Software Product Description

PRODUCT NAME: Distributed Routing Software, Version 2.0 **SPD 54.96.04**

This SPD describes Version 2.0 of Distributed Routing Software, which provides multiprotocol routing and bridging. This software is implemented on the products listed in Table 1.

Table 1
Distributed Routing Software Version 2.0 Products

Product	Interfaces	Form Factor
RouteAbout Access EW	Ethernet, 2 T1/E1 Serial Lines	Standalone, MultiStack, or DEChub 90 Module
RouteAbout Access TW	Token Ring, 2 T1/E1 Serial Lines	Standalone or Half-Height DEChub 900 Module
RouteAbout Access EI	Ethernet, Basic Rate ISDN, T1/E1 Serial Line	Standalone, Multi-Stack, or DEChub 90 Module
RouteAbout Central EW	2 Ethernet, 8 T1/E1 Serial Lines	Standalone in DEChub ONE or Full-Height DEChub 900 Module
RouteAbout Central EI	2 Ethernet, 4 T1/E1 Serial Lines, 12 Basic Rate ISDN	Standalone in DEChub ONE or Full-Height DEChub 900 Module
DECswitch 900EE	6 Ethernet	Standalone in DEChub ONE or Full-Height DEChub 900 Module
DECswitch 900EF	6 Ethernet, FDDI	Standalone in DEChub ONE or Full-Height DEChub 900 Module

Information applies to all products with the interface being discussed unless otherwise specified. In this SPD, the term *Router* refers to an implementation of Distributed Routing Software.

DESCRIPTION

Overview

Distributed Routing Software is available in two packages. The IP package includes IP routing along with bridging and all WAN services except for X.25 Switching. The Multiprotocol package supports all of the above plus these protocols:

- Novell NetWare IPX
- AppleTalk
- DECnet Phase IV
- DECnet/OSI
- Data Link Switching (DLSw)
- SDLC Relay
- Boundary Access Node
- X.25 Switching

The Bridging function interconnects networks for protocols that are not routed by the Router, and for protocols that do not have a Network layer to support routing. The Router can route some protocols while concurrently bridging others. All models support Transparent bridging as defined in the IEEE 802.1d protocol. The RouteAbout Access TW also supports Adaptive Source Route Bridging, which combines Transparent and Source Route bridging, along with translational bridging between the two. The DECswitch 900EE and 900EF support port groups, where the DECswitch bridges a protocol within a port group while concurrently routing the protocol between port groups.

All of the RouteAbout models described in this SPD have at least one T1/EI serial interface. The serial interface supports the PPP, Proteon Serial Line, SDLC, X.25 LAPB, and Frame Relay data links. The X.25 and Frame Relay public network services are supported. V.25 *bis* is supported for dial backup and bandwidth on demand. The Bandwidth Reservation System allocates the WAN bandwidth to classes of traffic, prioritizes traffic within each class, and provides MAC filtering.

The RouteAbout Central EI has 12 Basic Rate ISDN interfaces for fanning in remote sites, and the RouteAbout Access EI has a single Basic Rate ISDN interface. This interface can serve as a backup for WAN restoral when the T1/E1 serial line fails, supporting multiprotocol bridging and routing. The B channels are available when additional bandwidth is needed to supplement a leased line or ISDN connection. The Basic Rate ISDN interface also supports dial on demand for TCP/IP and Novell IPX routing, as well as OSI static routing. Multilink PPP aggregates ISDN B channels and serial lines into higher bandwidth channels. IPX spoofing reduces the amount of acknowledgement traffic that traverses the WAN, and triggered RIP reduces the number of routing update messages.

Distributed Routing Software is factory installed in the flash memory of the Router. Updates and reloads can be performed from a load host using the BOOTP/TFTP protocol. Configuration and management are through the Router command line interface, either locally or remotely via Telnet. There is also a graphical Router Configurator tool for preparing configuration files. SNMP Gets and Traps are supported for monitoring, while Sets are available for enabling and disabling the Router interfaces. The Event Logging System (ELS) logs event and error messages for analysis of failures. The Digital Trace Facility (DTF) facilitates debugging network problems. Several graphical tools are available as part of the *clear*VISN product set, including MultiChassis Manager for DEChub 900 configuration and Router Manager for monitoring performance, tracing network paths, and generating reports.

TCP/IP Routing

Routing Protocols: Distributed Routing Software routes data in accordance with the TCP/IP standards. Routing table entries may be static, in which case they are configured by the user from the console, or they can be dynamically created by routing protocols. The Open Shortest Path First (OSPF), Routing Information Protocol (RIP), Border Gateway Protocol (BGP-4), Exterior Gateway Protocol (EGP), and Integrated Intermediate System to Intermediate System (IS-IS) protocols are supported.

Subnetting: Subnetting support is fully compliant with RFC 950. Any number of IP networks may be subnetted. When using OSPF or IS-IS, the Router supports variable length subnet masks as specified in RFC 1009. Subnet masks are specified on a per-subnet basis. When using RIP, subnet masks are specified on a per-network basis. In this case, a given IP network may have only one subnet mask.

Fragmentation: If the destination network does not support packets as large as those to be sent, the Router fragments the packets before transmission.

Access Control: The IP implementation supports selective packet filtering for security. Access control lists can be applied separately to each interface for either incoming or outgoing traffic. Packets can be filtered based on the source or destination address, IP protocol number, or TCP/UDP port number.

IP Header Compression: Distributed Routing Software supports IP header compression using the Van Jacobsen algorithm as defined in RFC 1144. The Router supports IP header compression over X.25, Frame Relay, and dialup serial lines. The compression algorithm is protocol dependent. IP header compression lowers the overhead associated with large TCP/IP headers as they traverse the WAN, and is especially effective on IP traffic consisting of small packets with only a few bytes of data.

ICMP: The ICMP implementation generates ICMP error and informational messages in the appropriate circumstances.

Triggered RIP: Distributed Routing Software supports triggered RIP as defined in the draft standard with several extensions. Triggered RIP reduces WAN traffic by sending routing table updates only when the network topology changes. In addition, the updates must be acknowledged by the remote routers. If the updates are not acknowledged, the sending router retransmits them.

Distributed Routing Software provides several extensions to the standard. The Router sends only new information to the neighbor router, which the neighbor router can apply immediately. A call sensitivity feature instructs the Router to hold "bad news" route changes if a dialup circuit is not connected. When the dialup circuit is connected, the Router forwards the stored route changes over the circuit. The Router also keeps a history of each route metric exchanged with the neighbor router on a dialup circuit. This extension prevents WAN transmission costs caused by route "bounces" by waiting for the network to stabilize before sending the routing table updates.

BGP-4: The Router supports the Border Gateway Protocol (BGP-4) as defined in RFC 1745 and 1771. The BGP-4 implementation is not downwardly compatible with the previous versions of BGP. BGP-4 is an exterior gateway routing protocol used to exchange network reachability information among autonomous systems. An autonomous system is analogous to a domain—a collection of routers and end nodes administered by an organization.

The Router operates as a BGP speaker, exchanging routing information with other BGP speakers within the same domain and other domains. It propagates routing information learned via BGP into the routing tables of other IGP protocols.

OSPF: The OSPF implementation allows multiple "best routes" to a destination network. Load balancing is supported. OSPF loopback detects loopback and makes the lines unavailable for traffic transmission. Access controls are supported. The OSPF Management Information Base is supported for SNMP monitoring.

MOSPF Multicast Routing: The IP implementation supports the routing of IP multicast datagrams, which are identified as packets whose destinations are class D IP addresses (where the first byte lies in the range 224–239 inclusive). A single multicast datagram may be delivered to multiple destinations, called a multicast group. Both peer-to-peer and client/server groups are supported. Multicast routing is achieved through Multicast Extensions to OSPF (MOSPF) using the point-to-multipoint interface type.

Distributed Routing Software includes several native multicast applications. The ICMP ping command in the IP console can use an IP multicast address. The software can also be configured to send SNMP traps to one or more IP multicast addresses.

Protocol Independent Multicast (PIM): Protocol Independent Multicast (PIM) is an IP multicast routing protocol, much like MOSPF and DVMRP. PIM extends the LAN multicast functionality to the Network layer, allowing a sender to send a single packet to multiple receivers. The protocol discovers the receivers, also known as group members, through the IGMP protocol and then builds a path between any sender and all the receivers in the group.

The Distributed Routing Software implementation supports both PIM Sparse-Mode (PIM-SM) and PIM Dense-Mode (PIM-DM) protocols. PIM Sparse-Mode is used in networks where the sources and receivers of multicast traffic are sparsely distributed. The members must explicitly join to participate in PIM.

PIM Dense-Mode is used in networks where the sources and receivers of multicast traffic are densely distributed through the network.

DVMRP Routing: Distributed Routing Software includes the *mrouted* routing daemon, allowing the Router to be used in the MBONE in addition to or instead of UNIX workstations. Also, support of the Distance Vector Multicast Routing Protocol (DVMRP) allows MOSPF domains to be substituted for collections of DVMRP tunnels, easing bandwidth demands.

The DVMRP/MOSPF implementation can be run in one of three modes, described below in order of increasing functionality. In Mode 1, the Router serves as a regular DVMRP router, like a UNIX workstation running the mrouted program.

In Mode 2, the Router connects an MOSPF domain to the MBONE via one or more encapsulated DVMRP tunnels. In this mode, the Router advertises selected MOSPF networks on the MBONE DVMRP network and advertises a subset of the DVMRP sources on the MOSPF networks as OSPF AS external LSAs. An MOSPF domain joined to the MBONE in this way receives the benefit of MOSPF's pruning, so that only those multicast datagrams with active group members are forwarded on the MOSPF domain.

In Mode 3, the Router serves as an MOSPF router, using an MOSPF domain as a "transit" network. In this mode, DVMRP runs over MOSPF, as if the entire MOSPF domain were a single LAN. This allows an MOSPF domain to replace a collection of DVMRP tunnels, decreasing multicast traffic.

ISDN Support: Dial on demand with an ISDN B channel as the primary circuit is supported for IP routing using triggered RIP. Each B channel can be routed to a separate destination. The B channels and serial lines can be aggregated to form a higher speed link to the same destination.

The Router can automatically establish an ISDN connection to the destination router when its serial line fails. Multiprotocol bridging and routing is supported in this WAN restoral mode.

X.25 Support: IP traffic is supported on X.25 networks using either the encapsulation and addressing procedures specified in RFC 877 and RFC 1356, or those specified in DDN Standard X.25.

Frame Relay Support: The Router supports routing of IP traffic over Frame Relay networks as specified in RFC 1490. The Router Frame Relay interface also supports IP traffic over PPP via an encapsulation technique. ARP correctly resolves MAC addresses, while Inverse ARP maps the MAC address to the IP address, as defined in RFC 1293.

IP Standards: The IP implementation is based on the following set of RFCs:

- RFC 768—User Datagram Protocol
- RFC 791—Internet Protocol
- RFC 792—Internet Control Message Protocol
- RFC 793—Transmission Control Protocol
- RFC 854—Telnet Protocol Specifications
- RFC 877—Transmission of IP Datagrams Over Public Data Networks
- RFC 888—"STUB" Exterior Gateway Protocol
- RFC 904—Exterior Gateway Protocol Formal Specifications
- RFC 919—Broadcasting Internet Datagrams
- RFC 922—Broadcasting Internet Datagrams in the Presence of Subnets
- RFC 925—Multi-LAN Address Resolution
- RFC 950—Internet Standard Subnetting Procedure
- RFC 951—Bootstrap Protocol
- RFC 1009—Requirements for Internet Gateways
- RFC 1058—Routing Information Protocol
- RFC 1112—Host Extensions for IP Multicasting
- RFC 1123—Requirements for Internet Hosts
- RFC 1144—Compressing TCP/IP Headers for Low Speed Serial Links
- RFC 1155—Structure and Identification of Management Information for TCP/IP-Based Internets
- RFC 1157—Simple Network Management Protocol (SNMP)
- RFC 1191—Path MTU Discovery
- RFC 1195—Use of OSI IS-IS for Routing in TCP/IP and Dual Environments
- RFC 1213—Management Information Base for Network Management of TCP/IP-Based Internets: MIB-II
- RFC 1247—OSPF Version 2
- RFC 1253—OSPF Version 2 Management Information Base
- RFC 1293—Inverse Address Resolution Protocol
- RFC 1340—Assigned Numbers
- RFC 1350—TFTP Protocol Version 2
- RFC 1356—Multiprotocol Interconnect on X.25 and ISDN in the Packet Mode (X.25 Support Only)
- RFC 1360—IAB Official Protocol Standards
- RFC 1395—Bootstrap Protocol (BOOTP)
- RFC 1490—Multiprotocol Interconnect Over Frame Relay Networks
- RFC 1573—Evolution of the Interfaces Group of MIB-II
- RFC 1745—BGP-4/IDRP for IP—OSPF Interaction
- RFC 1771—A Border Gateway Protocol 4 (BGP-4)

Novell NetWare Routing

The IPX implementation routes NetWare traffic in accordance with the Novell specifications for the IPX protocols. A Multiprotocol software license is required for Novell NetWare routing.

IPX RIP and SAP: IPX support includes full implementations of NetWare Routing Information Protocol (RIP) and Service Advertising Protocol (SAP). The Router keeps multiple equal cost routes to a given remote IPX network but selects a primary route that it uses exclusively when the route is available. Path splitting is not supported.

RIP and SAP Broadcast Timing: To conserve WAN bandwidth, the frequency of RIP and SAP periodic updates can be set to nonstandard values. IPX Type 20 Propagation is supported.

Filtering: Distributed Routing Software supports access controls, RIP filtering, SAP filtering, and GNS response suppression.

Novell Server Spoofing: Novell server spoofing is supported, where the router at the Novell server site responds to server KeepAlive messages on behalf of the remote clients. This spoofing eliminates a great deal of WAN traffic.

LAN Encapsulation: Distributed Routing Software supports all of the Novell sanctioned encapsulations for IPX (see below). The Router supports only one type of encapsulation at a time on each interface.

- ETHERNET_II
- ETHERNET_8022 (default as of NetWare V4.0)
- ETHERNET_8023 (IEEE 802.3 without 802.2)
- ETHERNET_SNAP (used for bridging)
- TOKEN-RING MSB/LSB (DSAP/SSAP)
- FDDI (8022 DSAP/SSAP)
- FDDI_SNAP

Serial Line Support: The IPXWAN Control Protocol supports use of PPP for native IPX traffic according to RFC 1634. The options are not supported. IPXCP is also implemented according to RFC 1552, but the options are not supported. IPX also runs over the Proteon Serial Line data link protocol.

IP Encapsulation over WAN Links: Novell IPX is supported over wide area links via IP encapsulation according to RFC 1234.

ISDN Support: Dial on demand is supported for Novell NetWare routing. Each B channel can be routed to a separate destination. The B channels and serial lines can be aggregated to form a higher speed link to the same destination.

The Router can automatically establish an ISDN connection to the destination router when its serial line fails. Multiprotocol bridging and routing is supported in this WAN restoral mode.

X.25 Support: Native IPX traffic is supported over X.25 in accordance with RFC 1356. The implementation uses the Call User Data (CUD) field for IPX.

Frame Relay Support: The Router supports routing of IPX traffic over Frame Relay networks as specified in RFC 1490. ARP correctly resolves MAC addresses, while Inverse ARP maps the MAC address to the IPX address, as defined in RFC 1293.

IPX Standards: The IPX implementation is based on the following specifications:

- IPX Router Specification
- Advanced NetWare V2.0 Internetwork Packet Exchange Protocol
- Advanced NetWare V2.0 Service Advertising Protocol
- NetWare Driver Specifications for Network Interface Cards
- Novell IPX Management Information Base
- Novell RIP-SAP Management Information Base
- RFC 1234—Tunneling IPX Traffic Through IP Networks
- RFC 1293—Inverse Address Resolution Protocol
- RFC 1356—Multiprotocol Interconnect on X.25 and ISDN in the Packet Mode (X.25 Support Only)
- RFC 1490—Multiprotocol Interconnect Over Frame Relay Networks
- RFC 1552—PPP Internetwork Packet Exchange Protocol (IPXCP)
- RFC 1634—Novell IPX Over Various WAN Media (IPXWAN)

AppleTalk Routing

Distributed Routing Software routes AppleTalk traffic in accordance with the AppleTalk Phase 1 and Phase 2 protocols. These two protocols are implemented as two separate modules with their own configuration and console monitors. The phases have different encapsulations for each network, which allows them to be run in parallel without conflict. A transition gateway provides connectivity between the two protocols for migration purposes. A Multiprotocol software license is required for AppleTalk routing.

Routing Table Maintenance Protocol: The Router maintains its AppleTalk routing tables using the Routing Table Maintenance Protocol (RTMP). The Phase 2 implementation of RTMP has two extensions. The propagation of bad entries is faster with a notify neighbor technique. A second technique, split horizon, is used to shrink the size of the RTMP route update. Split horizon can be disabled to support AppleTalk Phase 2 in partially meshed Frame Relay networks.

Zone Information Protocol: The Router maintains a Zone Information Table (ZIT) through its use of the Zone Information Protocol (ZIP). The ZIT consists of zone information associated with each network in the routing table. Phase 2 extends ZIP to allow zone lists for each network range along with a default zone name.

Name Binding Protocol: The Router participates in and facilitates the name binding process through the use of the Name Binding Protocol.

Network and Zone Filters: The AppleTalk Phase 2 implementation supports Network and Zonename filters for each interface. There are separate filter lists for incoming or outgoing information. The Router does not advertise filtered Zone information in the specified direction. Both inclusive (allowed Zone) and exclusive (blocked Zone) lists are supported.

Transition Gateway: The transition gateway provides connectivity between the AppleTalk Phase 1 and Phase 2, allowing Phase 1 AppleTalk nodes to connect to Phase 2 nodes.

EtherTalk Protocol: For AppleTalk Phase 1, the Router uses Apple's EtherTalk packet encapsulation for DDP packets transmitted on the Ethernet LAN. For Phase 2, it uses EtherTalk IEEE 802.3 encapsulation.

TokenTalk Protocol: For AppleTalk Phase 2, the Router uses Apple's TokenTalk encapsulation for DDP packets transmitted on 4 or 16 Mbps IEEE 802.5 Token Rings. Phase 1 AppleTalk is not supported on Token Ring.

Apple Address Resolution Protocol: The Apple Address Resolution Protocol (AARP), in conjunction with

EtherTalk and TokenTalk, maintains hardware to protocol address mappings.

Serial Line Support: The Router encapsulates Phase 1 and Phase 2 AppleTalk on Proteon Serial Line data links using a proprietary method. The PPP protocol is supported only for Phase 2. The AppleTalk Control Protocol used for PPP adheres to RFC 1378. The only option negotiated is the AppleTalk address; all other options are rejected.

IP Encapsulation over WAN Links: AppleTalk is supported over wide area links via IP encapsulation.

Half Router: The Router can act as an AppleTalk Half Router on PPP and Proteon Serial Line data links to support interoperability with other vendors' routers. By default, the Router is configured as a Half Router, meaning that it is not assigned an AppleTalk address. Both the network number and the AppleTalk node number are set to 0.

Frame Relay Support: The Router supports routing of AppleTalk Phase 1 and Phase 2 over Frame Relay networks as specified in RFC 1490. AppleTalk ARP correctly resolves MAC addresses, while Inverse ARP maps the MAC address to the AppleTalk address, as defined in RFC 1293. Manual configuration of AppleTalk Node and Network numbers onto specific DLCIs is also supported.

The Disable Split Horizon feature provides support for AppleTalk Phase 2 in partially meshed Frame Relay networks by ensuring that all routing tables are propagated from the "hub routers." A hub router is a router connected to two or more routers over a partially meshed network.

AppleTalk is not supported over X.25 except when encapsulated in IP.

AppleTalk Standards: The AppleTalk routing implementation conforms with the following specifications for Phase 1 and Phase 2:

- *Inside AppleTalk*, March 1989, Apple Computer, Inc., Addison Wesley (Phase 1)
- *Inside AppleTalk, Second Edition*, May 1990, Apple Computer, Inc., Addison Wesley (Phase 2)
- RFC 1243—AppleTalk Management Information Base
- RFC 1293—Inverse Address Resolution Protocol
- RFC 1378—PPP AppleTalk Control Protocol (ATCP)
- RFC 1490—Multiprotocol Interconnect Over Frame Relay Networks

DECnet Phase IV Routing

Distributed Routing Software routes DECnet Network Architecture (DNA) packets in accordance with the Phase IV router specifications for a Level II router. Certain extensions from the Phase IV+ architecture are also supported.

The basic routing functions are provided, with network management through the Router command line interface from the local and remote Telnet consoles. Remote network management using the NICE protocol is not supported, nor is network booting via MOP. Access control facilities protect groups of nodes from other nodes in the network. An area routing filter controls which areas routing information will be accepted from, and which areas routing information will be sent for. Load balancing is not supported. A Multiprotocol software license is required for DECnet Phase IV routing.

Support for Use of Arbitrary MAC Addresses: Distributed Routing Software supports extensions to Phase IV that allow the use of arbitrary MAC Individual Station Addresses on Token Ring networks. The Router supports both networks where arbitrary MAC addressing is used exclusively and networks where it is used in combination with standard Phase IV addressing.

Event Logging: The Router provides a large number of Phase IV diagnostic error messages. All of the appropriate Class 4 events (Routing) are logged through the error logging facilities. Additional messages report errors that are not specified in the DNA network management protocol and also provide tracing facilities.

Network Control Program: The DNA implementation can be fully configured using commands with a syntax modeled after Network Control Program (NCP) commands. Both SET and DEFINE operations are supported, as well as the corresponding SHOW and LIST operations.

X.25 Support: Distributed Routing Software supports Data Link Mapping (DLM)—DECnet Phase IV routing over X.25 SVCs in accordance with the Digital specification. DECnet Phase IV connections over X.25 are supported only to other Routers, and only when the Router is configured as a pure Phase IV router. (DECnet/OSI cannot be configured at the same time.) One X.25 SVC can be configured for DLM on each physical interface.

Frame Relay Support: The Router supports routing of DECnet Phase IV traffic over Frame Relay networks as specified in RFC 1490.

DECnet Phase IV Standards: The DECnet Phase IV implementation is based on the following specification:

- *DECnet Digital Network Architecture Phase IV Routing Layer Functional Specification, Version 2.0.0*, December 1993

- RFC 1490—Multiprotocol Interconnect Over Frame Relay Networks

DECnet/OSI (Phase V) Routing

The DECnet/OSI (Phase V) implementation routes packets in accordance with the Phase V and Phase IV router specifications of the DECnet DNA protocol family. These, in turn, are based on the OSI protocols for Connectionless-Mode Network Service (CLNP), Intermediate System to Intermediate System (IS-IS) routing, and End System to Intermediate System (ES-IS) routing. A Multiprotocol software license is required for DECnet/OSI routing.

Phase IV Compatibility: The implementation includes all of the Phase IV compatibility features that are part of the Phase V specifications, which allow interconnections of Phase IV and V hosts and networks. The Router can be configured to use the Phase IV or Phase V routing protocols at Level 1 (intra-area) and Level 2 (interarea). All combinations of routing protocols at Level 1 and Level 2 are supported.

IS-IS and ES-IS Routing: The Router routes data in accordance with the Intermediate System to Intermediate System (IS-IS) and End System to Intermediate System (ES-IS) protocols. Routing table entries are created dynamically by the operation of these protocols. Load balancing is not supported.

ISO Function Support: The following ISO 8473 functions are implemented:

- PDU Composition
- PDU Decomposition
- Header Format Analysis
- PDU Lifetime Control
- Route PDU
- Forward PDU
- Segmentation
- Discard PDU
- Error Reporting
- PDU Header Error Detection

The following ISO 9542 functions are implemented:

- Report Configuration by Intermediate Systems
- Record Configuration by Intermediate Systems
- Configuration Notification
- Request Redirect
- PDU Header Error Detection

All mandatory functions of ISO 10589, with the exception of Timer Jitter, are implemented. In addition, the following optional functions are supported:

- PDU Authentication
- Subnetwork Dependent functions for Broadcast Subnetworks
- Subnetwork Dependent functions for ISO 8208 Subnetworks (not completely based on the standard)
- Subnetwork Dependent functions for Point-to-Point Subnetworks
- Level 2 IS-IS functions
- Reachable Address Prefixes

Integrated IS-IS Support: Distributed Routing Software supports Integrated Intermediate System to Intermediate System (IS-IS) routing in accordance with RFC 1195. RFC 1195 defines IP extensions to ISO 10589.

Network Management: Network management is available from the local and Telnet remote consoles. Configuration is via the Distributed Routing Software command line interface. For tracing, the Trace Route diagnostic tool displays the hop-by-hop path between nodes. The RFC 1139 Echo function tests the responsiveness of target nodes and also generates echo replies, much like the TCP/IP ping function. Remote network management operations using NICE or CMIP are not supported, nor is network booting via MOP.

ISDN Support: Dial on demand with an ISDN B channel as the primary circuit is supported for DECnet/OSI static routing. Each B channel can be routed to a separate destination. The B channels and serial lines can be aggregated to form a higher speed link to the same destination.

The Router can automatically establish an ISDN connection to the destination router when its serial line fails. Multiprotocol bridging and routing is supported in this WAN restoral mode.

Frame Relay Support: The Router supports routing of DECnet/OSI traffic over Frame Relay networks as specified in RFC 1490.

X.25 Support: Distributed Routing Software supports Data Link Mapping (DLM)—DECnet/OSI (Phase V) routing over X.25 SVCs in accordance with the Digital specification. The Router supports dynamically assigned routing circuits as well as static incoming and outgoing routing circuits.

For DECnet/OSI DLM support, the Router must be configured as a pure DECnet/OSI router. (DECnet Phase IV cannot be configured at the same time.) Integrated IS-IS routing is not supported over X.25 routing circuits. Frame Relay support for DECnet/OSI cannot be configured when DECnet/OSI X.25 routing circuits are configured.

Distributed Routing Software supports a maximum of 31 routing circuits on a Router. This includes X.25 routing circuits as well as other serial and broadcast routing circuits.

DECnet/OSI (Phase V) Standards: The DECnet/OSI implementation is based on the following specifications:

- *DECnet Digital Network Architecture (Phase V) Network Routing Layer Functional Specification*, Part Number EK-DNA03-FS-001, Version 3.0.0, July 1991
- ISO 8473—Protocol for Providing the Connectionless-Mode Network Service
- ISO 9542—End System to Intermediate System Routing Exchange Protocol
- ISO 10589—Intermediate System to Intermediate System Intra-Domain Routing Information Exchange Protocol
- FIPS PUB 146—GOSIP, U.S. Department of Commerce, August 24, 1988
- RFC 1139—An Echo Function for ISO 8473
- RFC 1195—Use of OSI IS-IS for Routing in TCP/IP and Dual Environments
- RFC 1490—Multiprotocol Interconnect Over Frame Relay Networks

Data Link Switching (DLSw)

Data Link Switching (DLSw) is supported on the Ethernet, Token Ring, and serial ports of the RouteAbout products described in this SPD. Distributed Routing Software routes SNA wide area data and SNA and NetBIOS local area data over TCP/IP networks as specified in RFC 1795 (AIW Version 1 DLSw). This version of DLSw will interoperate with earlier versions based on RFC 1434, such as the implementations in Distributed Routing Software V1.0 and V1.1. The Router initial protocol capabilities exchange automatically adjusts the DLSw Switch-to-Switch Protocol (SSP) version for compatibility with the neighbor router. A Multiprotocol software license is required for DLSw.

The SNA wide area traffic supported by DLSw is SDLC, while the local area traffic supported is IEEE 802.2 Logical Link Control Type 2 (LLC2) over Token Ring or Ethernet. The Bandwidth Reservation System, described in detail below, provides the allocation of WAN bandwidth and prioritization needed to support DLSw traffic.

The DLSw implementation interoperates with the IBM 6611, IBM 2210, Proteon CNX/DNX/RBX, and compatible RFC 1795-based products.

The DLSw implementation supports T2.0 (PU Type 2.0) and T2.1 nodes, as well as Type 4 and 5 SNA Subarea nodes. T2.0 nodes (such as IBM 3174s) and T2.1 nodes (such as IBM AS/400 systems) can be connected to the Router via SDLC or LLC2. They can then communicate across the TCP/IP network to a host connected to another Router via LLC2 or SDLC. T2.1 nodes can communicate directly without host intervention via DLSw across a TCP/IP backbone.

The Router at the host site can be connected to a T4 front end processor (FEP) or directly connected to a T5 host equipped with a LAN to mainframe attachment device such as an IBM 3172. Alternatively, the Router can be attached to the front end processor via an SDLC line. In the first two cases, the LLC2 data link protocol is used for the connection. When the LLC2 frames from a host are too large for the remote SDLC controller, the Router segments the SNA FID-2 frames from the host so that they fit into smaller frames that the controller can handle. In the case of an SDLC connection, the Router acts as the SDLC secondary as described in more detail below. T4 to T4 (FID4) connections are not supported.

Instead of bridging SNA traffic, DLSw terminates the Level 2 SDLC or LLC2 data link, using TCP/IP as a reliable transport when both the source and destination are not on the same Router. Data link termination can decrease timeouts and retransmissions, while decreasing WAN traffic by eliminating SDLC polling on the WAN.

When using DLSw, SDLC attached devices appear to be attached via Token Ring to a 3745, 3172, or similar device. The Router supports a large number of downstream SDLC stations by mapping a LAN address to each SDLC station.

All of the RFC 1795 functions of the DLSw protocol for SNA are supported. These functions include finding destinations with the CANUREACH protocol, coordinating the termination of SDLC and LLC2 sessions, reestablishing the logicial link between two terminated link sessions, acting as a transport gateway using TCP/IP for data transfer, and providing for orderly disconnect. DLSw dynamically establishes TCP/IP sessions on demand as needed. DLSw can also automatically reestablish TCP connections upon powerup or after session loss. The size of the TCP receive buffer can be configured, improving performance over links with high delay, such as Frame Relay networks.

LLC2 Termination: The Router can support hundreds of concurrent locally terminated LLC2 sessions, as described above. DLSw uses a virtual segment (added to the RIF) on Source Routed networks.

SDLC Support and Termination: Distributed Routing Software provides either SDLC primary or SDLC secondary link role support on the local router. The link role can also be configured as Negotiable, in which case the Router dynamically determines its role based on negotiation with the attached T2.1 devices. The Router supports SDLC termination of T2.0 (such as 3270) and T2.1 (LEN and APPN) devices, including SDLC multidrop support in either a primary or secondary link role configuration. T2.0 and T2.1 nodes can be mixed on the same multidrop link. Since the SDLC data link is terminated in the Router, no SDLC control information is passed between Routers. The maximum number of SDLC stations supported is a function of memory available on the Router and configuration.

When acting as the SDLC secondary link station, the Router communicates with mainframe front end processors and T2.1 primary link stations. The Router supports secondary multipoint at the physical line level, the logical level, or both. At the physical line level, the Router is one of several SDLC secondary stations on the physical line. At the logical level, multiple SDLC secondary stations are defined in the Router, which is physically attached to a point-to-point line.

The Router also supports end-to-end role negotiation with T2.1/APPN stations. The negotiation is accomplished by exchange of XID3 frames. Dynamic T2.1 SDLC station address resolution is not supported.

SDLC Group Polling: SDLC group polling is supported with the Router as the local SDLC secondary. This feature is typically configured on the IBM mainframe NCP using the GP3174 keyword in the PU definition statement. With group polling, the mainframe or front end processor sends one unnumbered poll that addresses a group of stations. The Router transmits from the attached secondary stations in round-robin fashion based on whether they have data to send. The alternative to group polling is explicit polling to each station.

Local Conversion: As Distributed Routing Software supports both SDLC and LLC2 termination concurrently in the same Router, DLSw can perform LLC2 to SDLC conversion. This feature allows connection of SDLC devices to LLC2-based SNA LAN environments, and vice versa. DLSw Local Conversion utilizes an internal "virtual" TCP connection, collapsing the standard two-router DLSw topology into a single Router.

NetBIOS Support: In addition to supporting SNA traffic, Distributed Routing Software also supports NetBIOS traffic via DLSw. Duplicate UI frame filters eliminate unnecessary or redundant NetBIOS frames by allowing only the first frame to be forwarded. This filtering can be applied to both inbound and outbound frames.

The Router maintains a NetBIOS name cache that matches NetBIOS names with the destination DLSw router or bridge port. This cache greatly reduces the processing required to determine where to send each NetBIOS frame. It is also more efficient than using the NetBIOS name list filters supported for DLSw.

Distributed Routing Software provides UI frame type filters that can filter out all of a certain type of NetBIOS frame. For example, all Trace Control frames or Name Conflict Resolution frames can be filtered.

Dynamic Discovery via DLSw Groups: In addition to the static entry of DLSw router neighbors, DLSw neighbors can dynamically find each other by using the DLSw Group Membership functionality based on Multicast OSPF. DLSw groups alleviate the need for long lists of static IP addresses. The Router can be a member of as many as 64 groups. Both Client/Server and Peer-to-Peer groups are supported.

DLSw Neighbor Priority: All DLSw groups and TCP/IP transport connections can be assigned one of three priorities. When the Router broadcasts a CANUREACH message and receives multiple responses for a given destination, the Router uses the neighbor with the highest priority. Likewise, transport priorities determine the TCP/IP transport connection to be used. If transport priorities are not set, the Router uses load balancing. Transport priority works with any peer DLSw router, regardless of whether it is based on RFC 1434 or RFC 1795.

Capabilities Exchange: When the Router establishes a transport connection with another RFC 1795 compliant router, they exchange configuration messages. These messages communicate the supported optional DLSw features and SAP/NetBIOS name lists. The Router will always attempt to use only one TCP connection for the transport connection with the remote router. However, it will use two unidirectional TCP connections at the request of the remote router. Two TCP connections are required for RFC 1434 transport connections. A single TCP connection improves performance.

The Router also establishes the largest frame size to be used for a DLSw circuit during the explorer CANUREACH_ex - ICANREACH_ex exchange. The frame size used in the explorer exchange is based on the request from the end station. If the end station is on a Transparent bridge port, the Router uses the largest frame size value that does not exceed the MTU size of the LAN on which the end station is located.

Flow Control: DLSw supports both TCP and DLSw circuit flow control. When interoperating with other RFC-1795-based routers, the Router performs per-circuit flow control using either adaptive or fixed pacing. The Router uses adaptive pacing unless the peer router supports only fixed pacing.

When interoperating with RFC-1434-based routers, the Router uses two Distributed Routing Software enhancements to DLSw, SSP_ENTER_BUSY and SSP_EXIT_BUSY. These messages support DLSw circuit level flow control, allowing one end of the circuit to notify the other end of congestion and the clearing of congestion.

In addition, DLSw flow controls the SNA data link with Receiver Not Ready (RNR) in the event of TCP transmit congestion. Routers congested on TCP receive decrease their TCP window. TCP flow control is accomplished using the TCP slow start algorithm.

Circuit Prioritization: The Router supports prioritization of DLSw circuits. Each circuit can request one of four different priorities or unspecified (meaning no priority) in the CANUREACH_cs message. The Distributed Routing Software circuit prioritization allocates transport bandwidth according to protocol type—SNA or NetBIOS.

Broadcast Reduction: The Router limits unnecessary broadcasts by using several caches. First, the Router caches the IP address of the destination DLSw router for all MAC addresses learned from ICANREACH messages. The size of the MAC address to IP address cache is configurable. Secondly, the Router caches all pending CANUREACH messages to avoid generating redundant messages. On the Token Ring interface, the Router caches Route Information Fields (RIFs) to reduce the number of Explorer broadcasts.

Ethernet Support: DLSw supports LLC2 termination on Ethernet. Any Ethernet attached SNA devices such as 3174s and 3745s are supported. In most topologies, only one DLSw Router can be attached to an Ethernet segment. Also, the topology must not include parallel bridge and DLSw paths between source and destination Ethernet end stations.

DLSw Management Information Base (MIB): The Router supports Gets and Traps of DLSw MIB variables as defined in Internet Draft Version 06. The Node, Transport Connection, Interface, Directory, Circuit, and Virtual and Non-LAN End Station groups are supported.

LLC and SDLC Management Information Bases (MIBs): The LLC and SDLC MIBs are supported for monitoring. For the LLC MIB, the Physical Ports group, Local SAPs group, and Connection Components groups are supported. For the SDLC MIB, the Ports group, Link Station group, and traps are supported.

DLSw Standards: The DLSw implementation is based on the following specifications:

- 6611 Network Processor Network Management Reference IBM Document GC30-3567
- DLSw Management Information Base (Internet Draft Version 06)
- LLC Management Information Base (Internet Draft Version 01)
- RFC 1434—Data Link Switching: Switch-to-Switch Protocol
- RFC 1747—SDLC Management Information Base
- RFC 1795—Data Link Switching: Switch-to-Switch Protocol

SDLC Relay

The SDLC Relay function allows pairs of point-to-point Synchronous Data Link Control (SDLC) devices to be connected locally or remotely via an internetwork. This is done by connecting the SDLC device to a synchronous interface on the Router and then passing SDLC frames between the Routers encapsulated in UDP/IP packets. The destination IP address is based on the source serial port of the frame. High-Level Data Link Control (HDLC) frames are supported in the same way. A Multiprotocol software license is required for SDLC Relay.

The operation of the Relay is transparent to the SDLC devices; the Relay looks like a full-duplex leased line. There is no processing of the data in the SDLC frames, other than protection from undetected data errors. The Relay does not support half-duplex or multidrop operation.

SDLC Relay Standards: The SDLC Relay implementation is based on the following specifications:

- IBM SDLC General information (IBM Document GA27-3093)
- ISO 3309-1984—High-Level Data Link Control (HDLC) - Frame Structure
- RFC 1747—SDLC Management Information Base

Boundary Access Node

The RouteAbout Access TW supports Boundary Access Node (BAN), a function that connects remote SNA sites directly to an IBM mainframe using Frame Relay. With BAN, dedicated SDLC links are replaced by Frame Relay connections, substantially reducing network cost. Both SNA PU2.0 and T2.1 node types are supported, with either LLC2 (Ethernet or Token Ring LAN) or SDLC device attachment at the remote site. The Boundary Access Node function works in two modes—bridge mode and DLSw mode, as described below. A Multiprotocol software license is required for the Boundary Access Node function.

The BAN function, developed by IBM, is an efficient alternative to RFC 1490 SNA (FRF.3) encapsulation. BAN has all the advantages of RFC 1490, including direct attachment to the IBM mainframe via Frame Relay without the need for a second router at the host site. BAN has the additional advantage of supporting multiple remote SNA devices over a single Frame Relay DLCI without the need for SAP multiplexing. This reduces the number of Frame Relay PVCs required while greatly simplifying configuration and monitoring at the IBM mainframe site.

Internally, BAN utilizes the RFC 1490 bridged-frame 802.5 format. BAN requires support in the IBM environment, which is included with IBM Network Control Program (NCP) V7R3 or later running on the 3745/3746 host front end processor.

Note that Distributed Routing Software provides several alternatives to BAN. The DLSw protocol also supports SNA over Frame Relay. The SDLC Relay function supports SDLC to SDLC over Frame Relay. These alternatives to BAN might be more appropriate for networks that are already using IP over Frame Relay.

Bridge Mode: BAN Type 1 is Bridge Mode. The Router acts as a bridge, passing LLC2 traffic end-to-end between the IBM host front end processor and the remote SNA device. The Router converts received frames to IEEE 802.5 bridged frame format and transmits them across the Frame Relay network in accordance with RFC 1490.

DLSw Mode: BAN Type 2 is DLSw BAN. The Router locally terminates the LLC2 traffic received from the remote SNA device in accordance with the Data Link Switching (DLSw) standard. At the same time, the Router establishes a second LLC2 segment over the Frame Relay network to the host front end processor.

BAN Type 1 is normally sufficient; Type 2 is used in some topologies where end-to-end LLC2 timeouts present a problem. Type 2 is also necessary where the remote SNA PU2/T2.1 devices are attached to the Router via SDLC.

LAN Network Manager

The RouteAbout Access TW contains a LAN Network Manager (LNM) Agent. This agent works with the IBM LAN Network Manager V2.0 product to manage Token Ring networks interconnected by Source Route bridges. LNM monitors rings, bridges, and Token Ring stations, configures bridges, and provides a connection to NetView for centralized management. Information collected by LNM agents on bridges is sent to LNM management stations.

The LNM Station is a system running the OS/2 or AIX operating system and the LNM management station software. The LNM Station establishes an LLC2 connection with the LNM Agent running on the Brouter and communicates using an IBM proprietary LAN Reporting Mechanism (LRM) protocol. LNM can be enabled on any Brouter Token Ring port that has Source Route bridging enabled.

The Distributed Routing Software LNM implementation supports the following LNM agents:

Configuration Report Server: Collects and reports MAC ring topology changes. Queries the status of other ring stations upon request from the LNM Station.

Ring Error Monitor: Collects MAC error reports from ring stations and forwards them to the LNM Station when thresholds are exceeded.

Ring Parameter Server: Services MAC requests from ring stations for ring parameter information and informs the LNM station of ring insertion.

LAN Bridge Server: Reports on the number of packets transmitted. Does not support configuration of the Brouter by the LNM Station.

Bridging

The Adaptive Source Route Bridging function combines Transparent and Source Route bridging, along with translational bridging between the two. The bridging support varies from model to model, depending on the interfaces on each model (see Table 2).

Table 2
Bridging Support on Router Models

Product	IEEE 802.1d Transparent	Source Route	Source Route Transparent	Port Group Support
RouteAbout Access EI	Yes			
RouteAbout Access EW	Yes			
RouteAbout Access TW	Yes	Yes	Yes	
RouteAbout Central EW	Yes			
RouteAbout Central EI	Yes			
DECswitch 900EE	Yes			Yes
DECswitch 900EF	Yes			Yes

The Bridging function interconnects networks for protocols that are not routed by the Router, and for protocols such as LAT and NetBIOS that do not have a Network layer to support routing. The Router can route some protocols, while concurrently bridging others. It can concurrently bridge and route over the same interfaces. If a protocol is not explicitly configured to be routed, it is bridged by default.

For all models except for the DECswitch 900EE and 900EF, each protocol must be configured to be bridged or routed for the Router as a whole. The DECswitch 900EE and 900EF support port groups, where the DECswitch bridges a protocol within a port group while concurrently routing the protocol between port groups. For more information, see the section entitled Port Group Support.

Transparent Bridging: The Router performs Transparent bridging as defined in the IEEE 802.1d standard. It serves as a learning bridge in promiscuous mode, building a table of addresses and their source interface. These learned addresses are aged and deleted if not seen within the configurable timeout period. Permanent entries can be added to the address table. The Router can filter frames based on their destination address.

The Router participates in the IEEE 802.1d Spanning Tree Bridge algorithm, forming a loop-free network topology that connects all bridged LANs. Configuration parameters can be used to create a predictable network topology, but the default values are usually adequate. The Spanning Tree Bridge algorithm can be enabled or disabled on each port of the Router.

MAC Address Filtering: The RouteAbout products perform MAC address filtering. Frames can be filtered or tagged for Bandwidth Reservation based on the source or destination address, a mask applied to the frame, an interface number, or an input/output designation. Filters can be applied separately to each port on the Router. Filters can also be applied to ports established for IP tunneling. Filtered packets cannot pass through the Router; tagged packets are forwarded based on the configured bandwidth allocation and prioritization.

Protocol Filtering: Configuration parameters limit what protocol types are bridged in order to confine certain protocols to certain networks. These protocols can be specified based on the value in one of these fields:

- Ethernet Type
- IEEE 802.2 Destination Service Access Point
- IEEE 802 Subnetwork Access Protocol (SNAP) Protocol Identifier

Source Route Bridging: The RouteAbout Access TW provides Source Route Bridging, which also can be used concurrently with Transparent Bridging on an interface, as defined in the IEEE 802.5M-D6 proposal. Concurrent use of the two types of bridging is referred to as Source Route Transparent (SRT) bridging.

The Router participates in the route discovery process whereby both end stations and the Router learn about paths to a destination node. The Router supports both All Routes Explorer (ARE) and Spanning Tree Explorer (STE) frame types. The difference is that STEs are sent and received only on interfaces that are part of a spanning tree. If Transparent bridging is also enabled on an interface, the forwarding of STE frames is controlled by the spanning tree state of the interface. If Transparent bridging is not enabled on an interface, the forwarding of STE frames is manually configured, with the default being to forward them. The Router does not participate in the proprietary spanning tree protocol that is optional on the IBM Token-Ring Network Bridge Program, Version 2.0 and higher.

The Router enforces the maximum hop count on explorer frames. The serial interfaces and IP tunnel interface are treated as segments, using one route descriptor field in the Routing Information Field (RIF). If the Router has more than two interfaces participating in Source Routing, counting the Bridging function itself as one interface, a virtual segment is required. The virtual segment uses an additional route descriptor in the RIF.

Adaptive (Translational) Bridging: The RouteAbout Access TW supports Adaptive Bridging, a proprietary extension to the SRT standard. While SRT requires all Source Routed frames to remain Source Routed and stay in the limited Token-Ring Source Routing domain, adaptive bridging translates these frames into Transparent frames to reach the transparently bridged domain. Adaptive Bridging also does the reverse when necessary, translating Transparent frames into Source Route Bridging frames by adding a RIF field.

When serving as an Adaptive bridge, the Router not only learns MAC addresses, but also learns RIFs from frames that are Source Routed. By doing this, the Router learns which nodes can be reached by Translational bridging and which can be reached only by Source Routing.

The Adaptive bridge function does not use a spanning tree protocol for loop detection. There must not be redundant connections between a Source Routing Domain and a Transparent bridging domain.

The Distributed Routing Software Adaptive bridging functionality is interoperable with the IBM 8209 bridge, but its capabilities are not identical. In particular, the Router does not participate in the proprietary IBM 8209 loop detection protocol.

IP Tunneling: Bridging across an IP network can be supported by adding a port (interface) to the Router bridging function. The IP tunnel provides for optimal IP routing of Transparent frames to known destinations.

When the Router receives a Transparent frame from the IP tunnel, it places the IP address of the source tunnel portal in the address table along with the MAC address. The Router can then place frames sent back to that MAC address in the correct IP portal. Similarly, the Router learns the Source Routing segment numbers that can be reached through each IP portal.

The IP tunnel can be configured to use IP Class D multicast via the Internet Group Multicast Protocol (IGMP) and the Multicast Extensions to Open Shortest Path First (MOSPF) routing protocol. This approach simplifies configuration because all Routers participating in the IP tunnel need only to be configured for the same IP Class D address. IGMP and OSPF find the paths between them.

Port Group Support: The DECswitch 900EE and 900EF support port groups, where the DECswitch bridges a protocol within a port group while concurrently routing the protocol between port groups.

A port group is a set of switch ports assigned by the user. A port can be a member of only one port group. Each port group is assigned a name by the user and a number by the system. Protocols that are configured to be routed on the DECswitch are actually bridged between members of the port group.

Each port group has an associated virtual interface. The DECswitch routes traffic to and from this virtual interface as if it were a single connection to a bridged LAN consisting of the underlying switch ports. Therefore, in the case of IP, there is a single subnet for all the switch ports in the port group.

Protocols that are not configured to be routed on the DECswitch are bridged between all the ports regardless of the port group configuration.

Ethernet Frame Format Translation: An Ethernet/IEEE 802.3 network can simultaneously support use of the Ethernet and IEEE 802.3 Data Link layers. However, Ethernet frames must be translated to the IEEE 802.2 format for transmission across Token Ring and FDDI LANs. The Router provides this transparency across mixed LAN types in accordance with the IEEE standards.

Token Ring Frame Format Translation: The RouteAbout Access TW provides certain translations between frame formats on Token Ring LANs and those on the other LAN networks. These translations compensate for some of the peculiarities of protocol encapsulations on Token Ring. They are needed only if Token Ring nodes are to communicate with nodes on other LAN types. If Token Ring serves as a backbone for other LANs, or if another LAN serves as a backbone for Token Ring LANs, the translations are not needed.

The primary translation is the mapping of standard IEEE 802 Group Addresses to the special Functional Addresses used on IEEE 802.5 Token Ring. The other translation addresses the use of non-canonical (802.5 native bit order) MAC addresses as data by protocols on Token Ring networks.

The protocols that can be bridged from Token Ring to other LAN types are IBM SNA, NetBIOS, DECnet Phase IV, LAT, and ISO CLNP. The IPX and AppleTalk Phase 2 protocols are not supported.

NetBIOS Filtering: The RouteAbout Access TW filters NetBIOS packets based on values in the fields of the NetBIOS portion of the packets. This function allows filtering of packets with specific NetBIOS host names, or based on other fields in the packet.

NetBIOS Name Caching: The RouteAbout Access TW caches the source routes and MAC addresses of NetBIOS servers. Subsequent requests to resolve the name of the server are handled locally, preventing large numbers of multicast STE and ARE packets from traversing the bridged network.

Bridging Standards: The bridging implementation is based on the following specifications:

- IEEE 802—LAN and MAN Overview and Architecture
- IEEE 802.1d—Media Access Control (MAC) Bridges
- IEEE 802.1d—Source Routing Transparent Bridge Extension
- IBM Token Ring Network Architecture Reference (SC30-3374-02)
- RFC 1286—Bridge Management Information Base
- RFC 1490—Multiprotocol Interconnect Over Frame Relay Networks

PPP Data Link

The Point-to-Point Protocol (PPP) data link is supported for the IP, IPX (IPXWAN), AppleTalk, DECnet Phase IV, and DECnet/OSI protocols. Other protocols are supported if encapsulated within IP.

Physical Interface Support: Distributed Routing Software supports the PPP data link over serial lines, V.25 *bis* dialup lines, and ISDN lines. PPP is handled over the Frame Relay interface via an encapsulation technique.

Multilink PPP (MP): Distributed Routing Software provides the ability to aggregate multiple PPP links into bundles for increased bandwidth using Multilink PPP (MP) as defined in RFC 1717. The PPP links can be combined statically upon restart or dynamically by use of the Bandwidth on Demand Monitor. PPP links on a leased line, V.25 *bis* dialup lines, or ISDN B channels can be aggregated. On the RouteAbout Access EI, a maximum of 3 PPP links can be bundled—the serial line and the 2 ISDN B channels. On the RouteAbout Central EI, the maximum bundle is 8 PPP links.

Bandwidth on Demand: The Bandwidth on Demand Monitor monitors bandwidth usage on Multilink PPP bundles and brings up additional PPP links as needed. The monitor brings up additional PPP links when a configurable bandwidth threshold (70% usage by default) is exceeded during a historical time period (30 seconds by default).

Multilink Configurations Supported: Multilink PPP bundles comprise a base link and secondary links. The base link is the first link to be activated. The secondary links are either defined by a static configuration or dynamically added by the Bandwidth on Demand Monitor. The base link can be PPP on a leased line, V.25 *bis* dial-up line, or an ISDN B channel. The secondary link must be a PPP dial circuit—either a V.25 *bis* dial-up line or an ISDN B channel. Bundling of PPP leased lines is not supported.

There are three Multilink PPP configurations supported in Distributed Routing Software V2.0.

The first is a static configuration that automatically brings up Multilink PPP on the two channels of a Basic Rate ISDN interface upon restart.

The second is a dynamic configuration with Multilink PPP on one Basic Rate ISDN B channel at restart, with the second B channel or a V.25 *bis* dialup line brought up by the Bandwidth On Demand Monitor when the traffic threshold is exceeded.

The third is a dynamic configuration with Multilink PPP running on a PPP leased line at restart, with additional ISDN B channels or V.25 *bis* dialup lines brought up as needed. PAP or CHAP security must be used for both dynamic configurations.

Bridging Control Protocol: The Bridging Control Protocol (BNCP) supports bridging over PPP in conformance with RFC 1220. The PPP link can be configured for Transparent bridging, Source Route bridging, or both. BNCP negotiates the source route segment number. LAT tinygram compression is supported.

WAN Restoral and Rerouting: WAN restoral and WAN rerouting is provided for PPP data links, as described in the sections entitled Frame Relay, Serial Line Interface, and ISDN Interface.

Data Compression: Distributed Routing Software supports the PPP Compression Control Protocol (CCP) as defined in RFC 1962. The Router uses CCP to negotiate data compression with the peer router on a PPP link.

Distributed Routing Software uses STAC LZS V5.0 technology as defined in RFC 1974 to provide compression on PPP data links over leased lines, Frame Relay circuits, and ISDN lines. Compression over Frame Relay is provided on a per PVC basis. Compression ratios as high as 4 to 1 are possible. The Bandwidth Reservation System and filters apply to compressed circuits.

Distributed Routing Software also provides LAT tinygram compression over PPP as described above, and IP header compression as described in the TCP/IP Routing section.

Challenge Handshake Authentication Protocol: Distributed Routing Software uses the Challenge Handshake Authentication Protocol (CHAP) as defined in RFC 1334 to verify the identity of the peer router on the other side of a PPP link. CHAP uses a three-way handshake to identify a peer router upon initial PPP link establishment. The Router may periodically check authentication any time after the link has been established.

The Router can serve as the CHAP authenticator or as the peer. When serving as the authenticator, the Router sends a challenge message to the peer router that is placing the call. The peer router then generates a response using the challenge value and the appropriate secret. The Router compares the peer router's response with the result of its own calculation and sends a success message if they match. If the values do not match, the Router sends a failure message and terminates the connection.

With CHAP, the secret used for authentication is never passed over the link. Instead, the secret resides on both the authenticator and the peer systems. CHAP provides protection against playback attack by using an incrementally changing identifier and a variable challenge value. Since response packets may be lost, a timer limits the time between challenge and response. If timeout occurs, a new unique challenge is sent. The use of repeated challenges limits the time of exposure to any single attack. The authenticator is in control of the frequency and timing of the challenges.

PPP Authentication Protocols (PAP): The PPP Authentication Protocols (PAP) provide security through a password authentication method.

PPP Standards: The PPP data link is based on the following specifications:

- RFC 1144—Compressing TCP/IP Headers for Low-Speed Serial Links
- RFC 1220—PPP Extensions for Bridging
- RFC 1332—PPP Internet Control Protocol (IPCP)
- RFC 1334—PPP Authentication Protocols (PAP /CHAP)
- RFC 1362—Novell IPX Over Various WAN Media (IPXWAN)
- RFC 1376—PPP DECnet Phase IV Control Protocol (DNCP)
- RFC 1377—PPP OSI Network Layer Control Protocol (OSINLCP)
- RFC 1378—PPP AppleTalk Control Protocol (ATCP)
- RFC 1471—PPP Link Control Protocol Management Information Base
- RFC 1548—Point-to-Point Protocol (PPP)
- RFC 1552—PPP Internetwork Packet Exchange Protocol (IPXCP)
- RFC 1717—Multilink PPP Protocol (MP)
- RFC 1962—PPP Compression Control Protocol (CCP)
- RFC 1974—PPP STAC LZS Compression Protocol

Proteon Serial Line Data Link

The Proteon Serial Line (PSL) is a proprietary implementation of PPP over HDLC. PSL transports all the supported upper layer protocols.

SDLC Data Link

The Synchronous Data Link Control (SDLC) protocol supports the Data Link Switching (DLSw), Boundary Access Node, and SDLC Relay functions. SDLC is supported on X.21, V.35, RS232/V.28 and the other physical interfaces. Distributed Routing Software provides SDLC primary link station functionality, SDLC secondary link station functionality, and end-to-end role negotiation for DLSw. For details, refer to the section on Data Link Switching (DLSw).

SDLC Management Information Base (MIB): The SDLC MIB is supported for monitoring. The Ports group, Link Station group, and traps are supported.

SDLC Data Link Standards: The SDLC data link is based on the appropriate IBM specifications and the following RFC:

- RFC 1747—SDLC Management Information Base

X.25

The X.25 interface links Routers over public or private X.25 networks. The interface acts as a leased circuit service DTE port. The X.25 software implements the Physical, Data Link, and Network layers to transport upper layer protocol packets to other Routers. Each line can be configured separately, so that they can be connected to different X.25 networks. Each line supports as many as 227 outgoing switched virtual circuits (SVCs). Priority is given to locally originated traffic.

The Router also has an X.25 switching function that provides X.25 access for systems on a LAN. X.25 switching also relays calls between the public X.25 network and X.25 DTEs attached to the Router serial lines. A Multiprotocol software license is required for the X.25 switching function.

Physical Interface: Table 3 shows the physical interfaces that are supported via the appropriate adapter cables, along with the supported baud rates. The serial ports provide the electrical interface of a DTE rather than that of a DCE. An external clock source, such as a modem, is required for each serial line.

Table 3
X.25 Physical Interfaces and Supported Baud Rates

Interface	Baud Rate	Adapter Cable
X.21	4800–256K	BC12F-06
V.35	4800–256K	BC12G-06
EIA 232/V.28	4800–19.2K	BC12L-06

Switched and Permanent Virtual Circuits: The X.25 interface initiates and manages X.25 Switched Virtual Circuits (SVCs) to transport higher level protocol data. SVCs, once opened, remain open during periods of activity, and close following a configurable period of inactivity. The X.25 interface load shares over SVCs transporting data for a higher layer protocol to a given destination DTE and attempts to open adjacent SVCs during congestion periods. Permanent Virtual Circuits (PVCs) are a configurable option. PVCs have precedence over SVCs.

Static and Dynamically Assigned Circuits: Dynamically assigned circuits are brought up only when there is data to send, conserving WAN tranmission costs. Static routing circuits are brought up or down by CLI commands.

Protocol Support: The X.25 interface supports the IP, IPX, DECnet Phase IV, and OSI protocols, as well as protocols such as Source Route Bridging and SDLC Relay that are encapsulated in IP.

The IP protocol can use either the encapsulation and addressing procedures specified in RFC 877 and RFC 1356, or those specified in DDN Standard X.25.

The IPX protocol is supported via use of the Call User Data (CUD) field, in accordance with RFC 1356.

Distributed Routing Software supports Data Link Mapping (DLM)—DECnet Phase IV and DECnet/OSI (Phase V) routing over X.25 SVCs in accordance with the Digital specification. DECnet Phase IV connections over X.25 are supported only to other Routers, and only when the Router is configured as a pure Phase IV router.

DECnet/OSI (Phase V) routing over X.25 is supported only when the Router is configured as a pure DECnet /OSI router. For DECnet/OSI routing over X.25, the Router supports dynamically assigned routing circuits as well as static incoming and outgoing routing circuits.

X.25 Switching: The Router supports an X.25 switching function that provides X.25 access for systems on a LAN. This function translates the X.25 LAPB data link protocol to LLC2. In effect, the Router serves as an X.25 gateway, relaying X.25 calls between the public X.25 network and local LAN-attached X.25 DTE systems. The LAN-attached X.25 DTE must be a system that supports ISO/IEC specification 8881, such as an OpenVMS AXP system running X.25 software. The Digital GAP protocol is not supported.

X.25 switching also relays calls between the public X.25 network and X.25 DTEs such as ATM cash machines that are attached to the Router via local serial lines. X.25 switching is supported only for SVCs. Data compression is not supported with X.25 switching.

Table 4 shows the maximum number of LLC2 DTEs, synchronous DTEs, and X.25 switched connections supported on each platform. Each X.25 switched connection requires two SVCs. A maximum of 512 SVCs can be configured on a DTE.

The actual number of X.25 connections or DTEs that can be supported on a platform depends on factors including the window sizes, channel ranges, rate of call setup and cleardown, traffic rates, line speed, and the memory requirements for other protocols and functions.

Table 4
X.25 Switching Maximum Configurations

Platform	LLC2 DTEs	Synchronous DTEs	X.25 Switched Connections
RouteAbout Access EW	15	2	128
RouteAbout Access TW	N/A	2	128
RouteAbout Access EI	15	2	128
RouteAbout Central EW	15	8	512
RouteAbout Central EI	15	4	512

X.25 Data Compression: The Router compresses X.25 user data by means of STAC compression over the LAPB data link. Compression ratios as high as 4 to 1 are possible.

X.25 Standards: The X.25 implementation is based on the following specifications:

- DECnet Network Architecture (DNA) Phase V Network Routing Layer Specification

- Defense Data Network X.25 Host Interface Specification
- ITU Recommendation X.25 1980 and 1984 (Multilink protocol and operation of the D-bit protocol are not supported.)
- ISO/IEC 8208—X.25 Packet Level Protocol for Data Terminal Equipment
- ISO/IEC 10589
- RFC 877—Standard for the Transmission of IP Datagrams Over Public Data Networks
- RFC 1356—Multiprotocol Interconnect on X.25 and ISDN in the Packet Mode

Frame Relay

Frame Relay provides extended LAN services over a wide area network in a point-to-point or point-to-multipoint manner. The Frame Relay interface gives access to Frame Relay services based on the Core Aspects of the LAPD data link layer protocol, ANSI T1.618-1991. The Frame Relay interface provides network addressing, congestion control, and network synchronization for Permanent Virtual Circuit (PVC) connections. Each Router interface supports as many as 64 PVCs.

Physical Access Over Serial Line: Physical access is through the serial port, either point-to-point or via the network side of a CSU/DSU. Frame Relay can run up to T1/E1 speeds.

PPP Data Link Support: PPP is handled over the Frame Relay interface via an encapsulation technique. When using PPP, the Frame Relay network appears to be multiple point-to-point links. This implementation is compatible with the DECNIS implementation.

Protocol Support: The network layer protocols supported according to RFC 1490 include IP, IPX, AppleTalk, DECnet Phase IV, DECnet/OSI, and SNA. Transparent bridging is also supported as specified in RFC 1490, as is SDLC Relay encapsulated in IP. The segmentation and reassembly options are not supported. When using RFC 1490, the Frame Relay network appears to be an extended LAN.

The disable split horizon function supports AppleTalk II in partially meshed Frame Relay networks by ensuring that all routing tables are propagated from "hub routers." A hub router is a router connected to two or more routers over a partially meshed network.

The RouteAbout Access TW supports Boundary Access Node (BAN), a function that connects IBM Type 2.0 and Type 2.1 nodes over a Frame Relay network directly to the Frame Relay interface on the host front end processor. Boundary Access Node eliminates the need for a router at the host site. Both BAN Type 1 (Bridge Mode) and BAN Type 2 (DLSw BAN) are supported, as detailed in the Boundary Access Node section of this SPD.

Connection Management: The Frame Relay interface supports point-to-point Permanent Virtual Circuit (PVC) connections. The state of each PVC configured on the Frame Relay interface is monitored by network management on a periodic basis for remote end point status. Connections can be configured manually, learned dynamically by network management, or both. Connections learned dynamically by network management, termed "orphan connections," can be disabled for security.

Protocol Multiplexing: Packets forwarded on the Frame Relay interface are multiplexed on different PVCs, depending on the network protocol address to PVC mapping. Network protocol addresses are mapped to PVCs dynamically by the ARP protocol. The Router also uses Inverse ARP to map the DLCI to the IP, IPX, or AppleTalk address, as defined in RFC 1293. Static address assignments are also supported, allowing interoperability with Frame Relay devices that do not support ARP.

Multicast Emulation: The Frame Relay interface can be configured to emulate multicasting, allowing protocols such as ARP and RIP to function as in a LAN environment. Data Link Connection Identifiers (DLCIs) can be learned by the LMI interface or can be assigned during interface configuration. In either case, the DLCIs are treated as a list of possible logical points of attachment, all of which are candidates for directed multicast requests. The Frame Relay interface supports 2 octet DLCI addressing.

Congestion Avoidance: The Frame Relay interface avoids congestion by using Variable Information Rate (VIR) to determine the information rate for each PVC. Variable Information Rate supports three parameters per PVC: Committed Information Rate (CIR), Committed Burst Size (Bc), and Excess Burst Size (Be). The Router uses these parameters with congestion monitoring to optimize PVC throughput. When the network is congested, the Router reduces the calculated value for each PVC's VIR to the minimum. The Router also determines the maximum value each PVC can transmit using the Committed Information Rate and Committed Burst Size.

The Frame Relay switches inform the Router of network congestion using Backward Explicit Congestion Notification (BECN). The Router responds by throttling back CIR and by using a protocol congestion mechanism to notify DECnet Phase IV and OSI systems to throttle back.

Management: The Frame Relay interface complies with the Local Management Interface (LMI) protocol defined in Annex A of ITU Recommendation Q.933. LMI

Interim Revision 3 as outlined in StrataCom's Frame Relay Interface specification is supported, along with the ANSI Annex D Specification.

An extension of RFC 1315 provides SNMP access to LMI information on the physical interface, as well as configuration and run-time statistics on each virtual circuit on the physical interface. Traps provide information on circuit state changes.

Bandwidth Reservation Support: On the Frame Relay interface, Bandwidth Reservation can be applied separately to each virtual circuit. Bandwidth available to a circuit can be allocated to classes of traffic, protocols and filters assigned to those classes, and priority assigned to each protocol and filter in the class.

Alternatively, Bandwidth Reservation can be applied at the interface (physical DLCI) level. In this case, the bandwidth of the Frame Relay interface as a whole is allocated to classes of virtual circuits (DLCIs).

WAN Rerouting: The Router provides WAN rerouting to the same router or a third router in the event that the primary Frame Relay circuit fails. PPP over Frame Relay circuits can be rerouted to V.25 *bis* dialup lines or Basic Rate ISDN lines.

Compression: Distributed Routing Software uses the PPP Compression Control Protocol (CCP) to negotiate data compression with the peer router on a PPP link. The Router uses STAC LZS V5.0 technology to provide compression over Frame Relay circuits on a per PVC basis. Compression ratios as high as to 4 to 1 are possible. The Bandwidth Reservation System and filters apply to compressed circuits.

Frame Relay Standards: The Frame Relay implementation is based on the following specifications:

- ANSI T1.617—DSSI Signaling Specification for Frame Relay Bearer Service
- ANSI T1.617 Annex D—Additional Procedures for Permanent Virtual Connections (PVCs) Using Unnumbered Information Frames
- ANSI T1.618—DSSI Core Aspects of Frame Protocol for Use with Frame Relay Bearer Service
- Frame Relay Interface Specification, Revision 3.0, StrataCom, Inc., 1990
- ITU Q.933 Annex D—DSSI Signaling Specification for Frame Mode Basic Call Control
- RFC 1293—Inverse Address Resolution Protocol
- RFC 1315—Frame Relay DTE Management Information Base
- RFC 1490—Multiprotocol Interconnect Over Frame Relay Networks

Serial Line Interface

All of the RouteAbout models described in this SPD have at least one T1/E1 serial port, as described in Table 1. This port supports line speeds from 4800 baud to 2.048 Mb/s. Bandwidth Reservation is supported on serial lines.

Physical Interface: The front panel serial port connectors support the X.21, V.35, EIA232/V.28, EIA422/EIA449/V.11, and EIA530A physical interfaces, depending on the adapter cable installed (see Table 7). The Router automatically senses the type of cable installed and provides the appropriate physical interface. X.21 call control is not supported.

The serial line interface acts as DTE. NRZ and NRZI encoding are supported, with a maximum frame size of 18,000 bytes.

Data Link Support: The serial line supports the PPP, Proteon Serial Line, SDLC, X.25 LAPB, and Frame Relay data links.

V.25 *bis* Dialup Support: The Router initiates and accepts dialup (switched circuit) connections, either on demand, automatically from restart, or on command from the operator. Dial backup is also supported, as described below. As many as 100 dialup circuits are supported on each Router. Bandwidth Reservation is supported on V.25 *bis* switched circuits.

An idle timer disconnects the dialup line when there is no traffic, reducing WAN transmission costs in use-based tariff regions. This timer can be tuned to prevent premature disconnection in regions that have an initial charge period.

Switched circuit support requires use of a V.25 *bis*-compliant synchronous modem, CSU/DSU, or terminal adapter (for ISDN services). The data rate is limited by the DCE device and the carrier service used for the serial line.

WAN Restoral: When configured for WAN restoral, two Routers are linked by primary and secondary WAN circuits. Both circuits must be running the same Data Link protocol—either PPP or SLP. Routing of Network layer protocols must not be configured on the secondary WAN circuit. On detection of primary link failure, the Routers substitute the secondary WAN circuit. Since WAN restoral is handled at the Data Link layer, there is no impact to the routing table.

Routers with multiple serial lines support V.25 *bis* for dial backup. Dial backup instructs the secondary serial line to automatically set up a dialup connection to the remote site when the primary line connection is lost. Dial backup is supported on PPP and Proteon Serial Line data links.

The RouteAbout Access EI and the RouteAbout Central EI can automatically establish a PPP over ISDN connection to the destination router when the PPP over serial line circuit fails.

WAN Rerouting: To support WAN rerouting, the secondary WAN circuit is connected to the same router as the primary circuit or to a third router. The primary and secondary WAN circuits can run different Data Link protocols—either PPP or SLP. (For Frame Relay, PPP must be used.) Routing of a Network layer protocol must be configured on the secondary WAN circuit. The routing tables are updated after WAN rerouting takes place because the changes occur at the Network layer. The WAN rerouting configurations shown in Table 5 are supported.

Table 5
WAN Rerouting Configurations

Primary Circuit	Secondary Circuit
PPP over Leased Line	Dialup
PPP over Leased Line	Basic Rate ISDN
PPP over Frame Relay	Dialup
PPP over Frame Relay	Basic Rate ISDN

Multilink PPP (MP) and Bandwidth on Demand: Distributed Routing Software provides the ability to aggregate multiple PPP links into bundles for increased bandwidth using Multilink PPP (MP) as defined in RFC 1717. The Bandwidth on Demand Monitor monitors bandwidth usage on Multilink PPP bundles and brings up additional PPP links as needed.

The RouteAbout Access EI and the RouteAbout Central EI support a dynamic configuration with Multilink PPP running on a PPP leased line at restart, with additional ISDN B channels and V.25 *bis* dialup lines brought up as needed. For more information, refer to the section entitled PPP Data Link.

Compression: Distributed Routing Software uses the PPP Compression Control Protocol (CCP) as defined in RFC 1962 to negotiate data compression with the peer router on a PPP link. The Router uses STAC LZS V5.0 technology as defined in RFC 1974 to provide compression ratios as high as 4 to 1. The Bandwidth Reservation System and filters apply to compressed circuits.

Serial Line Standards: The serial line interface is based on the following specifications:

- ITU V.25 *bis*
- RFC 1317—RS232-Like Hardware Device Management Information Base

ISDN Interface

The RouteAbout Access EI has a single ISDN Basic Rate interface, and the RouteAbout Central EI has twelve. Each ISDN Basic Rate interface provides two 64 Kb/s B channels for data and a 16 Kb/s D channel for signaling. As many as 100 dialup circuits are supported on each Router. Bandwidth Reservation is supported on the ISDN interface.

Physical Interface: An RJ45 interface on the front panel of the RouteAbout Access EI provides an ISDN S/T interface. The RouteAbout Central EI has 12 RJ45 interfaces on the front panel that work the same way. The S/T interface collapses the TE 1 Subscriber Terminal and the NT 2 Network Termination into a single interface. In North America, an external NT 1 is required for connection to the carrier ISDN local loop. Elsewhere in the world, the carrier provides the NT 1.

Data Link Support: The PPP and Proteon Serial Line data links are supported on the ISDN line.

Multilink PPP (MP) and Bandwidth on Demand: Distributed Routing Software provides the ability to aggregate multiple PPP links into bundles for increased bandwidth using Multilink PPP (MP) as defined in RFC 1717. The Bandwidth on Demand Monitor monitors bandwidth usage on PPP connections and brings up additional PPP links as needed. Multilink PPP on ISDN is a cost-effective way to provide bandwidth on demand for peak usage periods. For more information, refer to the section entitled PPP Data Link.

Dial on Demand for TCP/IP and OSI: Dial on Demand with an ISDN B channel as the primary circuit is supported for TCP/IP routing using triggered RIP and OSI static routing. Each B channel can be routed to a separate destination or the B channels and serial lines can be aggregated to form a higher speed link.

Dial on Demand for Novell IPX: Dial on demand for Novell NetWare routing is supported as described above for TCP/IP and OSI. Novell server spoofing is supported, where the router at the Novell server site responds to server KeepAlive messages on behalf of the clients. This spoofing eliminates a great deal of WAN traffic. Timing of RIP/SAP broadcasts and targeting filtering of RIP/SAP packets also reduce WAN overhead.

Calling ID Verification: The RouteAbout Access EI and the RouteAbout Central EI check the calling ID of incoming calls against an authorized list before accepting the connection.

WAN Restoral: The Router can automatically establish an ISDN connection to the destination router when its serial line fails. In this WAN restoral mode, all multiprotocol bridging and routing is supported, just as it is on the serial line.

WAN Rerouting: The Router provides WAN rerouting to the same router or a third router in the event that the primary circuit fails. PPP over a leased line or PPP over a Frame Relay circuit can be rerouted to a Basic Rate ISDN circuit.

Compression: Distributed Routing Software uses the PPP Compression Control Protocol (CCP) as defined in RFC 1962 to negotiate data compression with the peer router on a PPP link. The Router uses STAC LZS V5.0 technology as defined in RFC 1974 to provide compression ratios as high as 4 to 1. The Bandwidth Reservation System and filters apply to compressed circuits.

Idle Timer: An idle timer disconnects the ISDN circuit when there is no traffic, reducing WAN transmission costs in use-based tariff regions. This timer can be tuned to prevent premature disconnection in regions that have an initial charge period.

ISDN National Standards and Switch Support: The RouteAbout Access EI and the RouteAbout Central EI have been tested for compatibility with the national standards and ISDN switches described in Table 6.

Table 6
Supported ISDN National Standards and Switches

Country	National Standard	Supported Switches
United States	National ISDN 1	AT&T 5ESS NT DMS100
Austria, Belgium, Denmark, Finland, Germany, Greece, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom	Euro-ISDN Net3	ETSI Net3
France	Euro-ISDN plus Deltas	VN3, VN4
Australia	AUSTEL	TS-013
Japan	NTT	INS64

Ethernet Interface

Ethernet Protocol Support: When configured for Ethernet operation, the interface provides the Physical and Data Link layers. For IEEE 802.3 operation, the interface provides the Physical and Ethernet layers. The IEEE 802.2 Logical Link Control layer is supported, but only for Class 1 (connectionless) operation.

RouteAbout Access EW and RouteAbout Access EI: The RouteAbout Access EW and the RouteAbout Access EI have an Ethernet ThinWire (BNC) interface on the side and an unshielded twisted-pair (RJ45) interface on the front panel. When the unit is used as a standalone Router, it detects connection to either the ThinWire or the unshielded twisted-pair interface and autoconfigures accordingly. When installed in a DEChub 90 or a DEChub 900, the Ethernet connection is to the ThinWire channel in the DEChub and the front panel interface is not used. However, the command line interface can be used to reconfigure the unit to use the front panel Ethernet interface.

RouteAbout Central EW and RouteAbout Central EI: The RouteAbout Central EW and the RouteAbout Central EI have two unshielded twisted-pair (RJ45) interfaces on the front panel. When the unit is installed in a DEChub 900, each interface can be switched individually to a hub backplane channel by the *clear*VISN MultiChassis Manager. When the unit is installed in a DEChub ONE, front panel port 1 can be switched to the DEChub ONE AUI port.

Ethernet Standards: The Ethernet interface is based on the following specifications:

- ANSI/IEEE 802.3—Carrier Sense Multiple Access With Collision Detection
- Ethernet Version 2.0, Digital/Intel/Xerox, November 1982
- ISO/DIS 8802/3—Carrier Sense Multiple Access With Collision Detection
- LLC Management Information Base (Internet Draft Version 01)
- RFC 826—Ethernet Address Resolution Protocol
- RFC 894—Standard for the Transmission of IP Datagrams over Ethernet Networks
- RFC 1293—Inverse Address Resolution Protocol
- RFC 1623—Ethernet Management Information Base

Token Ring Interface

RouteAbout Access TW: The RouteAbout Access TW has a single interface for 4 Mb/s or 16 Mb/s Token Ring, selectable under software control. The front panel has a 9-pin D-subminiature connector for 150-ohm STP cables. An external media filter supplied with the Router provides an 8-pin RJ45 connector for 100-ohm UTP cable.

The front panel connector provides the Token Ring interface when the RouteAbout Access TW is used standalone or inserted in a DEChub 90 for power only (the DEChub 90 does not have a Token Ring backplane channel). When the Router is installed in a DEChub 900, it can be configured with the command line interface to use either the DEChub backplane or the front panel connectors. When configured for DEChub backplane use, *clear*VISN MultiChassis Manager can be used to select the Token Ring backplane channel.

NetBIOS Name Caching: On Token Ring interfaces, the Router caches NetBIOS names and their associated Routing Information Fields (RIFs) and MAC addresses. This reduces the number of Explorer frames broadcasted onto the network.

Logical Link Control Support: The Token Ring interface supports both types of Logical Link Control defined in the IEEE 802.2 standard. Type 1 is an unacknowledged connectionless service. Type 2 is a connection-oriented service that provides reliable, sequenced delivery at the Link layer.

The Token Ring interface is based on the following specifications:

- ANSI/IEEE 802.2—Logical Link Control Class 1 and 2
- ANSI/IEEE 802.5—Logical Link Control for Token Ring
- IBM Token Ring Architecture Reference (IBM Publication SC30-3374-02)
- IBM LAN Technical Reference (IBM Publication SC30-3587-00)
- LLC Management Information Base (Internet Draft Version 01)
- RFC 1231—IEEE 802.5 Token Ring Management Information Base

FDDI Interface

The DECswitch 900EF has one Dual Attachment Station (DAS) interface that consists of two FDDI physical ports: 1A/M and 1B/S. This product supports FDDI treeing, also known as concentrator emulation; that is, when FDDI port 1A/M is configured to be an M port, FDDI port 1B/M automatically becomes an S port. The Physical and Data Link layers are provided, along with support for the Station Management (SMT) protocol.

When the DECswitch 900EF is installed in a DEChub 900, each FDDI port can be switched individually to a hub backplane channel. When the unit is installed in a DEChub ONE-MX for standalone use, each FDDI port can be switched individually to a DEChub ONE-MX backplane channel.

FDDI Standards: The FDDI interface is based on the following specifications:

- ANSI X3.139-1987—FDDI Medium Access Control (MAC)
- ANSI X3.148-1988—FDDI Physical Layer Protocol (PHY)
- ANSI X.166-1990—FDDI Physical Layer, Medium Dependent (PMD)
- ANSI X3T9.5/84-89—FDDI Station Management (SMT)
- ISO 9413-1:1989—FDDI Part 1: Token Ring Physical Layer Protocol (PHY)
- ISO 9413-2:1989—FDDI Part 2: Token Ring Media Access Control (MAC)
- ISO 9413-3:1990—FDDI Part 3: Token Ring Physical Layer, Medium Dependent (PMD)
- LLC Management Information Base (Internet Draft Version 01)
- RFC 1285—FDDI Management Information Base
- RFC 1390—Transmission of IP and ARP over FDDI Networks

Bandwidth Reservation System

Bandwidth Reservation guarantees outgoing bandwidth on serial lines, Frame Relay interfaces, V.25 *bis* switched circuits, and ISDN lines. Uncompressed PPP, compressed PPP, and Proteon Serial Line data links are supported. Bandwidth Reservation is not available for X.25 interfaces. Each interface on the Router has its own Bandwidth Reservation settings. The system reserves percentages of the total bandwidth for specified classes of traffic. These percentages are a guaranteed minimum for the class when the serial line is fully loaded. A class can exceed its guaranteed minimum on a line with light traffic, using up to 100% of the line bandwidth. The system dynamically adapts to changes in line speed, applying the same percentage to the new line speed.

Bandwidth Classes: The serial line bandwidth can be divided among as many as 100 classes of traffic.

Priority Levels: There are four priority levels that prioritize traffic within a bandwidth class—Urgent, High, Normal, and Low. Normal is the default. The priority settings within a bandwidth class have no effect on the other classes. No bandwidth class has priority over the others.

Protocol Support: Only network protocols can be set to classes or priorities within a class, with the exception of the nine special filters discussed below. The supported protocols are IP, IPX, AppleTalk, DECnet Phase IV, and DECnet/OSI. Bridging is also supported.

MAC Address Filtering: MAC Address filtering can be used with the Bandwidth Reservation System. Frames can be filtered or tagged for Bandwidth Reservation based on the source or destination address, a mask applied to the frame, an interface number, or an input /output designation. Filters can be applied separately to each interface on the Router. Filtered packets cannot pass through the Router; tagged packets are forwarded based on the configured bandwidth allocation and prioritization.

Special Filters: The nine special filters listed below can be used as bandwidth classes or to set priority within a class. The filters can also be used to exclude traffic from the serial line. The filters are listed in order of precedence because it is possible for a packet to be a member of several filters.

- MAC Address (Universal Filter)
- NetBIOS
- SNA
- IP Tunneling
- SDLC Relay Encapsulation (IP)
- Multicast (IP)
- SNMP (IP)
- rlogin (IP)
- Telnet (IP)

Frame Relay Support: On Frame Relay interfaces, Bandwidth Reservation can be applied separately to each virtual circuit. Alternatively, Bandwidth Reservation can be applied at the interface (physical DLCI) level. In this case, the bandwidth of the Frame Relay interface as a whole is allocated to classes of virtual circuits (DLCIs).

Bandwidth Reservation System MIB: A private MIB is provided for monitoring the Bandwidth Reservation System. This MIB does not support the Frame Relay interface.

Installation

Factory Installation in Flash Memory: Distributed Routing Software is factory installed in the flash memory of the Router.

Updates and Upgrades: Updates and upgrades are performed with the Trivial File Transfer Protocol (TFTP) either locally or remotely over any supported interface. The software is provided on a CD-ROM in ISO 9660 format that can be read by any operating system. Any system that supports IP and TFTP can serve as the load host. Routing is suspended while the software load is taking place.

Reloads: For reloads when there is no valid software image in the flash memory of the Router, loading is supported by BOOTP/TFTP code in the Router PROM. The load host may be either local or remote.

***clear*VISN Flash Loader:** The *clear*VISN Flash Loader is a graphical utility included with MultiChassis Manager and Stack Manager. It can be used to install the Router software for reloads, updates, and upgrades. When commanded to download new software, Flash Loader automatically retrieves the current software version and compares it with the most recent software version. Flash loader then uses TFTP to download the software upgrade. Routers can be updated one at a time or in batch mode.

Configuration and Management

Initial Setup: The first step in configuring the Router is to make it remotely accessible by assigning it an IP address, subnet mask, and default gateway. An alternative is to use EasyStart, as described in the section below.

For the RouteAbout Central and DECswitch products, initial setup is accomplished by making a local terminal connection to the setup port on the DEChub ONE or DEChub 900. The setup port does not support modem control or network access of any kind. The setup port on the DEChub 900 provides a menu from the hub Management Access Module (MAM), through which you can attach to the module and see the setup menu of the RouteAbout Central or the DECswitch itself. The setup port on the DEChub ONE takes the user directly to the RouteAbout Central or DECswitch setup menu.

The RouteAbout Central or DECswitch setup menu minimally configures the Router so that it can send and receive IP datagrams. Another MAM menu option connects the user to the Router command line interface (CLI) for the remainder of the Router configuration.

For the RouteAbout Access products, a direct connection to the Router console port is required regardless of whether or not it is installed in a hub. A setup menu minimally configures the Router so that it can send and receive IP datagrams. The user is then transferred into the Distributed Routing Software command line interface.

For all of the products, the remainder of the Router configuration is performed using the Distributed Routing Software command line interface, the Quickconfig utility, or the *clear*VISN Router Configurator.

EasyStart: EasyStart supports installation of remote office Routers by allowing configuration files stored on a central server to be downline loaded over any interface on the Router except for the ISDN interface. The configuration files are identified by the MAC address of a LAN interface on the Router.

Under the EasyStart method, the Router is booted with no configuration file installed, eliminating the need for initial configuration via an ASCII terminal attached to the Router console port. When booted, the Router autoconfigures all interfaces and sends out BOOTP requests for a load of its configuration file. Once it has its configuration file, the Router automatically restarts to make the configuration parameters take effect.

Command Line Interface: The Distributed Routing Software command line interface (CLI) can be invoked by choosing the DEChub 900 Management Access Module menu option, launched from *clear*VISN MultiChassis Manager, and accessed remotely via TCP/IP Telnet or locally through an EIA-232 terminal connected to the RJ45 console port of the RouteAbout Access products. Dial-in access to the RouteAbout Access console port via a modem is also supported. The RouteAbout Central and DECswitch products do not support console port access. Telnet Client allows users to access Telnet servers from the Router console CLI. As many as three outbound Telnet sessions are supported.

Quickconfig Utility: The Quickconfig utility allows for fast configuration of the Router interfaces, IP addresses, bridging, and IP, IPX, and DECnet Phase IV protocol support.

***clear*VISN Router Configurator:** The *clear*VISN Router Configurator is a Windows 95 and Windows NT graphical utility for creating and modifying Router configuration files. The utility configures IP, IPX, DECnet, OSI, and bridging. Router configurations either can be generated live or generated off line for downline loading at a convenient time. Router Configurator also loads the configuration files using BOOTP and the Trivial File Transfer Protocol (TFTP).

A scripting feature allows advanced Distributed Routing Software command line interface commands to be recorded, edited, and then downloaded to the Router. This scripting feature facilitates configuration of functions that are not supported by the Router Configurator.

A ping button on the tool bar issues ping commands to a Router, checking its reachability and responsiveness. A Telnet button opens a Telnet window for issuing Distributed Routing Software command line interface commands.

Router Configurator can be used with EasyStart to automate the configuration process. The Router Configurator automatically sets up a BOOTP database using information entered in the graphical user interface. When a Router running EasyStart issues a load request, the BOOTP server loads the configuration file. If there is a script for the Router, the BOOTP server invokes the Router Configurator to complete the configuration by running the commands in the script.

Router Configurator is included on the software CD-ROM shipped with each Router, as well as being offered as part of the *clear*VISN product set.

***clear*VISN MultiChassis Manager:** The *clear*VISN MultiChassis Manager can be used to configure and manage Routers in DEChub 90, MultiStack, and DEChub 900 systems. The utility displays an icon of the Router within a display of the hub slot configuration. By clicking on the icon, the user can view several screens that summarize Router performance and error conditions or launch the Distributed Routing Software command line interface. For Routers in the DEChub 900, MultiChassis Manager selects the hub channel to which the Router LAN backplane interface is attached.

Configuration and monitoring using *clear*VISN MultiChassis Manager can be done over the network or via a TCP/IP SLIP connection to the DEChub out-of-band management (OBM) port.

***clear*VISN Stack Manager:** The *clear*VISN Stack Manager provides a subset of the MultiChassis Manager functions for managing the RouteAbout Access EW and RouteAbout Access EI in Digital MultiStack systems.

***clear*VISN Router Manager:** The *clear*VISN Router Manager manages multivendor networks comprised of RouteAbout, DECswitch, DECNIS, DECbrouter, Cisco Systems, Bay Networks, 3Com, and Novell routers. The application also supports other routers and switches to the extent that they support MIB-II and other standard MIBs. For RouteAbout and DECswitch Routers, Router Manager provides fault detection, path tracing between selected routers, event generation, reporting, and performance monitoring. The performance trending includes both real-time and historical views of data grouped by routers, interfaces, or protocols.

Event Logging System (ELS): The Event Logging System (ELS) is a monitoring system that manages messages generated by system components within Router. Messages are caused by system activity, status changes, service requests, data transmission and reception, and data and internal errors. User configuration determines the types of messages to be collected. The messages can be displayed on the console terminal screen or accessed through SNMP.

Digital Trace Facility (DTF): The Digital Trace Facility shows data as it flows through the layers and modules of a Router. A workstation-based DTF application listens on a Router port to receive data collected from trace points embedded in the Router modules. The DTF application supports in-depth tracing of data moving through the Router for troubleshooting and analysis.

SNMP: SNMP provides a method of monitoring and managing the operation of the Router remotely, using a standardized, extensible UDP-based protocol. It can examine the state of the Router, collect various statistics, and generate trap messages. The complete MIB-II is provided with the exception of ifInNUcastPkts, ifOutNUcastPkts, and the TCP group.

Sets are supported for enabling and disabling Router interfaces. The Address Translation and Routing tables are not settable.

SNMP Standards: The SNMP implementation is based on the following RFCs. SNMP Gets and Traps are supported for the MIBs listed below:

- RFC 1155—Structure and Identification of Management Information for TCP/IP-Based Internets
- RFC 1157—Simple Network Management Protocol (SNMP)
- RFC 1213—Management Information Base for Network Management of TCP/IP-Based Internets: MIB-II
- RFC 1231—Token Ring MIB
- RFC 1243—AppleTalk MIB
- RFC 1253—OSPF Version 2 MIB
- RFC 1285—FDDI MIB
- RFC 1286—Bridge MIB
- RFC 1315—Frame Relay DTE MIB
- RFC 1317—RS232-Like Hardware Device MIB
- RFC 1471—PPP Link Control Protocol MIB
- RFC 1573—Evolution of the Interfaces Group of MIB-II
- RFC 1623—Ethernet MIB
- RFC 1747—SDLC MIB
- Bandwidth Reservation System Private MIB
- Distributed Routing Software Private MIB (Resource Group, ELS Group, and Traps)
- Data Link Switching (DLSw) MIB (Internet Draft Version 06)
- LLC MIB (Internet Draft Version 01)
- Novell IPX MIB
- Novell RIP-SAP MIB

SNMP LAN Support: Error statistics are collected on a node and port basis for both Token Ring and Ethernet. In addition, the ring ordered node list, otherwise known as NUAN (Nearest Upstream Active Node) list, is maintained. System delta events are captured in an event log for retrieval by an SNMP network management system. Automatic mapping of MAC address to physical port is provided for Token Ring only. For Token Ring, certain events such as ring beaconing cause the SNMP agent to automatically isolate the faulty port and remove it from the ring.

SNMP Security: For security, specific portions of the MIB or the entire MIB can be assigned to a community. Each community has a list of IP addresses that can access the community and/or receive traps.

INSTALLATION

If the Router is to be connected to a public X.25 network, Digital recommends that a customer's first purchase of the product include Digital Installation Services. These services provide installation of the software by an experienced Digital software specialist.

HARDWARE REQUIREMENTS

Distributed Routing Software requires the following hardware:

Router Hardware Unit: A RouteAbout or DECswitch hardware unit is required, as described in Table 1.

DEChub: DEChub variants of the RouteAbout Access EW and RouteAbout Access EI require a DEChub 90 or a DEChub 900. For use in a DEChub, the RouteAbout Access TW requires a DEChub 900. A DEChub 90 can be used for power only. Standalone and MultiStack variants of the RouteAbout Access products do not require additional hardware, as they are supplied with a power supply and power cord. The RouteAbout Access TW is not available as a MultiStack variant because it has a Token Ring LAN interface rather than Ethernet.

The RouteAbout Central and DECswitch products require either a DEChub 900 for hub configuration or a DEChub ONE for standalone use.

Version 5.0 or later of the Management Access Module (MAM) software is required to access the Distributed Routing Software command line interface through the MAM.

Console Terminal: A terminal is required for local configuration of the Router.

Ethernet Cables: For the Ethernet interface on a RouteAbout Access EW or the RouteAbout Access EI, a 10Base-2 (BNC) or 10Base-T (RJ45) Ethernet connection is required.

On the RouteAbout Central EW and the RouteAbout Central EI, a 10Base-T (RJ45) Ethernet connection is required for each Ethernet interface on the front panel.

For the Ethernet interfaces on the DECswitch 900EE and 900EF, four 10Base-T (8-pin MJ) and two AUI (15-pin D-subminiature) connections are required.

Token Ring Cables: For the Token Ring interface on the RouteAbout Access TW, a 150-ohm STP cable is required for connection to the front panel 9-pin D-subminiature connector. Alternatively, a 100-ohm UTP cable can be attached to the external media filter that is supplied with the unit.

FDDI Cables: The FDDI interface on the DECswitch 900EF requires two standard FDDI MIC connectors. For appropriate cabling, refer to the BN24B series in the *OPEN DECconnect Applications Guide*.

Serial Port Cables: An adapter cable is required for each serial interface on the Router. This cable provides the required physical interface, as shown in Table 7.

Table 7

Physical Interfaces and Adapter Cables

Interface	Adapter Cable
X.21	BC12F-06
V.35	BC12G-06
EIA 232/V.28	BC12L-06
EIA 530A	BC12J-06
EIA 422/EIA 449/V.11	BC12H-06

ISDN Port Cables: For the RouteAbout Access EI and the RouteAbout Central EI, a single three-foot cable is provided for connecting the RouteAbout ISDN port to the NT 1. To purchase additional cables for the other ISDN ports on the RouteAbout Central EI, order part number BN25G-03.

DCE Device for Serial Lines: A DCE device (DSU/CSU or modem) is required for each serial line. Switched circuit support requires use of a V.25 *bis*-compliant synchronous modem, CSU/DSU, or terminal adapter (for ISDN services). Dialup support requires a modem with an exact implementation of the V.25 *bis* specification, such as the Motorola Codex 3266 Fast.

NT 1 for ISDN Lines: In North America, an NT 1 Network Termination is required for connecting the RouteAbout Access EI ISDN line to the ISDN carrier local loop. Elsewhere in the world, the carrier provides the NT 1.

SOFTWARE REQUIREMENTS

TCP/IP System: A TCP/IP System is required for remote configuration and management of the Router via Telnet. Trivial File Transfer Protocol (TFTP) support is required for performing reloads, updates, and upgrades of the Router software and for receiving dumps.

OPTIONAL SOFTWARE

***clear*VISN Flash Loader:** The *clear*VISN Flash Loader V1.2 can be used to install the Router software for reloads, updates, and upgrades.

***clear*VISN MultiChassis Manager:** The *clear*VISN MultiChassis Manager Version 5.0 is required for configuring the hub backplane channel attachment of modules in DEChub configurations.

***clear*VISN Stack Manager:** The *clear*VISN Stack Manager V1.0 or later can be used to manage the RouteAbout Access EW and RouteAbout Access EI in Digital MultiStack systems.

***clear*VISN Router Manager:** The *clear*VISN Router Manager V1.0 can be used to monitor performance, trace network paths, generate events, and produce reports.

SNMP NMS: An SNMP Network Management Station is required for monitoring and setting SNMP variables.

GROWTH CONSIDERATIONS

The minimum hardware/software requirements for any future version of this product may be different from the requirements for the current version.

DISTRIBUTION MEDIA

The Router software is distributed on a CD-ROM in ISO 9660 format that can be read by any operating system. The product documentation is also provided on a Network Product Information Library CD-ROM, along with a *Dyna*Text reader. Table 8 describes the system requirements for the *Dyna*Text reader.

Table 8
***Dyna*Text System Requirements**

Platform	Operating System	Windowing System	RAM	Disk Space
IBM PC or compatible; 386sx or greater	MS–DOS 5.0 or greater	Windows 3.1 in enhanced mode, Windows 95, or Windows NT	4 MB	4 MB
Sun SPARC System	SunOS 4.1.*x* or Solaris 2.2	X11R4, X11R5, Motif 1.2.x	12 MB	4 MB
IBM RS/6000	AIX 3.2.5 or later	X11R4, X11R5, Motif 1.2.x	12 MB	3 MB
HP9000 Series 700	HP-UX 9.0 or later	X11R4, X11R5, Motif 1.2.x	12 MB	3 MB
Digital Alpha Systems	Digital UNIX V3.0 or later[1]	X11R4, X11R5, Motif 1.1.x	12 MB	3 MB

[1]Requires that you install the C++ Run-Time Library option.

ORDERING INFORMATION

For initial purchase of a Router, use the DE***-** option number shown in Table 9 and Table 10. This part number is a complete package including the hardware unit with the software preloaded in the flash memory, and the software license. CD-ROMs shipped with each Router contain the software, the software documentation, and a *Dyna*Text documentation reader. A hardware installation manual and a set of software quick reference cards are also included. To purchase a complete hardcopy documentation set, use the GZ kit part number listed in Table 9 and Table 10.

Table 9
Distributed Routing Software V2.0 Ordering Information for Access Routers

	RouteAbout Access EW	RouteAbout Access TW	RouteAbout Access EI
Initial Ordering			
Router Unit with IP Software			
Standalone	DEX2R-F*	DEWTR-F*	DEXBR-F*
Hub	DEX2R-MB	DEWTR-MB	DEXBR-MB
MultiStack	DEX2R-T*	N/A	DEXBR-T*
Router Unit with MP Software			
Standalone	DEX2R-D*	DEWTR-D*	DEXBR-D*
Hub	DEX2R-MA	DEWTR-MA	DEXBR-MA
MultiStack	DEX2R-S*	N/A	DEXBR-S*
Updates and Upgrades			
IP Software Update License	QL-4C1A9-RA	QL-4BQA9-RA	QL-4SQA9-RA
Multiprotocol Software Update License	QL-4C2A9-RA	QL-4BRA9-RA	QL-4SRA9-RA
IP to Multiprotocol Upgrade License	QL-4C3A9-AA	QL-4BSA9-AA	QL-4SSA9-AA
IP Software Media and Documentation	QA-4C1AA-H8	QA-4BQAA-H8	QA-4SQAA-H8
MP Software Media and Documentation	QA-4C2AA-H8	QA-4BRAA-H8	QA-4SRAA-H8
Hardcopy Documentation and Services			
Hardcopy Software Documentation	QA-4P3AA-GZ	QA-4P3AA-GZ	QA-4P3AA-GZ
IP Software Product Services	QT-4C1A*-**	QT-4BQA*-**	QT-4SQA*-**
MP Software Product Services	QT-4C2A*-**	QT-4BRA*-**	QT-4SRA*-**

*Denotes the country kit variant or memory option. For additional information on available country kits, memory options, licenses, services, and media, refer to the appropriate price book.

Table 10
Distributed Routing Software Ordering Information for Central and DECswitch Routers

	RouteAbout Central EW	RouteAbout Central EI	DECswitch 900EE	DECswitch 900EF
Initial Ordering				
Router Unit with IP Software	DEZ8R-SB	DEZBR-SB	DEBMP-FA	DEFBA-FA
Router Unit with MP Software	DEZ8R-RB	DEZBR-RB	DEBMP-DA	DEFBA-DA
Updates and Upgrades				
IP Software Update License	QL-4P2A9-RA	QL-5FAA9-RA	QL-4F4A9-RA	QL-4F0A9-RA
Multiprotocol Software Update License	QL-4P3A9-RA	QL-5FBA9-RA	QL-2XPA9-RA	QL-2XRA9-RA
Switching to IP Routing Upgrade License	N/A	N/A	QL-4F4A9-AA	QL-4F0A9-AA
Switching to MP Routing Upgrade License	N/A	N/A	QL-2XPA9-AA	QL-2XRA9-AA
IP to Multiprotocol Upgrade License	QL-4P4A9-AA	QL-5FCA9-AA	QL-4F5A9-AA	QL-4F1A9-AA
IP Software Media and Documentation	QA-4P2AA-H8	QA-5FAAA-H8	QA-4F4AA-H8	QA-4F0AA-H8
MP Software Media and Documentation	QA-4P3AA-H8	QA-5FBAA-H8	QA-2XPAA-H8	QA-2XRAA-H8
Hardcopy Documentation and Services				
Hardcopy Software Documentation	QA-4P3AA-GZ	QA-4P3AA-GZ	QA-4P3AA-GZ	QA-4P3AA-GZ
IP Software Product Services	QT-4P2A*-**	QT-5FAA*-**	QT-4F4A*-**	QT-4F0A*-**
MP Software Product Services	QT-4P3A*-**	QT-5FBA*-**	QT-2XPA*-**	QT-2XRA*-**

*Denotes the country kit variant or memory option. For additional information on available country kits, memory options, licenses, services, and media, refer to the appropriate price book.

IP Software License: The IP Software license provides IP, bridging, and WAN services including PPP, Frame Relay, X.25, V.25 *bis*, and Bandwidth Reservation.

Multiprotocol Software License: The Multiprotocol Software license includes all the IP Software protocols, as well as Novell IPX, AppleTalk, DECnet Phase IV, DECnet/OSI, Data Link Switching (DLSw), Boundary Access Node, SDLC Relay, and X.25 Switching.

Upgrade License: An IP to Multiprotocol Software Upgrade license is available for all the products. Customers who are upgrading should also purchase the Multiprotocol Software Media and Documentation kit for the Router.

SOFTWARE LICENSING

A separate license is required for each Router hardware unit on which the software product is to be used. This license is included in the price of the Router hardware. A license letter shipped with the hardware unit, along with the invoice, serves as proof of license. The software license may also be purchased separately.

The licensing provisions of Digital's Standard Terms and Conditions specify that the software and any part thereof (but excluding those parts specific to the load hosts) may be used only on the single Router hardware unit on which the software is operating, but may be copied, in whole or in part (with the proper inclusion of Digital's copyright notice and any proprietary notices on the software) between multiple load hosts on the same LAN.

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