Table 1-3. Control Field Bits and Functions ..... 1-15
Table 1-4. Command Names and Definitions ..... 1-16
Table 2-1. Virtual MAC to Frame Relay Topology ..... 2-6
Table A-1. LLC2 Global Parameters ..... A-1
Table A-2. LLC2 Interface Parameters ..... A-1

# Preface

This guide describes Logical Link Control (LLC) services and what you do to start and customize ATM services on a Bay 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).

## 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 BayStack Remote Access*, or *Connecting ASN Routers to a Network)*.

Make sure that you are running the latest version of Bay 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.<br>Example: If the command syntax is:<br><br>**ping** *<ip_address>*, you enter:<br>**ping 192.32.10.12** |
| **bold text** | Indicates text that you need to enter and command names and options.<br>Example: Enter **show ip** {**alerts** \| **routes**}<br><br>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.<br>Example: If the command syntax is:<br><br>**show ip** {**alerts** \| **routes**}, you must enter either:<br>**show ip alerts** or **show ip routes**. |
| brackets ([ ]) | Indicate optional elements in syntax descriptions. Do not type the brackets when entering the command.<br>Example: If the command syntax is:<br><br>**show ip interfaces** [**-alerts**], you can enter either:<br>**show ip interfaces** or **show ip interfaces -alerts**. |
| ellipsis points (. . . ) | Indicate that you repeat the last element of the command as needed.<br>Example: If the command syntax is:<br><br>**ethernet/2/1** [<*parameter*> <*value*>] . . ., you enter **ethernet/2/1** and as many parameter-value pairs as needed. |

| | |
|---|---|
| *italic text* | Indicates file and directory names, 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.<br>Example: If the command syntax is:<br><br>**show at** <*valid_route*><br>*valid_route* is one variable and you substitute one value for it. |
| `screen text` | Indicates system output, for example, prompts and system messages.<br>Example: `Set Bay Networks Trap Monitor Filters` |
| separator ( > ) | Shows menu paths.<br>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.<br>Example: If the command syntax is:<br><br>**show ip** {**alerts** \| **routes**}, you enter either:<br>**show ip alerts** or **show ip routes**, but not both. |

## Acronyms

| | |
|---|---|
| ANSI | American National Standards Institute |
| APPN | Advanced Peer-to-Peer Networking |
| DLCI | data link connection identifier |
| DLSw | Data Link Switching |
| DSPU | downstream physical unit |
| FDDI | Fiber Distributed Data Interface |
| FEP | front-end processor |
| FR | Frame Relay |

| | |
|---|---|
| FRAD | Frame Relay Access Device |
| IEEE | Institute of Electrical and Electronic Engineers |
| ISO | International Standards Organization |
| LAN | Local Area Network |
| LLC | Logical Link Control |
| LNM | LAN Network Manager |
| LSAP | Link Service Access Point |
| LSB | least significant bit |
| LSDU | Link Service Data Unit |
| MAC | Media Access Control |
| MSB | most significant bit |
| NCP | Network Communications Program |
| NetBIOS | Network Basic Input-Output System |
| OSI | Open Systems Interconnection |
| PDU | Protocol Data Unit |
| RFC | Request for Comment |
| SAP | Service Access Point |
| SDLC | Synchronous Data Link Control |
| SNA | Systems Network Architecture |
| SR | source routing |
| SRB | source-route bridging |
| WAN | wide area network |

## Bay Networks Technical Publications

You can now print Bay Networks technical manuals and release notes free, directly from the Internet. Go to *support.baynetworks.com/library/tpubs/*. Find the Bay Networks product for which you need documentation. Then locate the specific category and model or version for your hardware or software product. Using Adobe Acrobat Reader, you can open the manuals and release notes, search for the sections you need, and print them on most standard printers. You can download Acrobat Reader free from the Adobe Systems Web site, *www.adobe.com*.

You can purchase Bay Networks documentation sets, CDs, and selected technical publications through the Bay Networks Collateral Catalog. The catalog is located on the World Wide Web at *support.baynetworks.com/catalog.html* and is divided into sections arranged alphabetically:

- The “CD ROMs” section lists available CDs.
- The “Guides/Books” section lists books on technical topics.
- The “Technical Manuals” section lists available printed documentation sets.

Make a note of the part numbers and prices of the items that you want to order. Use the “Marketing Collateral Catalog description” link to place an order and to print the order form.

## How to Get Help

For product assistance, support contracts, or information about educational services, go to the following URL:

*http://www.baynetworks.com/corporate/contacts/*

Or telephone the Bay Networks Technical Solutions Center at:

800-2LANWAN

# Chapter 1
# Logical Link Control Overview

LLC is a standard protocol within the 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 providing a local acknowledgment to SNA/NetBIOS workstations. The LLC2 subsystem provides these services.

The Bay 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

- DLSw
- APPN
- LAN Network Manager (LNM)

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

Generally there is no need to change the LLC2 default settings in Site Manager. However, you can tune the network by changing these default settings. In Site Manager, you should not select LLC2 on an interface without also selecting one of the preceding protocols.

## Using LLC2 with SNA and NetBIOS

SNA needs a connection-oriented datalink 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 in terms of 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. These interfaces include

- Interfaces configured with APPN
- Interfaces configured with DLSw

  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. These interfaces include

- LAN interfaces
  - -- Token Ring
  - -- Ethernet
  - -- Any other LAN media supporting Source Route Bridge, including FDDI

- WAN interfaces
  - -- Frame Relay Boundary Network Node (BNN) and Boundary Access Node (BAN) interfaces
  - -- Any other WAN media supporting Source Route Bridge (SRB) traffic, including Point-to-Point (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.

Bay 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 (RFC 1490)
- Boundary Access Node

## Boundary Network Node (RFC 1490)

The Boundary Network Node (BNN) refers to RFC 1490, Routed SNA over Frame Relay. This implementation of LLC2 also complies with the Frame Relay Forum 3 (FRF.3), “Multiple Protocol Encapsulation over Frame Relay Implementation Agreements,” 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).

Since 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 the permanent virtual circuit (PVC) to carry the packet to its destination. You do this with the LLC2 Frame Relay Mapping Table. The mapping table consists of three fields:

- DLCI
- Remote (or Destination) MAC
- Local (or Source) MAC

Each entry requires that you specify the Remote MAC, Local MAC, or both. A packet that matches this entry is then forwarded to the specified DLCI.

Bay Networks routers select BNN when you configure the Frame Relay network *without* source route encapsulation.

## 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).

Since BAN carries the destination and source MAC addresses in the network packets, this format carries more bits per packet.

Standard BAN uses the Source Route Bridge frame format with local termination. Bay Networks routers select BAN when you configure the Frame Relay network *with* source route encapsulation.

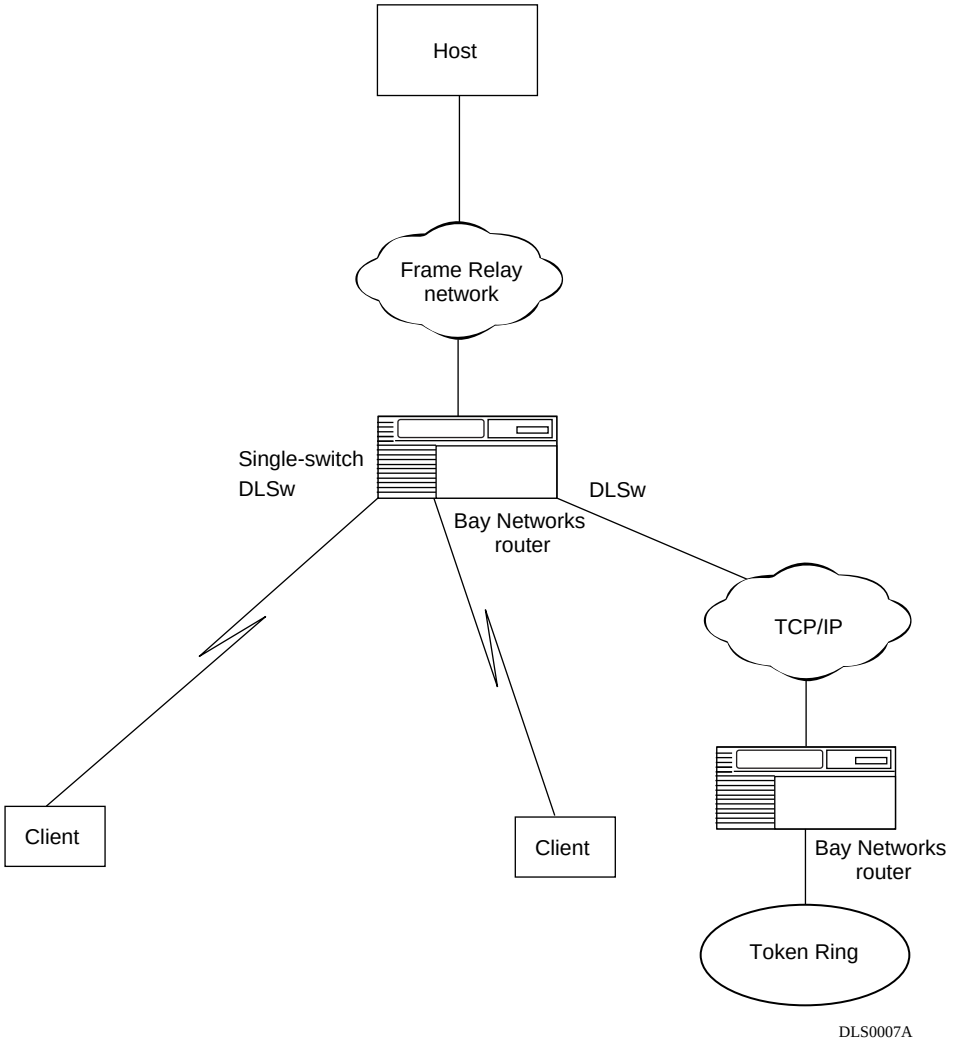


**Figure 1-1. Sample Frame Relay Network**

# LLC 8802/802.2 Standards

The LLC protocols comply with the CCITT 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.

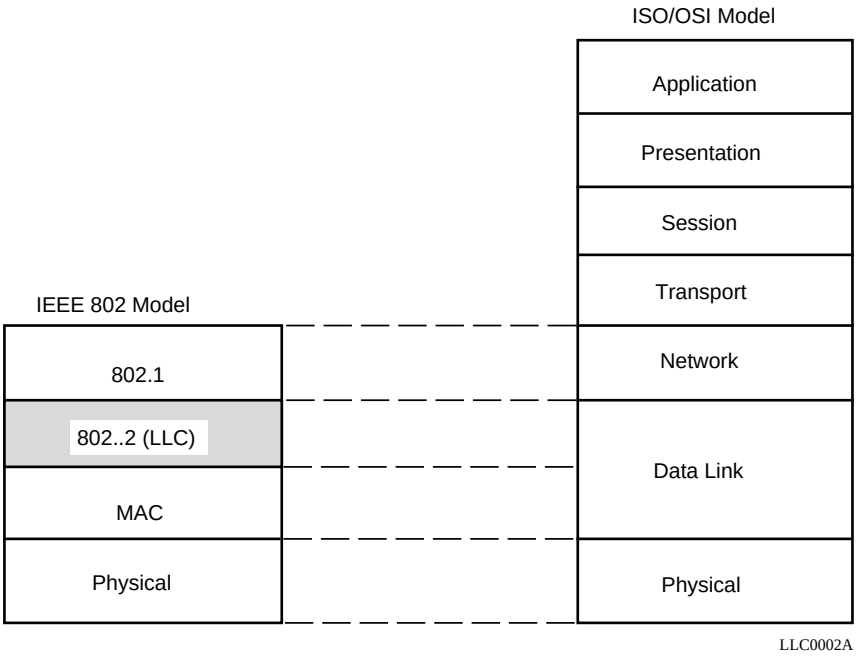


**Figure 1-2. The LLC Sublayer in the IEEE 802.*x* and OSI Models**

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 (media access control [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:** Bay Networks 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).

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

## LLC2 (Connection-Oriented Service)

LLC2 secures a point-to-point virtual circuit connection between link service access points (LSAPs). The LLC2 protocol

- Responds to a request from a higher-level protocol to open a connection through the datalink layer
- Notifies a higher-level protocol that a connection through the datalink layer has been established successfully
- Enables a higher-level protocol to
  - -- Send or receive LSDUs over an established datalink-layer connection
  - -- Sequence LSDUs sent over a datalink-layer connection
  - -- Control the flow of LSDUs over a datalink-layer connection

The LLC2 service also

- 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 datalink layer rather than in higher layers, LLC2 performs frame sequencing, flow control, and error recovery services for the datalink 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 datalink 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 datalink-layer virtual circuit/connection prior to any exchange of data.
- The source and destination are peer LLCs in an asynchronous, balanced datalink 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 sublayer can support multiple logical links concurrently. The LLC protocols generate and interpret command packets or frames called protocol data units (PDUs), which Table 1-1 describes. The LLC sublayer

- Initiates and terminates control signal interchange with the XID, TEST, SABME, and DISC PDUs.
- Organizes data flow with the U, I, and UA PDUs. The level of organization differs between Type 1 and Type 2 operations.
- Interprets command PDUs it receives, and generates appropriate response PDUs, which differ between Type 1 and Type 2 operations and 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*:

- 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.

**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) |

*(continued)*

**Table 1-1. LLC Command PDUs** *(continued)*

| Operation Type | Command | Response |
|---|---|---|
| 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) |

# LLC Protocol Data Unit Formats

The LLC protocol data unit (PDU) contains fields for addressing, control, and data, as shown in Figure 1-3. This section provides additional information on 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.

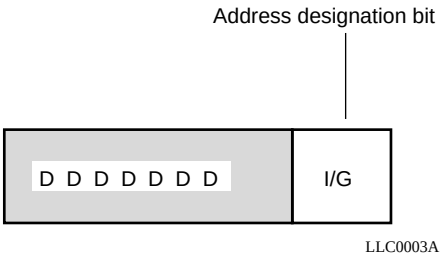


**Figure 1-4. DSAP Address Field**

- 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.

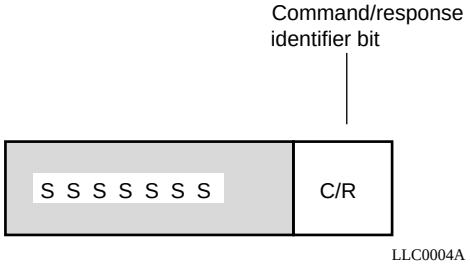


**Figure 1-5. SSAP Address Field**

- 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 of the 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 denotes all other published and unpublished SAPs.

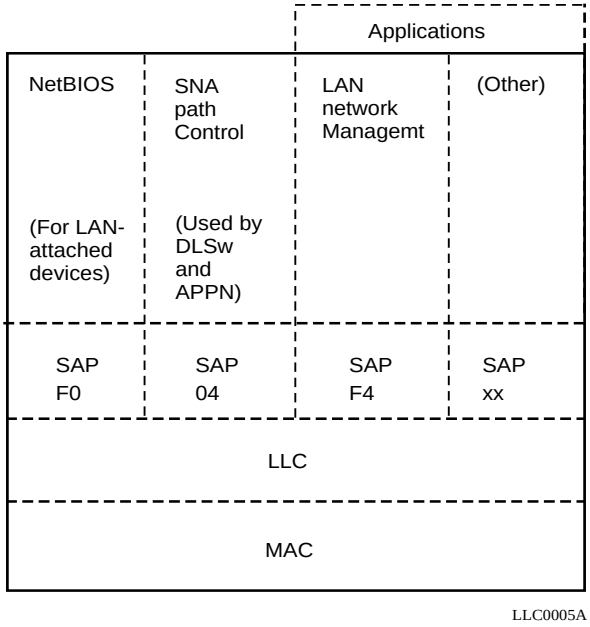


**Figure 1-6. SAPs for LLC Clients**

SAP addresses can be

- *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 the network layer or any SAP 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.

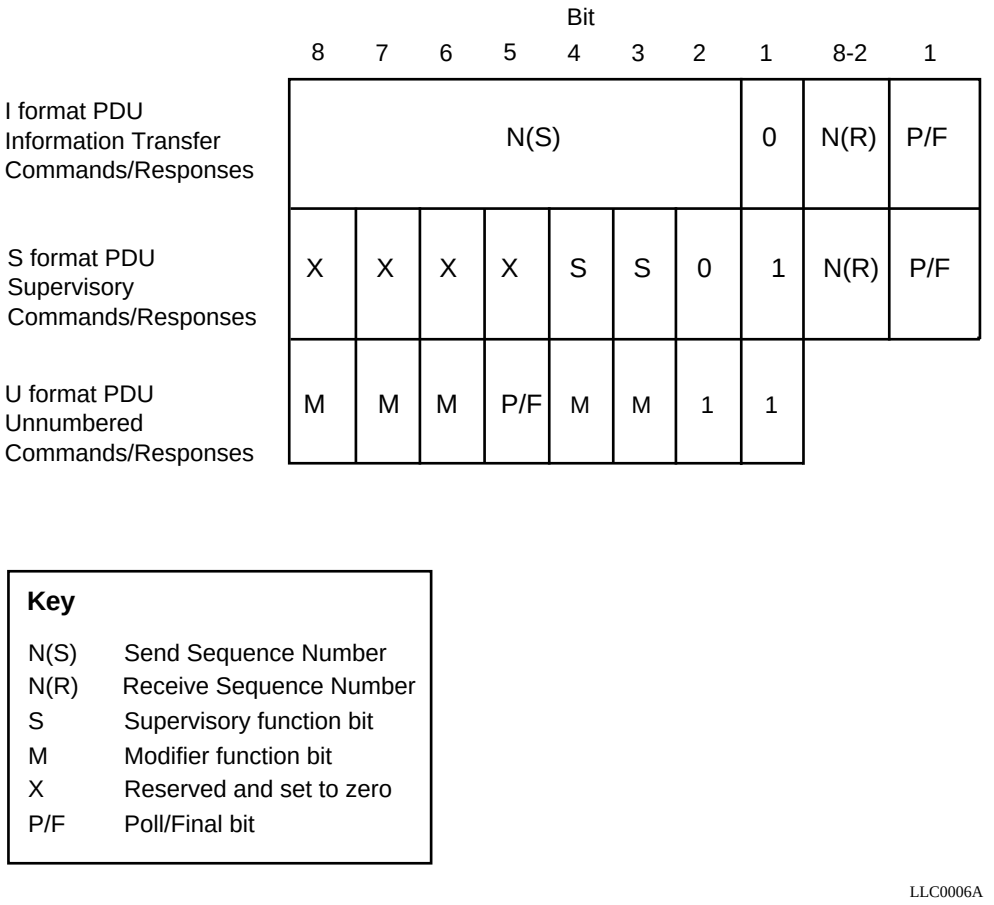


**Figure 1-7. LLC PDU Control Field Format**

## 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. (Refer to "Information Field" later in this chapter for more details.) |
| Supervisory Format (S) | The S format PDU performs datalink supervisory control functions in Type 2 operation, such as acknowledging I format PDUs, requesting retransmission of I format PDUs, and requesting a temporary suspension of transmission of I format PDUs. |
| Unnumbered Format (U) | The U format PDU is available for Type 1 or Type 2 operations, and provides additional datalink 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 datalink 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 Names and Definitions**

| Command/ Response | Control Field Value | Definition |
|---|---|---|
| Unnumbered Information (UI) | 0x13 or 0x03 | Transports information to one or more LLCs. Since this is a Type 1 operation, there is no corresponding response/reply PDU. |
| Exchange Identification (XID) | 0xBF or 0xAF | The XID command PDU conveys to the destination LLC:<br>• The types of LLC services the source LLC supports<br>• The receive window size the source LLC supports per datalink connection (per virtual circuit)<br>The XID response PDU identifies the responding LLC and conveys to the source LLC:<br>• The types of LLC services the destination LLC supports<br>• The receive window size the destination LLC supports per datalink 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.<br>The TEST response PDU confirms the establishment of an LLC1 link. |
| Information (I) | 6xxx0 or xx even | The I command PDU indicates to the destination LLC:<br>• The sequence number for each I command PDU<br>• The I PDU sequence number the destination LLC expects next<br>The I command PDU also serves as an I response PDU by indicating to the destination LLC that the source LLC has received I PDUs up to a designated number from that destination LLC. |

*(continued)*

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

| Command/ Response | Control Field Value | Definition |
|---|---|---|
| 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.<br><br>If the destination LLC receives from its network layer a DataLink Connect request, the destination LLC responds to the SABME PDU with a UA PDU. If the destination LLC receives from its network layer a DataLink Disconnect request, it does not send a UA PDU. |
| 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 datalink connection, and the destination LLC should assume the Disconnected Mode.<br><br>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. |

*(continued)*

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

| Command/ Response | Control Field Value | Definition |
|---|---|---|
| Unnumbered Acknowledg-ment (UA) | 73 or 63 | The UA response PDU acknowledges the receipt and acceptance of a SABME or DISC command PDU relating to a specific datalink connection to be opened or closed, as appropriate for the type of command PDU it has received. |
| Disconnected Mode (DM) | 1F or 0F | The DM response PDU indicates that the LLC sending the response is logically disconnected from the datalink 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.<br><br>The LLC receiving the FRMR PDU<br>• Initiates the appropriate mode setting<br>• Initiates corrective action by reinitializing transmission in both directions on the datalink connection, using the SABME and DISC command PDUs, as appropriate |

## Information Field

The contents of the Information field depend on the type of PDU in which it appears, 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. (The contents of the Information field of an FRMR PDU is beyond the scope of this publication. For more details on the FRMR PDU, refer to the *ISO 8802/IEEE Std 802.2 1989*.)

## For More Information about Logical Link Control

The following publications give technical details on 802.2/Logical Link Control, Token Ring LANs, DLSw, APPN, IBM LAN Network Manager, and LNM Servers:


- Institute of Electrical and Electronics Engineers. *International Standard ISO 8802-2/ANSI/IEEE Std 802.2 1989. Information Processing Systems, Local Area Networks, Part 2: Logical Link Control.* Washington, D.C., 1989.
- IBM Corporation, SC30-3374-02. *IBM Token Ring Network Architecture Reference.* 3rd ed. September 1989.
- IBM Corporation, 31G6962. *IBM LAN Network Manager User's Guide*.
- Perlman, Radia. *Interconnections: Bridges and Routers*. Reading, Massachusetts: Addison-Wesley Publishing Company, 1992.

# Chapter 2
# LLC2 Routed over Frame Relay

LLC2 (connection-oriented service) in a Bay Networks router supports Frame Relay with both Data Link Switching (DLSw) and Advanced Peer-to-Peer Networking (APPN), based on RFC 1490.

## 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 Bay Networks router implementation of LLC exceeds RFC 1490 (SNA encapsulation in Frame Relay only) by complying with the Frame Relay Forum's "Protocol Encapsulation over Frame Relay Implementation Agreements." 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 Bay 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 Higher

LLC2 routed over Frame Relay is fully compatible with IBM NCP 7.1 and higher, 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 save the expense of leased lines. Additional savings accrue because one port on a communications controller can support hundreds of data link connection identifiers (DLCIs).

Bay Networks interoperates with NCP 7.1 and higher 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. LLC can also route SDLC and Ethernet traffic, in addition to APPN, Token Ring, and IP traffic.

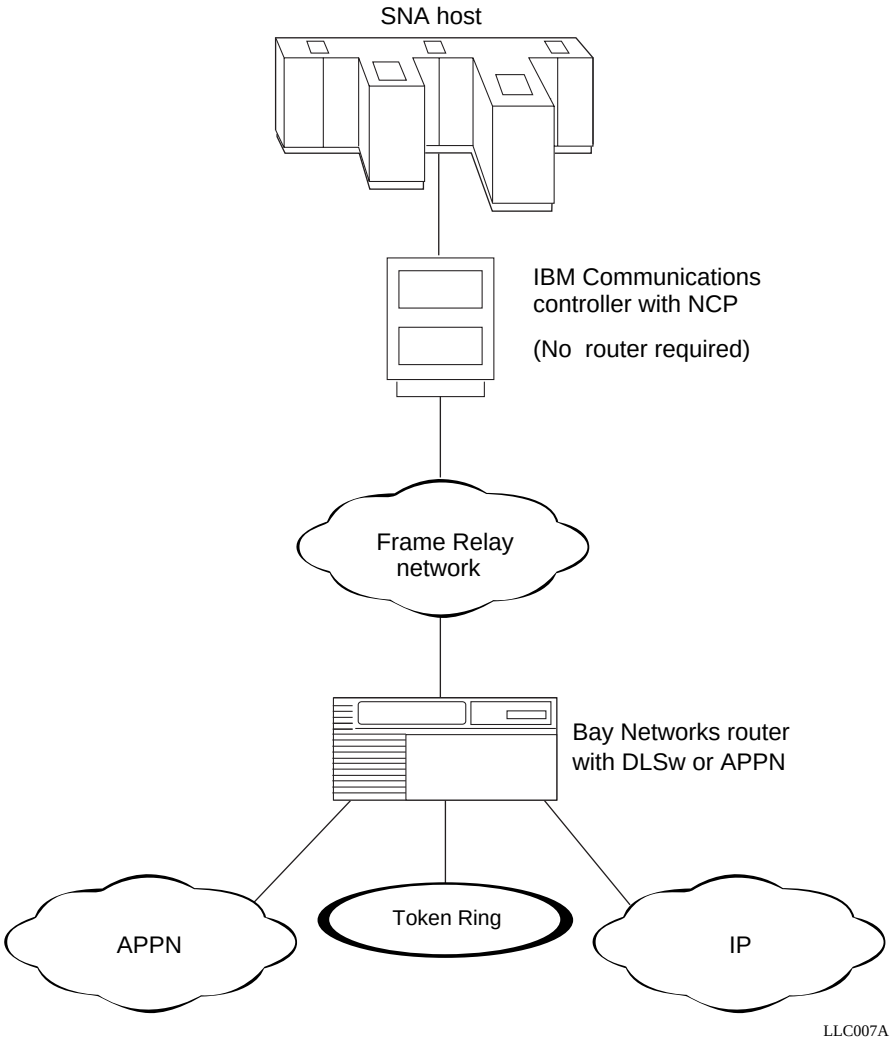


**Figure 2-1. Sample Frame Relay Network Using LLC2**

## FRAD-like Functionality

Token Ring, Ethernet, and SDLC endstations communicate with a Frame Relay attached host via Frame Relay Access Devices (FRADs). The Bay Networks router with DLSw operating in single-switch mode has FRAD-like capability, supporting Token Ring, Ethernet, and SDLC endstations. The router performs the following actions:

- Terminates the Data Link Control level sessions
- Strips the link-level header off the SNA packet
- Puts an RFC1490 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 form the basis for connections between 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 endstation’s physical or locally configured MAC address. In this case, be aware that if you change your hardware or endstation configuration, you have to reconfigure the DLCI mapping table.

When the router receives an LLC frame from the DLSw network with a dmac not starting 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 have to define DLCIs.

Usually you configure only the remote MAC 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 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 for 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 to Frame Relay

Figure 2-1 illustrates a sample virtual MAC address to Frame Relay DLCI mapping. In this illustration, the PC makes connection requests to Host 1 and Host 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 of the PC MAC and a destination MAC address of Remote Host 1 or 2.

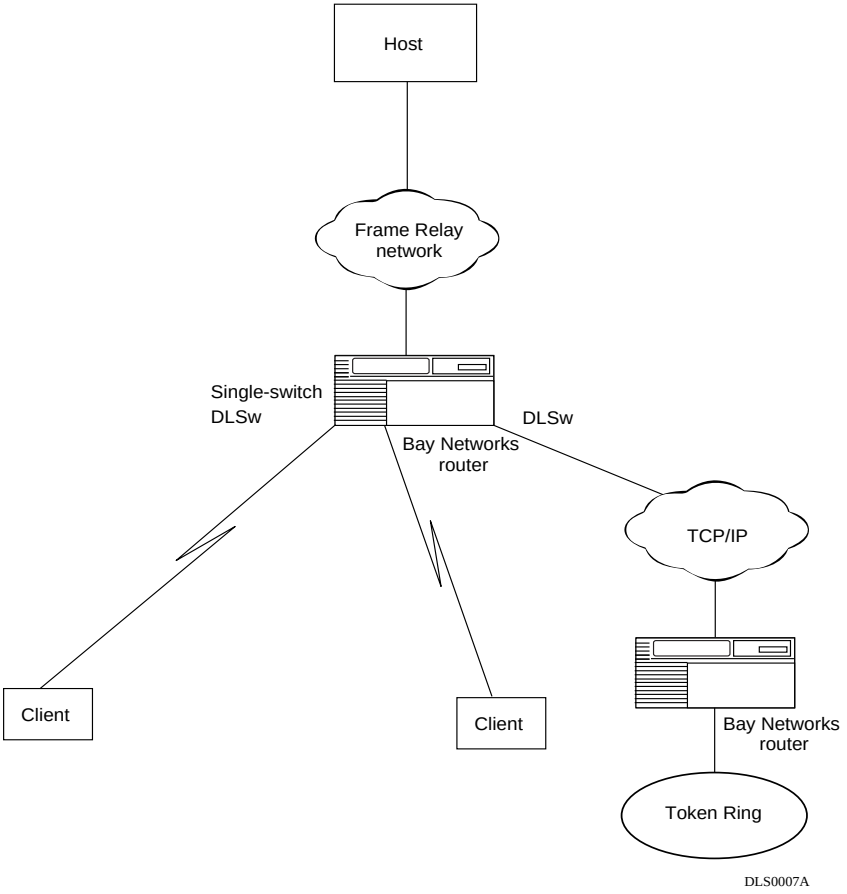


**Table 2-1. Virtual MAC to Frame Relay Topology**

## Frame Relay to Virtual MAC

Figure 2-2 illustrates a sample Frame Relay DLCI to virtual MAC address mapping. In this network, Host 1 and Host 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 Host 1 and Host 2 DLCIs 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 Host 1 and Host 2 DLCIs. 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 if there is a remote MAC address configured in the mapping table.

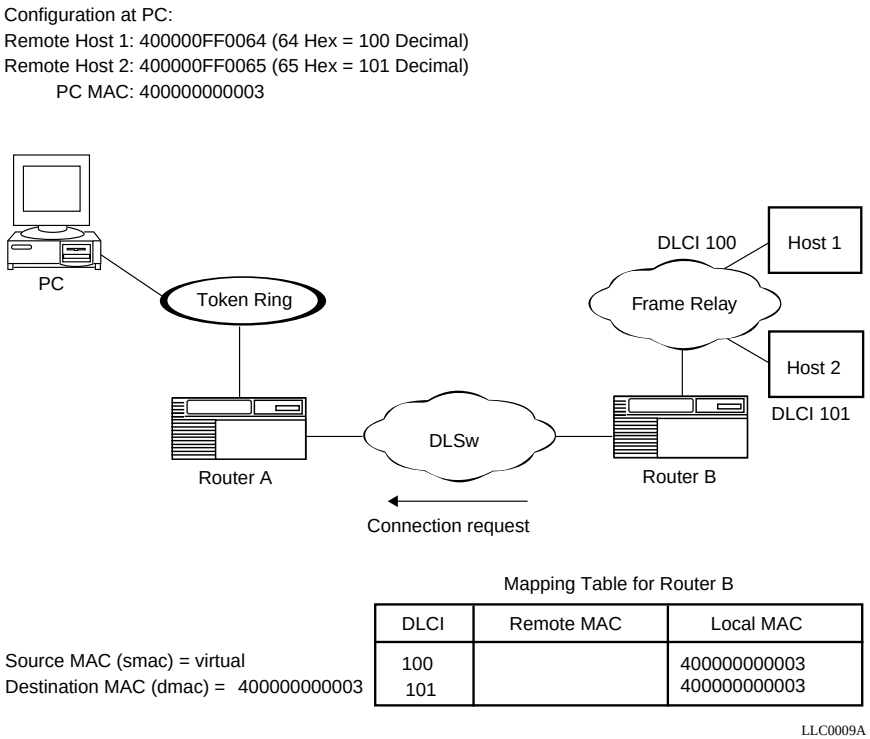


**Figure 2-2. Frame Relay to Virtual MAC Topology**

## Physical MAC to Frame Relay

Figure 2-3 illustrates a sample physical MAC address to Frame Relay DLCI mapping. In this network, the PC makes connection requests to Host 1 and Host 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 Host 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.

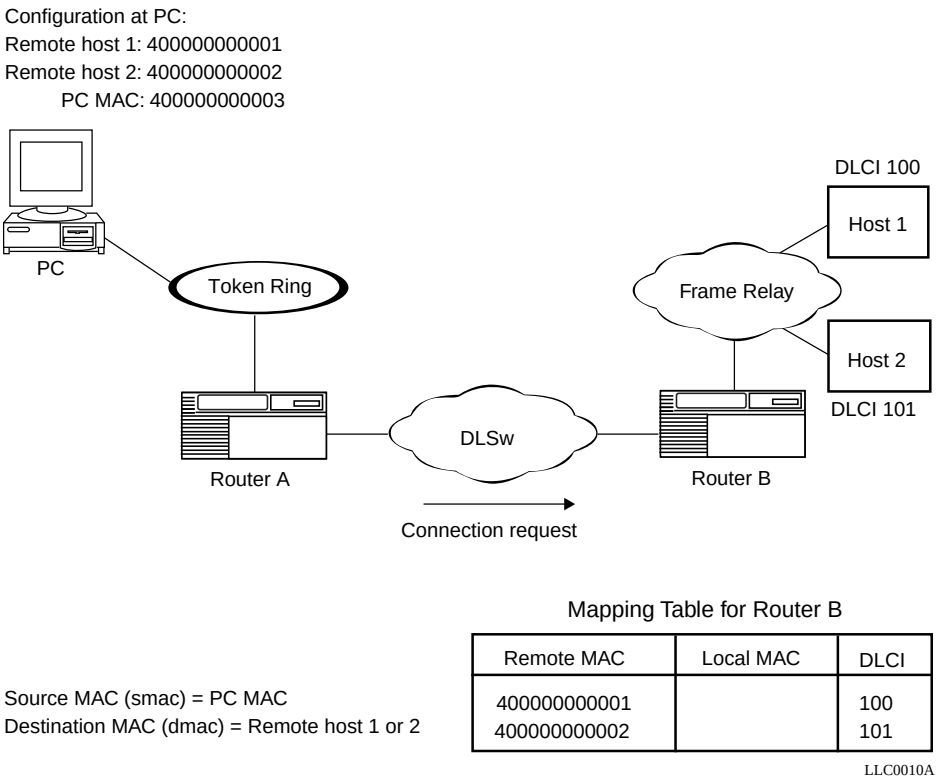


**Figure 2-3. Physical MAC to Frame Relay Topology**

## Frame Relay to Physical MAC

Figure 2-4 illustrates a sample Frame Relay DLCI to Physical MAC mapping. In this network, Host 1 and Host 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 Host 1 and Host 2 DLCIs 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 Host 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 if there is a remote MAC address configured in the mapping table.

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

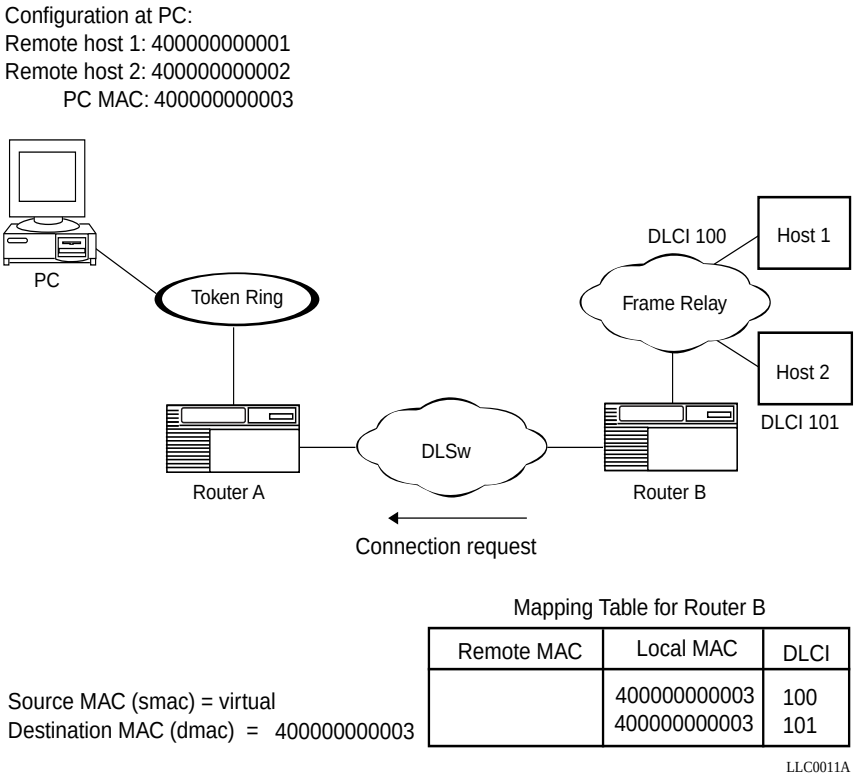


**Figure 2-4. Frame Relay to Physical MAC Topology**

## Frame Relay to Frame Relay

Figure 2-5 illustrates a sample Frame Relay DLCI-to-Frame Relay DLCI mapping. In this network, the PC makes connection requests to both Host 1 and Host 2. The workstation administrator has configured the PC with Remote Host 1 and Remote Host 2 equal to the assigned DLCIs. Router A requires a mapping table to map Remote Host 1 and 2 DLCIs to a virtual MAC address corresponding to Host 1 or Host 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.

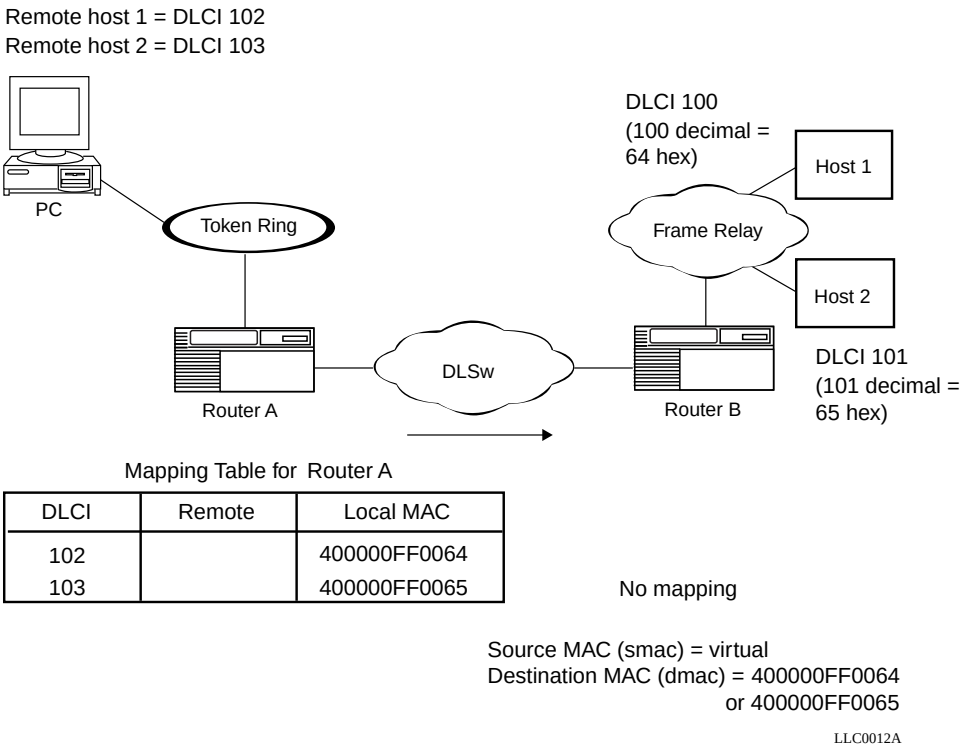


**Figure 2-5. Frame Relay-to-Frame Relay Topology**

# LLC2 over Frame Relay: Routed versus Bridged

Figure 2-6 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 is passed through bridging but terminated at the router for more flexible routing.

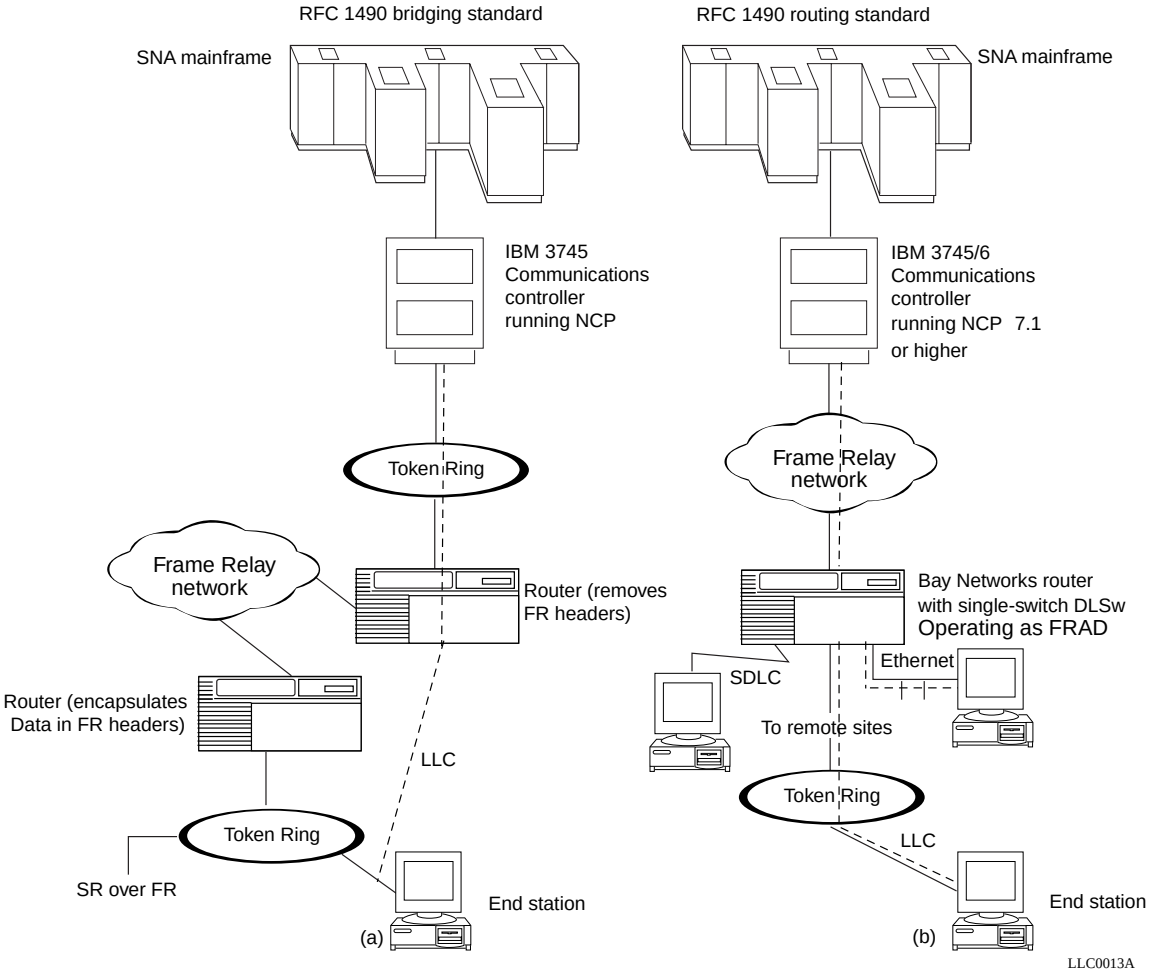


**Figure 2-6. RFC 1490 Bridging and Routing Standards for SNA**

# For More Information about LLC2 over Frame Relay

The following publications give technical detail on LLC2 over Frame Relay.

Bradley, Terry; Brown, Caralyn; and Malis, Andrew G. “Multiprotocol Interconnect over Frame Relay,” RFC 1490, Wellfleet Communications and Ascom Timplex, Inc., July 1993.

Rao Cherukuri, ed. “Multiprotocol Encapsulation Implementation Agreement,” FRF.3, Frame Relay Forum.

# Chapter 3
# Enabling LLC Services

This chapter describes how to enable LLC services. It assumes that you have read *Configuring and Managing Routers with Site Manager* and that you have completed the following steps:

1. Opened a configuration file
2. Specified router hardware if this is a local mode configuration file
3. Selected the connector on which you are enabling LLC

When you enable LLC over Frame Relay with APPN and DLSw networks, you must specify the Frame Relay mapping parameters yourself, while the Configuration Manager sets default values for all the rest. If you want to modify LLC parameters, refer to Chapter 4. See Appendix A for a quick reference to the default LLC parameter settings.

## Using the Parameter Descriptions

Each LLC parameter description provides information about default settings, valid parameter options, the parameter function, instructions for setting the parameter, and the 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, refer to *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.

## Enabling LLC2 on an Interface

To enable LLC2 on an interface, select LLC2 from the Select Protocols window (Figure 3-1).


**Figure 3-1. Select Protocols Window (LLC only)**

This menu appears after you select a link or network module connector to which you are configuring LLC2. For other than Frame Relay configurations, you need not specify any additional configuration information. The system software provides default LLC2 services. To change the operating parameters of the default service, refer to Chapter 4.

# Enabling LLC2 Services over Native Frame Relay

If you are configuring and enabling Frame Relay on LLC2 media, Configuration Manager displays a set of screens that allow you to start LLC2 and related services such as APPN and DLSw. Perform the following steps.

1. **Select Frame Relay from the WAN Protocols menu (Figure 3-2).**
2. **Click on OK.**


**Figure 3-2. WAN Protocols Window (Frame Relay)**

The Select Protocols window appears (Figure 3-3).


**Figure 3-3. Select Protocols Window**

## For APPN Networks

1. **Select APPN from the Select Protocols window.**

   The Configuration Manager automatically selects LLC2 as well.

2. **Click on OK.**

   The Source Route Encapsulation dialog box appears (Figure 3-4).

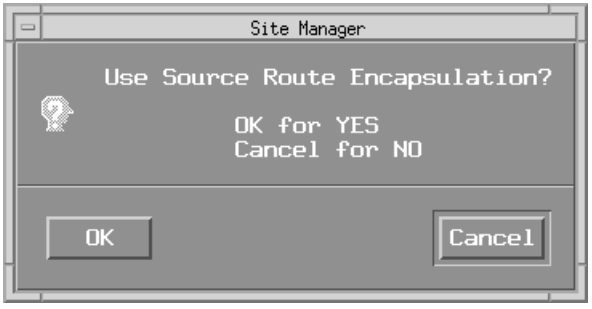


**Figure 3-4. Source Route Encapsulation Dialog Box**

3. **Select Cancel.**

   This selects native (routed) Frame Relay for LLC2.

4. **In the APPN Local Node Name Configuration window, specify the APPN Local Node Name parameter and click on OK.**

5. **When the APPN /FR Configuration window appears, specify the DLCI and SAP parameters and click on OK.**

   Refer to *Configuring APPN Services* for information.

## For DLSw Networks

1. **Select DLSw from the Select Protocols window.**

2. **Specify the IP Virtual Ring parameter in the DLSw Global Parameters window. Click on OK.**

   Refer to *Configuring DLSw Services* for information.

3. **In the Source Route Encapsulation dialog box (Figure 3-4), click on Cancel.**

   The LLC2 Frame Relay Mappings window appears (Figure 3-5).

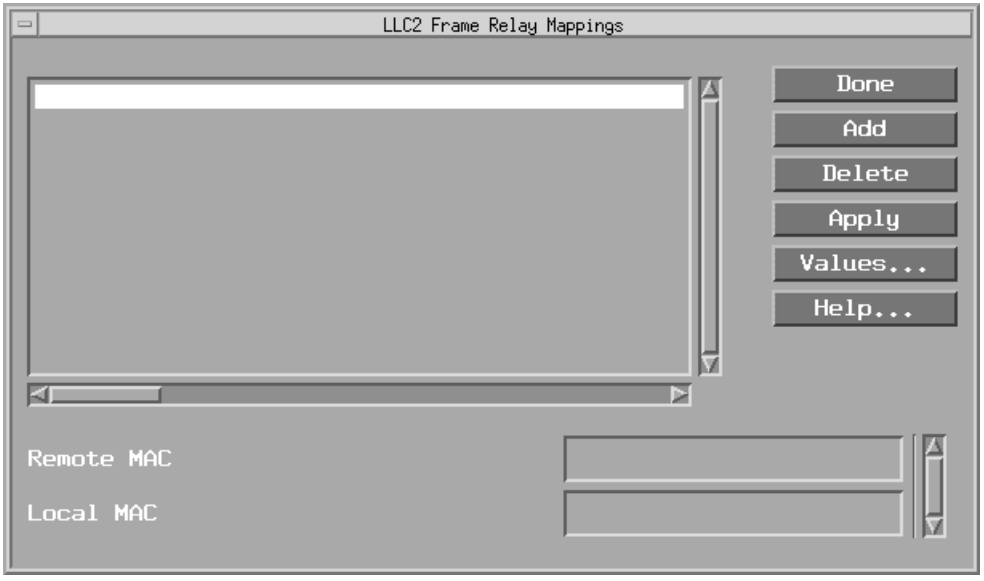


**Figure 3-5. LLC2 Frame Relay Mappings Window**

4. **Select Add.**

   The LLC2 Frame Relay Mapping Add window appears (Figure 3-6).

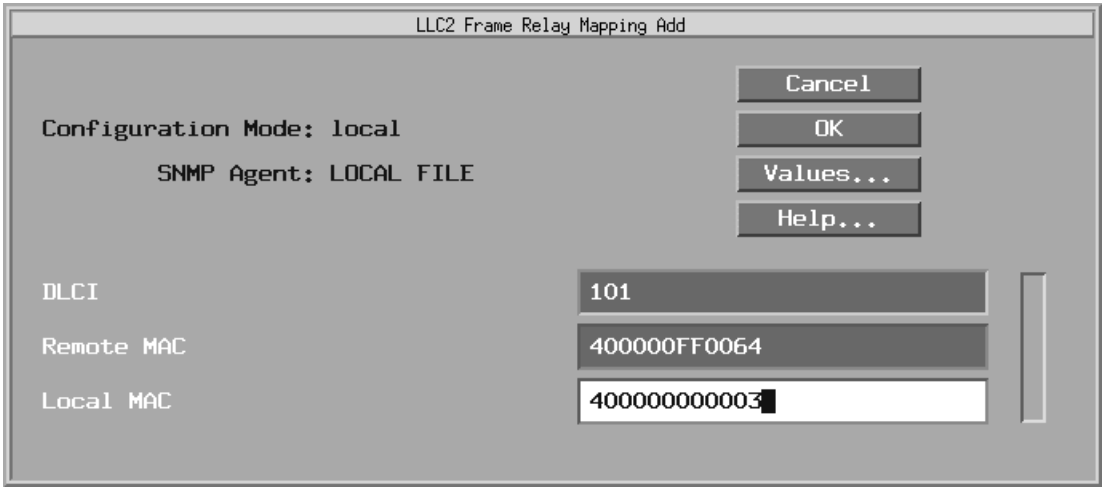


**Figure 3-6. LLC2 Frame Relay Mapping Add Window**

**5. Specify the DLCI, Remote MAC, and Local MAC parameters, as follows:**

| | |
|---|---|
| **Parameter:** | **DLCI** |
| Default: | None |
| Options: | Standard Data Link Connection Identifier numbers |
| 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** |
| 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** |
| Default: | None |
| Options: | Standard MSB Token Ring MAC addresses |
| Function: | This parameter 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 |

6. **Click on OK.**

   The Configuration Manager returns to the LLC2 Frame Relay Mappings window showing the added circuit (Figure 3-7).

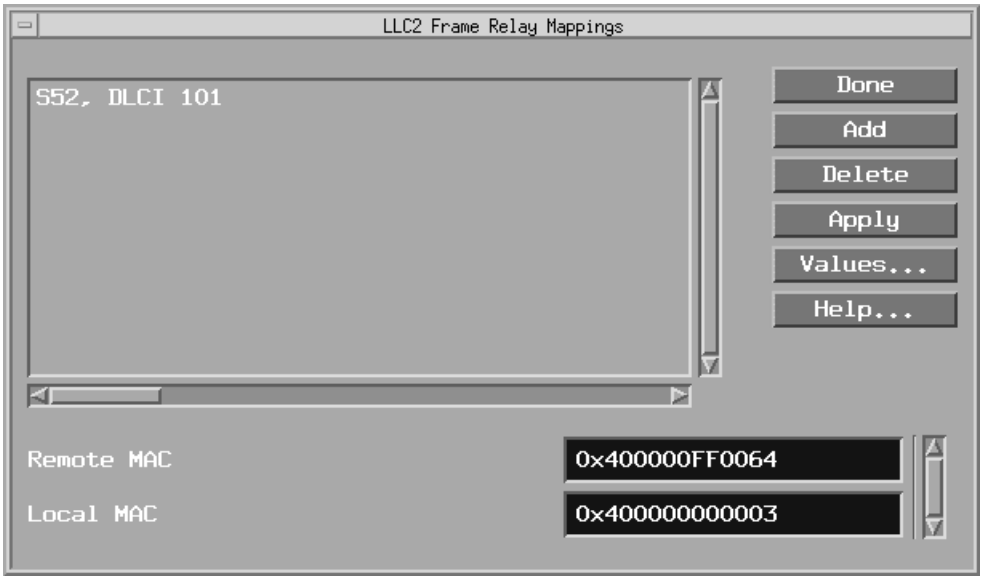


**Figure 3-7. LLC2 Frame Relay Mappings Window with DLCI Added**

7. **Select Apply.**

   Repeat Steps 4 through 6 for additional mappings. If you are finished, select Done. You return to the series of layered windows.

8. **Fill in any subsequent DLSw layered windows.**

   Refer to *Configuring DLSw Services* for information.

# Chapter 4
# Editing LLC Parameters

You can edit the parameters for the LLC interfaces that you configure on the router.

**Note:** To edit LLC parameters, you must first configure at least one LLC interface on the router. To configure an LLC interface, or to add additional LLC interfaces, see *Configuring and Managing Routers with Site Manager.*

You can configure only one LLC2 interface per physical circuit with native mode and source-route bridging; with routed Frame Relay, you can add more, depending on your system's resources.

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.

# Configuring LLC Parameters

To access and edit LLC parameters, begin at the Configuration Manager window (Figure 4-1) and select the Protocols > LLC2 menu path.

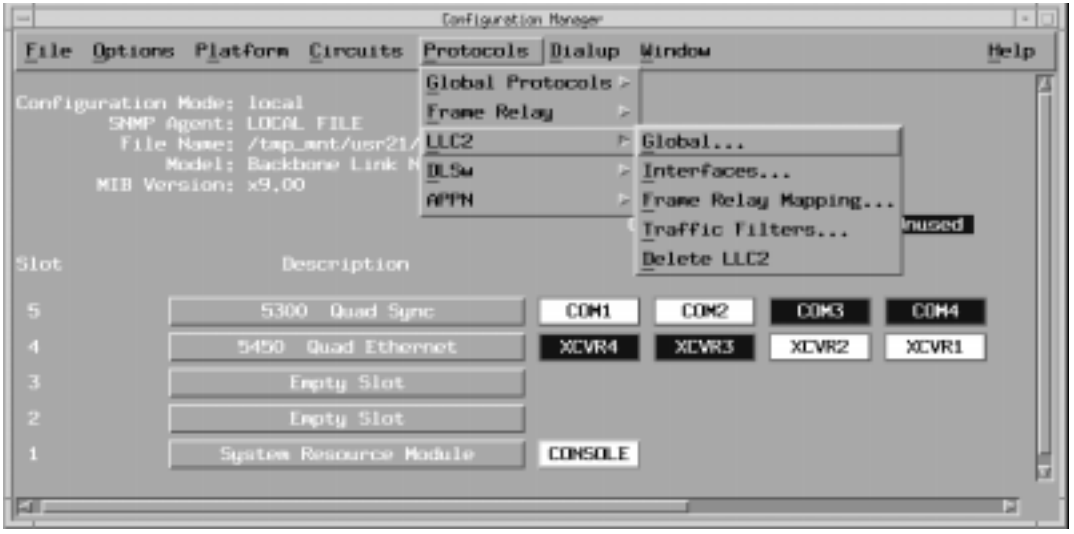


**Figure 4-1. Configuration Manager Window**

Alternatively, you can access LLC parameter windows by highlighting a circuit in the Configuration Manager window, and then selecting Edit Circuit to invoke the Circuit Definition window. This window is described in *Configuring and Managing Routers with Site Manager.* Use the LLC Circuit menu to access LLC parameters.

You can select either LLC1 Circuit or LLC2 Circuit from either menu. If you select LLC1 from the menu, the screen displays a list of interfaces that use LLC1 only (such as Source Routing Bridge). If you select LLC2, the screen displays a list of interfaces that require the services of LLC2 (such as APPN, DLSw, and the LNM Servers).

# Editing LLC2 Global Parameters

Only the Enable parameter is visible at the global (router) level for LLC. To change the setting of the Enable parameter, begin at the Configuration Manager window (Figure 4-1) and proceed as follows:

1. **Select Protocols > LLC2 > Global.**

   The Edit LLC2 Global Parameters window appears (Figure 4-2).

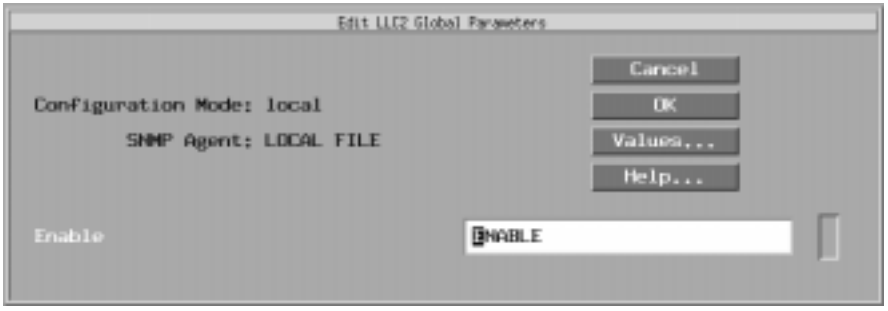


**Figure 4-2. Edit LLC2 Global Parameters Window**

2. **Change the Enable parameter to Disable if necessary.**

   (Refer to the description of the Enable parameter, which follows this procedure.)

3. **Click on OK to save your change and exit the Edit LLC2 Global Parameters window.**

| | |
|---|---|
| **Parameter:** | **Enable** |
| 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 any 802.*x* LAN physical circuit. You can configure only one LLC2 interface per physical LAN circuit. Other significant actions the system software performs when you choose a setting for the LLC Enable parameter include<br><br>*Disable* -- Forces every LLC2 interface on this node into the inoperative (down) state.<br><br>*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.<br><br>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 |

# Editing LLC2 Interface Parameters

Use the Configuration Manager to access and customize LLC2 interface parameters for specific clients such as DLSw and LAN Network Manager. These and other LLC2 clients may 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.

To access and edit LLC2 interface parameters, begin at the Configuration Manager window and proceed as follows:

1. **Select Protocols > LLC2 > Interfaces.**

   The LLC2 Interface Configuration window appears (Figure 4-3).

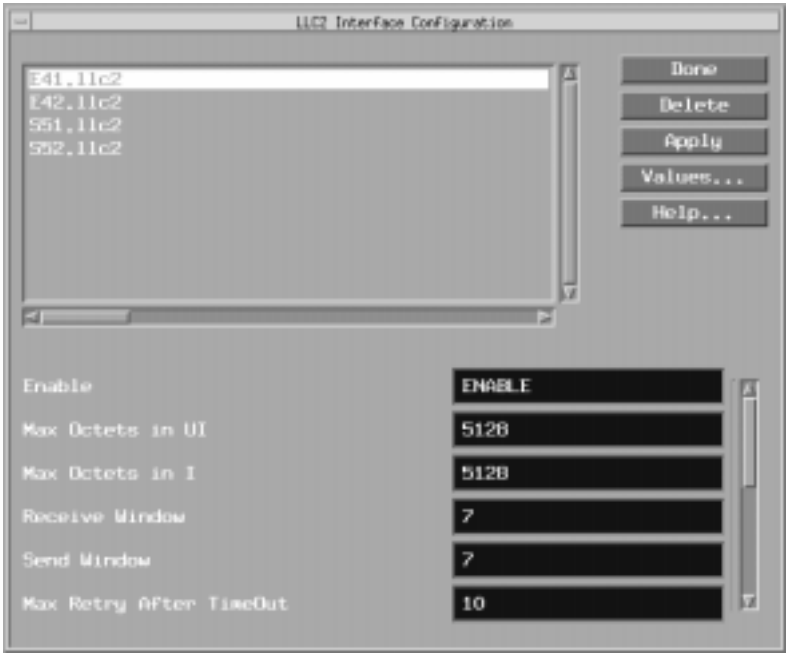


**Figure 4-3. LLC2 Interface Configuration Window**

Use the scroll bar on the lower right of your screen to view more parameters, including Frame Relay Virtual MAC Address Mask (Figure 4-4):


**Figure 4-4. LLC2 Interface Configuration Window (Bottom)**

The LLC2 Interface Configuration window contains the following information fields:

- The upper-left quarter contains a window that lists all LLC2 interfaces configured on physical circuits belonging to this node. This list does not appear in the Edit LLC2 Interface window.
- The lower-left quarter lists parameters you can alter to suit your network configuration requirements.
- The lower-right quarter shows the current interface parameter values.

2. **Select or highlight the interface you want to customize.**

   The values in effect for that interface appear (lower right) in the parameter value windows. (Click on Values to display the valid range of values for any parameter.)

3. **Edit those parameters you want to change.**

   Use the descriptions following this procedure as a guide.

4. **Click on Apply to save your changes.**

5. **Click on Done to exit.**

   You return to the original window.

**Note:** Alternatively, from the Circuit Definition window, select Protocols or Group Protocols > Edit LLC2 > Interface to display the Edit LLC2 Interface window. This window has the same parameters as the LLC Interface Configuration window. The Edit LLC2 Interface window shows only the circuit you have highlighted from the Circuit Definition window. Refer to *Configuring and Managing Routers with Site Manager* for information on editing circuits.

The LLC2 Interface Configuration window and Edit LLC2 Interface window include the following entries:

| | |
|---|---|
| **Parameter:** | **Enable** |
| Default: | Enable |
| Options: | Enable \| Disable |
| Function: | Enables or disables the LLC2 interface added previously to this LAN physical circuit. |
| Instructions: | Select Enable if you disabled this LLC2 interface previously and now want to re-enable the interface on its associated LAN physical circuit.<br><br>Select Disable if you want to disable this LLC2 interface on its associated LAN physical circuit. |
| MIB Object ID: | 1.3.6.1.4.1.18.3.5.1.6.2.1.2 |

| | |
|---|---|
| **Parameter:** | **Max Octets in UI** |
| Default: | 5128 (octets) |
| Range: | 1 to 5128 |
| Function: | Specifies, in octets, the maximum size of an Unnumbered Information (UI) PDU 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 LLC2 supports.<br><br>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** |
| Default: | 5128 (octets) |
| Range: | 1 to 5128 |
| Function: | Specifies, in octets, the size of an Information (I) PDU 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 LLC2 supports.<br><br>Refer to the various MAC descriptions to determine the precise value you should select 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** |
| Default: | 7 (PDUs) |
| Range: | 1 to 127 |
| Function: | Specifies a 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 to 127 LLC PDUs.<br><br>For sessions that do not negotiate XIDs (SNA PU 2.0 and NetBIOS) set the router Receive Window to the largest endstation'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 in the NCP is set to 127, you should set the router Receive Window to 127.<br><br>For sessions which negotiate XIDs (SNA PU 2.1), the Receive Window sets dynamically during connection establishment. The router uses the value specified here as an upper limit and negotiates down.<br><br>Choose a value that is appropriate for the applications LLC2 supports. |
| MIB Object ID: | 1.3.6.1.4.1.18.3.5.1.6.2.1.22 |

| | |
|---|---|
| **Parameter:** | **Send Window** |
| Default: | 7 (PDUs) |
| Range: | 1 to 127 |
| Function: | Specifies a 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. |
| Instructions: | Enter any valid value from 1 to 127 LLC PDUs.<br><br>For sessions that do not negotiate XIDs (SNA PU 2.0 and NetBIOS) set the router Send Window to the minimum endstation's receive window. If the Send Window is too large, endstations discard frames they receive outside their receive window. Timers recover these frames, and dropping these frames degrades performance.<br><br>For sessions that negotiate XIDs (SNA PU 2.1), the Send Window sets dynamically during connection establishment. The router uses the value specified here as an upper limit and negotiates down.<br><br>Choose a value that is appropriate for the requirements of the applications LLC2 supports. |
| MIB Object ID: | 1.3.6.1.4.1.18.3.5.1.6.2.1.23 |

| | |
|---|---|
| **Parameter:** | **Max Retry After TimeOut** |
| Default: | 10 (retransmissions) |
| Range: | 1 to 10 |
| Function: | Specifies the maximum number of times that a PDU can be sent following expiration of the Ack Timer for Xmt or the Reject timer. |
| Instructions: | Enter a valid value, from 1 to 10 retransmissions. Choose a value that is appropriate for the applications LLC2 supports. |
| MIB Object ID: | 1.3.6.1.4.1.18.3.5.1.6.2.1.7 |

| | |
|---|---|
| **Parameter:** | **Ack Timer for Xmt** |
| Default: | 1 s |
| Range: | 1 to 15 |
| Function: | Specifies the amount of time, in seconds, during which the local LLC expects to receive<br>- An acknowledgment for one or more outstanding I-PDUs sent during the timer window<br>- A response PDU for an unnumbered command PDU sent during the timer window<br>- A response PDU with the F bit set |
| Instructions: | Enter a valid value from 1 to 15.<br>The default value (1s) works with 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 endstation responds slowly to I-Frames.<br>Choose a value that is appropriate for the applications LLC2 supports. |
| MIB Object ID: | 1.3.6.1.4.1.18.3.5.1.6.2.1.13 |

| | |
|---|---|
| **Parameter:** | **Reject Timer** |
| Default: | 1 s |
| Range: | 1 to 30 |
| Function: | Specifies the amount of time, in seconds, during which the local LLC expects to receive a reply to a REJ PDU (Frame Reject response PDU).<br><br>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 to 30.<br><br>The default value (1s) works with 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 endstation responds slowly to I-Frames.<br><br>Choose a value that is appropriate for the applications LLC2 supports. |
| MIB Object ID: | 1.3.6.1.4.1.18.3.5.1.6.2.1.14 |

| | |
|---|---|
| **Parameter:** | **Busy Timer** |
| Default: | 60 s |
| Range: | 1 to 60 |
| Function: | Specifies the amount of time, in seconds, during which 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.)<br><br>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 again waits, either for the remote busy cleared indication or for expiration of the remote Busy timer interval. |
| Instructions: | Enter any valid value from 1 to 60. Choose a value that is appropriate for the applications LLC2 supports. |
| MIB Object ID: | 1.3.6.1.4.1.18.3.5.1.6.2.1.15 |

| | |
|---|---|
| **Parameter:** | **Inactivity Timer** |
| Default: | 30 s |
| Range: | 1 to 30 |
| Function: | Specifies the amount of time, in seconds, during which the local LLC expects to receive a PDU soliciting the status of the remote.<br><br>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. It initiates the Ack timer to handle retries. |
| Instructions: | Enter any valid value from 1 to 30.<br><br>This timer detects when an endstation no longer responds. The router uses the following formulas to recognize a non-responding LLC endstation:<br><br>*Inactivity Timer + (Ack Timer for Xmt * Max Retry After TimeOut)*<br><br>*Defaults: 30 + (1 * 10) = 40 seconds.*<br><br>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** |
| Default: | 255 (logical connections) |
| Range: | 4 to 5000 |
| Function: | Specifies the maximum number of logically independent, end-to-end connections the local LLC2 interface can allocate. |
| Instructions: | Enter any valid number of end-to-end connections, from 4 to 5000. Choose a value that is appropriate for the aggregate performance requirements of all applications 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** |
| Default: | 0x400000FF |
| Options: | Octal string |
| Function: | This mask 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** |
| Default: | None |
| Range: | 0x1 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 to 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 |

## Editing Frame Relay Mappings

To edit and delete Frame Relay mappings that you previously configured, start at the Configuration Manager window and

1. **Select Protocols > LLC2 > Frame Relay Mapping.**

   The LLC Frame Relay Mappings window appears.

2. **Edit the Remote MAC and the Local MAC parameters.**

   Refer to Chapter 3 for information on editing the Remote MAC and the Local MAC parameters.

## Deleting an LLC2 Interface

To delete an LLC2 interface from its associated physical circuit, start at the LLC2 Interface Configuration window (Figure 4-3) and

1. **Select the LLC2 interface.**
2. **Click on Delete.**

The system software deletes the LLC2 entry you selected, and the entry disappears from the list of LLC2 interfaces in the window.

## Editing LLC2 Inbound Traffic Filters

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

## Deleting LLC2 from the Node

To delete LLC2, begin at the Configuration Manager window and complete the following steps:

1. **Select Protocols > LLC2 > Delete LLC2.**

   A confirmation window appears.

2. **Select OK.**

   The Configuration Manager window appears. LLC2 interfaces are no longer configured on the router.

# Appendix A
# LLC2 Default Settings

Tables A-1 and A-2 list the default settings for LLC2 parameters. Use the Configuration Manager to edit any of the Site Manager default settings listed here.

**Table A-1. LLC2 Global Parameters**

| Parameter | Default |
|---|---|
| Enable | Enable |

**Table A-2. LLC2 Interface Parameters**

| Parameter | Default |
|---|---|
| Enable | Enable |
| Max Octets in UI | 5128 octets |
| Max Octets in I | 5128 |
| Receive Window | 7 PDUs |
| Send Window | 7 PDUs |
| Max Retry After TimeOut | 10 retransmissions |
| Ack Timer for Xmt | 1 s |
| Reject Timer | 1 s |

*(continued)*

**Table A-2. LLC2 Interface Parameters** *(continued)*

| Parameter | Default |
|---|---|
| Busy Timer | 60 s |
| Inactivity Timer | 30 s |
| Max Links | 255 (logical connections) |
| Frame Relay Virtual MAC Address Mask | 0x400000FF |
| Virtual Ring Number | None |

# Index


## A

Ack Timer for Xmt parameter, 4-10
acronyms, xiii
address mapping, 2-4 to 2-11
address mask, 4-13
addresses, real and virtual, 2-4

## B

Boundary Access Node (BAN), 1-4
Boundary Network Node (BNN), 1-3
Busy Timer parameter, 4-11

## C

classes of service, 1-6 to 1-8
  connection oriented (class 2), 1-7 to 1-8
  connectionless (class 1), 1-7
command PDUs
  disconnect (DISC), 1-17
  exchange identification (XID), 1-16
  frame reject (FRMR), 1-18
  information (I), 1-16
  receiver not ready (RNR), 1-17
  receiver ready (RR), 1-17
  reject (REJ), 1-17
  set asynchronous balanced mode extended (SABME), 1-17
  test (TEST), 1-16
  unnumbered information (UI), 1-16
Configuration Manager window, 4-2
configuring parameters in PDU control field, 1-13 to 1-15
control field formats
  information (I), 1-13 to 1-15
  supervisory (S), 1-13 to 1-15
  unnumbered (U), 1-13 to 1-15
control field parameters
  poll/final bit, 1-14, 1-15
  receive sequence number bit, 1-14, 1-15
  send sequence number bit, 1-14, 1-15
conventions, text, xii

## D

defaults for LLC2 parameters, A-1
deleting LLC2
  from a single interface, 4-14
  from all interfaces, 4-14
DLCI choice, 3-7
DLCIs, mapping to MACs, 2-4 to 2-11
documentation, additional, 1-19, 2-13

## E

educational services, xv
Enable (global) parameter, 4-3 to 4-4
Enable (interface) parameter, 4-7
enabling LLC services, 3-1
enabling LLC2 services, 3-2

## F

FRAD (frame relay access device)
  use of in LLC2, 2-1, 2-4
Frame Relay, 1-3 to 1-5
Frame Relay Mappings window, 3-6

Frame Relay to Frame Relay addressing, 2-10
Frame Relay to Physical MAC addressing, 2-9
Frame Relay to Virtual MAC addressing, 2-7
Frame Relay Virtual MAC Address parameter, 4-13

## I

IBM NCP compatibility, 2-1
Inactivity Timer parameter, 4-12
inbound traffic filters, editing, 4-14
information field formats, 1-18
interface parameters
  Ack Timer for Xmt, 4-10
  Busy Timer, 4-11
  Enable (interface), 4-7
  Frame Relay Virtual MAC Address, 4-13
  Inactivity Timer, 4-12
  Max Links, 4-12
  Max Octets in I, 4-8
  Max Octets in UI, 4-7
  Max Retry After Time Out (max number of transmissions), 4-9
  Receive Window, 4-8
  Reject Timer, 4-11
  Send Window, 4-9
  Virtual Ring Number, 4-13

## L

LLC parameters
  descriptions of, 3-1
LLC2 defaults, A-1
LLC2 Frame Relay Mappings window, 3-6
LLC2 Global Parameters window, 4-3
LLC2 Interface Configuration window, 4-4
Logical Link Control (LLC)
  and SNA protocols, 1-2
  classes of service in, 1-6 to 1-8
  functionality of, 1-9
  overview of, 1-1 to 1-19
  protocols requiring, 1-1
  types of operations in, 1-8 to 1-18

## M

MAC addresses, real and virtual, 2-4
mapping DLCIs to MAC addresses, 2-4 to 2-11
mask for frame relay MAC address, 4-13
Max Links parameter, 4-12
Max Octets in I parameter, 4-8
Max Octets in UI parameter, 4-7
Max Retry After Time Out parameter (max number of transmissions), 4-9

## N

NCP compatibility, 2-1

## O

operation types
  numbered, acknowledged (type 2), 1-8 to 1-18
  unnumbered, unacknowledged (type 1), 1-8 to 1-18
overview of LLC services supported, 1-1 to 1-19

## P

parameters
  Ack Timer for Xmt, 4-10
  Busy Timer, 4-11
  DLCI, 3-7
  editing, 4-1 to 4-13
  Enable (global), 4-4
  Enable (interface), 4-7
  Frame Relay Virtual MAC Address Mask, 4-13
  Inactivity Timer, 4-12
  Local MAC, 3-8
  Max Links, 4-12
  Max Octets in I, 4-8
  Max Octets in UI, 4-7
  Max Retry After Time Out (max number of transmissions), 4-9
  Receive Window, 4-8
  Reject Timer, 4-11
  Remote MAC, 3-8
  Send Window, 4-9
  Virtual Ring Number, 4-13

PDU formats
SAP addressing scheme for, 1-10 to 1-13
Physical MAC to Frame Relay addressing, 2-8
product support, xv
publications with additional information, 1-19, 2-13
publications, Bay Networks, xv

## R

Receive Window parameter, 4-8
Reject Timer parameter, 4-11
response PDUs
disconnected mode (DM), 1-18
exchange identification (XID), 1-16
information (I), 1-16
receiver ready, 1-17
test (TEST), 1-16
unnumbered acknowledged (UA), 1-18
RFC 1490, 2-1
RFC 1490 Frame Relay standard, 1-3
router
omitting with mainframe and DSPUs, 2-1
used as FRAD, 2-1, 2-4

## S

SAP addressing scheme
global, 1-13
group, 1-13
individual, 1-13
null, 1-13
source SAP (SSAP) field in, 1-12
Select (LAN) Protocols window, 3-3
Send Window parameter, 4-9
source SAP (SSAP) field, 1-12
support, Bay Networks, xv
supported media
Ethernet, 1-2
FDDI, 1-2
native Frame Relay, 1-2
source-route bridging, 1-2
synchronous, 1-2
Token Ring, 1-2

## T

technical publications, xv
technical support, xv
Technician Interface, 3-1
text conventions, xii
type 1 operation parameters
maximum octets (I PDU), 4-8
maximum octets (UI PDU), 4-7
type 2 operation parameters
Ack Timer for Xmt, 4-10
Busy Timer, 4-11
Inactivity Timer, 4-12
Max Links, 4-12
Max Octets (I PDU), 4-8
Receive Window, 4-8
Reject Timer, 4-11
Send Window, 4-9
types of operation
numbered, acknowledged (type 2), 1-8 to 1-18
unnumbered, unacknowledged (type 1), 1-8 to 1-18

## V

virtual MAC address mask, 4-13
Virtual MAC to Frame Relay mapping, 2-6
Virtual Ring Number parameter, 4-13