Software Product Description

PRODUCT NAME: Distributed Routing Software, Version 3.0 **SPD 54.96.05**

This SPD describes Version 3.0 of Distributed Routing Software, which provides multiprotocol routing and bridging. This software is implemented on the products listed in Table 1. 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. The RouteAbout Access ES Software is described in SPD 56.42. The RouteAbout Access ISDN Software is described in SPD 56.55.

Table 1

Distributed Routing Software Version 3.0 Products

Product	Interfaces	Form Factor
RouteAbout Access EW	Ethernet, 2 T1/E1 Serial Lines	Standalone, MultiStack, or DEChub 90 Module
RouteAbout Access EI	Ethernet, Basic Rate ISDN, T1/E1 Serial Line	Standalone, MultiStack, 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
RouteAbout Central EP	2 Ethernet, 4 T1/E1 Serial Lines, 2 Primary Rate ISDN (T1 Version with 23 B and 1 D Channel; E1 Version with 30 B and 1 D Channel)	Standalone in DEChub ONE or Full-Height DEChub 900 Module

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
- SDLC Relay
- 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.

All of the RouteAbout models described in this SPD have at least one T1/E1 serial interface. The serial interface supports the PPP, SDLC, X.25 LAPB, and Frame Relay data links. The X.25 and Frame Relay public network services are supported. V.25 *bis* and DTR dialing are 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. The RouteAbout Central EP has two Primary Rate ISDN Interfaces. The ISDN 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 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, dialup lines, and leased 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 Intranet Manager for monitoring performance, tracing network paths, and generating reports. The Telesavings Monitor gauges the effect of telesavings controls for the router as a whole or for individual circuits.

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.

Transparent Proxy ARP: The Router supports Transparent Proxy ARP as described in RFC 1027.

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 Frame Relay when using PPP encapsulation 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.

BOOTP Relay: Distributed Routing Software supports BOOTP relay as defined in RFC 1542.

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 RFC 2091 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.

The Query Interval and Join Interval Timers control the number of PIM protocol messages sent across 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 Frame Relay DLCI 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 1027—Using ARP to Implement Transparent Subnet 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 1519—Classless Inter-Domain Routing (CIDR)
- RFC 1542—Clarifications and Extensions for BOOTP (BOOTP Relay)
- 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)
- RFC 2091—Triggered Extensions to RIP to Support Demand Circuits

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. NetBIOS over IPX filtering is also provided. These filters control the transmission of IPX data based on the source or destination network, host, or socket.

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 the Novell sanctioned encapsulations for IPX shown 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)

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.

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. The Router Frame Relay interface also supports IPX traffic over PPP via an encapsulation technique. ARP correctly resolves MAC addresses, while Inverse ARP maps the Frame Relay DLCI 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.

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 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 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. The Router Frame Relay interface also supports AppleTalk traffic over PPP via an encapsulation technique. AppleTalk ARP correctly resolves MAC addresses, while Inverse ARP maps the Frame Relay DLCI 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.

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. It also supports DECnet Phase IV traffic using PPP encapsulation over a Frame Relay virtual circuit.

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 (inter-area). 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. It also supports DECnet/OSI traffic using PPP encapsulation over a Frame Relay virtual circuit.

X.25 Support: Distributed Routing Software supports 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 support over X.25, the Router must be configured as a pure DECnet/OSI router. DECnet Phase IV cannot be configured at the same time and the routing algorithm must be Link State. 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

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.

The SDLC MIB is supported for monitoring. The Ports group, Link Station group, and traps are supported.

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

Bridging

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.

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

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.

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.

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
- RFC 1286—Bridge Management Information Base
- RFC 1493—Bridge MIB Objects
- 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* and DTR 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* or DTR dialup lines, Frame Relay SVCs, or ISDN B channels can be aggregated. All links in a bundle must have the same bandwidth. Bundled Frame Relay PVCs and SVCs must have the same Committed Information Rate (CIR), Committed Burst Size (Bc), and Excess Burst Size (Be). The maximum bundle is 32 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.

In a static configuration, the Router automatically brings up multiple leased lines, Frame Relay SVCs, or ISDN B channels upon restart.

In a dynamic configuration, Multilink PPP is running on a leased line or ISDN B channel at restart, with additional V.25 *bis* or DTR dialup, ISDN B channels, or Frame Relay SVCs brought up by the Bandwidth On Demand Monitor when the traffic threshold is exceeded. PAP or CHAP security must be used for dynamic configurations. Table 2 shows the supported dynamic Multilink PPP configurations.

Table 2
Bandwidth on Demand Dynamic Configurations

Primary Circuit	Secondary Circuits
PPP over Leased Line	POTS Dialup Lines
PPP over Leased Line	ISDN B Channels
PPP over Leased Line	Frame Relay SVCs
PPP over Frame Relay PVC	POTS Dialup
PPP over Frame Relay PVC	ISDN B Channel
PPP over Frame Relay PVC	Frame Relay SVC
PPP over ISDN B Channel	POTS Dialup Lines
PPP over ISDN B Channel	ISDN B Channels
PPP over ISDN B Channel	Frame Relay SVC

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. 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 or SVC basis. Compression ratios as high as 4 to 1 are possible. The Bandwidth Reservation System and filters apply to compressed circuits. The RouteAbout Central EP contains a hardware co-processor that performs the data compression function.

Distributed Routing Software also provides LAT tinygram compression over PPP as described above, IP header compression as described in the TCP/IP Routing section, and X.25 data compression as described in the X.25 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

SDLC Data Link

The Synchronous Data Link Control (SDLC) protocol supports the SDLC Relay function. SDLC is supported on X.21, V.35, RS232/V.28, and the other physical interfaces.

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 supports X.25 over ISDN networks by providing transparent access over a B channel connection between point-to-point DTEs.

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

X.25 Over ISDN: Distributed Routing Software supports X.25 traffic over ISDN networks by providing point-to-point transparent access between two routers acting as DTEs. The Router uses ISDN D channel signalling to establish a B channel connection with the remote router. The routers then use the B channel in much the same way as a permanent X.25 PSDN connection. X.32 dialup access to a DCE is not supported.

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 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 running the Link State routing protocol. 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 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 EI	15	2	128
RouteAbout Central EW	15	8	512
RouteAbout Central EI	15	4	512
RouteAbout Central EP	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. The RouteAbout Central EP contains a hardware co-processor that performs the data compression function.

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.)
- ITU X.31 Recommendation (X.25 over ISDN B Channel: Case A)
- 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) and Switched Virtual Circuit (SVC) connections. Frame Relay can run up to T1/E1 speeds. Each Router interface supports as many as 64 Frame Relay virtual circuits.

Leased Line Access: The router can access the Frame Relay network via a leased line connection. In this case, physical access is through the serial port, either point-to-point or via the network side of a CSU/DSU.

Switched Access: The Router can access the Frame Relay network with a switched circuit connection, using ISDN, V.25 *bis* modems, or DTR dialing modems. Switched access saves the expense of having a permanent leased line for access to the Frame Relay network.

Permanent Virtual Circuits: 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.

Switched Virtual Circuits: The Frame Relay interface supports Switched Virtual Circuits (SVCs) as defined by Frame Relay Forum Implementation Agreement 4 (FRF.4). Frame Relay SVCs can be used as dial circuits with the PPP data link and all of its functions. E.164 Frame Relay dial addresses identify the remote router. Frame Relay SVCs also support RFC 1490 encapsulation of IP, Novell IPX, AppleTalk, or DECnet Phase IV. Frame Relay SVCs can serve as WAN reroute circuits for leased line, ISDN, or Frame Relay PVC connections. Frame Relay SVCs can also be used for bandwidth on demand for Multilink PPP bundles that contain leased lines, ISDN B channels, or Frame Relay PVCs.

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 Via RFC 1490: 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.

Protocol Multiplexing on PVCs: Packets forwarded on the Frame Relay interface are multiplexed on different permanent virtual circuits, depending on the network protocol address to virtual circuit mapping. Each permanent virtual circuit has a Data Link Connection Identifier (DLCI). Network protocol addresses are mapped to DLCIs 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.

Protocol Multiplexing on SVCs: For RFC 1490 encapsulation over Frame Relay SVCs, the Router multiplexes packets on different switched virtual circuits depending on the network protocol address to virtual circuit mapping. Each SVC is configured with the E.164 address of the remote router. Network layer addresses are then statically mapped to the remote router's E.164 address.

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 transmission of multicast traffic such as RIP over Frame Relay SVCs can be enabled on an SVC by SVC basis. 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 virtual circuit. Variable Information Rate supports three parameters per virtual circuit: Committed Information Rate (CIR), Committed Burst Size (Bc), and Excess Burst Size (Be). The Router uses these parameters with congestion monitoring to optimize virtual circuit throughput. When the network is congested, the Router reduces the calculated value for each virtual circuit's VIR to the minimum. The Router also determines the maximum value each virtual circuit 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: The Router supports Bandwidth Reservation over Frame Relay PVCs. Bandwidth Reservation can be applied separately to each permanent 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 permanent 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 PVC circuits can be rerouted to V.25 *bis* or DTR dialup lines, Basic Rate ISDN channels, or Frame Relay SVCs.

Dial on Demand for TCP/IP: Dial on Demand with a Frame Relay SVC as the primary circuit is supported for TCP/IP routing using triggered RIP and PPP encapsulation. The Router also supports dial on demand for TCP/IP static routing using RFC 1490 encapsulation.

Dial on Demand for Novell IPX: Dial on demand for Novell NetWare routing over Frame Relay SVCs is supported using either PPP encapsulation or RFC 1490 encapsulation. Novell server spoofing is supported for PPP encapsulation. With server spoofing, 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 reduces WAN overhead.

Dial on Demand for DECnet/OSI: Dial on Demand with a Frame Relay SVC as the primary circuit is supported for DECnet/OSI routing using using PPP encapsulation.

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 virtual circuit basis. Compression ratios as high as to 4 to 1 are possible. The Bandwidth Reservation System and filters apply to compressed circuits. The RouteAbout Central EP contains a hardware co-processor that performs the data compression function.

Calling ID Verification: The Router checks the calling ID of the calling router against an authorized list before accepting a Frame Relay SVC connection.

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 A—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 Forum User-to-Network SVC Implementation Agreement FRF.4
- Frame Relay Interface Specification, Revision 3.0, StrataCom, Inc., 1990
- ITU Q.922—LAPF (as specified by FRF.4)
- 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. These ports support line speeds from 4800 baud to 2.048 Mb/s, depending on the physical interface connector used. 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, SDLC, X.25 LAPB, and Frame Relay data links.

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 dialup circuits. Dialup circuits are established by a modem, CSU/DSU or ISDN Terminal Adapter on the serial line, by the Frame Relay interface, or by the ISDN interface. Refer to the Frame Relay Interface and ISDN Interface sections for more information.

The router supports dialup access through the serial line interface or ISDN interface to the Frame Relay network, saving the expense of having a permanent leased line for Frame Relay access.

An Idle Timer disconnects the dialup line when there is no traffic, reducing WAN transmission costs in use-based tariff regions.

Dialup Devices Supported: Switched circuit support via the serial line interface requires use of a V.25 *bis*-compliant synchronous modem, DTR dialing 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.

DTR dialing modems are simple, inexpensive devices that follow the "direct call" procedures outlined in the V.25 *bis* specification. DTR dialing modems store a single telephone number that is typically entered through Hayes AT commands from an asynchronous terminal attached to the modem during configuration. When the router has data to send on the dialup line, it raises the DTR signal, causing the modem to dial its stored number. Likewise, the modem raises the RI signal when there is an incoming call, causing the router to raise DTR and accept the call.

WAN Restoral: When configured for WAN restoral, two Routers are linked by primary and secondary WAN circuits. 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* or DTR dialing 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 data links.

The RouteAbout Access EI, the RouteAbout Central EI, and the RouteAbout Central EP 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. 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. In this table, the acronym *POTS*, Plain Old Telephone Service, refers to V.25 *bis* or DTR dialing modems.

Table 5

WAN Rerouting Configurations

Primary Circuit	Secondary Circuit
PPP over Leased Line	POTS Dialup
PPP over Leased Line	Basic Rate ISDN
PPP over Leased Line	Frame Relay SVC
PPP over Frame Relay PVC	POTS Dialup
PPP over Frame Relay PVC	Basic Rate ISDN
PPP over Frame Relay PVC	Frame Relay SVC
PPP over ISDN B Channel	Frame Relay SVC

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.

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. The RouteAbout Central EP contains a hardware coprocessor that performs the data compression function.

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. The RouteAbout Central EP has two Primary Rate ISDN interfaces. Each ISDN Basic Rate interface provides two 64 Kb/s B channels for data and a 16 Kb/s D channel for signaling. The RouteAbout Central EP has a T1 variant and an E1 variant. On the T1 variant, each Primary Rate ISDN interface provides 23 64 Kb/s B channels for data and a 64 Kb/s D channel for signaling. On the E1 variant, each interface provides 30 B channels, one D channel, and a signaling channel. As many as 100 dialup circuits are supported on each Router. Bandwidth Reservation is supported on the ISDN interface.

Basic Rate 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. Optional power feeding is not supported. 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.

Primary Rate Interface: The RouteAbout Central EP provides two Primary Rate ISDN interfaces via RJ45 connectors on the front panel. An external CSU is required for connection to the carrier ISDN local loop.

The T1 variant of the Primary Rate ISDN interface provides D4 or Extended Super Frame (ESF) framing, AMI or B8ZS line coding, and master or slave clocking. Optional power feeding is not supported.

The E1 variant provides Doubleframe or Multiframe framing, HDB3 or AMI line coding, and master or slave clocking. Optional power feeding is not supported.

The applicable Red, Yellow, and Blue alarms are reflected by the state of the LEDs on the front panel. Alarm state and error counters are also available through the command line interface.

PPP Data Link Support: The PPP data link is 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. ISDN B channels can be aggregated with leased lines, Frame Relay PVCs or SVCs, or other ISDN B channels. 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.

Frame Relay Over ISDN: The Router can access the Frame Relay network over an ISDN switched circuit, saving the expense of having a permanent leased line for Frame Relay access.

X.25 Over ISDN: The Router supports X.25 over ISDN networks by providing transparent access over a B channel connection between point-to-point DTEs. Refer to the X.25 section of this SPD for more information.

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 reduces WAN overhead.

Calling ID Verification and Call Acceptance: The RouteAbout Access EI, RouteAbout Central EI, and RouteAbout Central EP check the calling ID of incoming calls against an authorized list before accepting the connection. In V3.0, the Router checks incoming calls before accepting them to see if there is a suitable match on the list of dial circuits. If the Router does not find a suitable match, it releases the call.

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 PVC circuit can be rerouted to a Basic Rate ISDN circuit. PPP over an ISDN B Channel can be rerouted to a Frame Relay SVC.

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. The RouteAbout Central EP contains a hardware coprocessor that performs the data compression function.

Idle Timer: An Idle Timer disconnects the ISDN dial circuit when there is no traffic, reducing WAN transmission costs in use-based tariff regions. The Idle Timer does not apply to Frame Relay over ISDN connections.

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

Table 6

Supported ISDN Standards and Switches

Country or Region	Supported Standards	Supported Switches
United States	BRI: FCC Part 68 PRI: FCC Part 68	BRI: National ISDN 1 ATT 5ESS NT DMS100 PRI: National ISDN 2 ATT 4ESS ATT 5ESS NT DMS100
Canada	BRI: CS03 PRI: CS03	
Europe	BRI: CTR3 PRI: CTR4	BRI: Net3 VN3 PRI: NET5
Australia	BRI: TS013 TS031 PRI: TS014 TS038	BRI: AUSTEL TS013 PRI: AUSTEL TS014
Japan	Green Book	BRI: INS64 PRI: INS1500

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 Products: The RouteAbout Central products have two Ethernet unshielded twisted-pair (UTP) 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

Bandwidth Reservation System

Bandwidth Reservation guarantees outgoing bandwidth on serial lines, Frame Relay PVCs, V.25 *bis* switched circuits, DTR dialing switched circuits, and ISDN lines. Uncompressed PPP and compressed PPP data links are supported. Bandwidth Reservation is not available for X.25 interfaces and Frame Relay SVCs. 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 permanent 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 permanent 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.

Telesavings

Distributed Routing Software includes a number of Telesavings functions that control and monitor the use of demand circuits. Supported demand circuits include DTR and V.25 *bis* dialup lines, ISDN, X.25 over ISDN, Frame Relay over ISDN, and Frame Relay SVCs. These Telesavings functions take advantage of the Time of Year clock in the RouteAbout Central products. These functions are also supported on the RouteAbout Access products, but the time setting must be provided upon reboot or by a local time server. The Telesavings Monitor is a web based graphical tool that monitors the effects of telesavings features, allowing you to tune and control telesavings.

Budget Controls by Router or Circuit: The Budget Control function sets a budget for the router as a whole or for individual circuits. This function prevents surprise bills due to high usage, incorrect tuning of timers and filters, or poor usage practices. Budget Control monitors usage, allowing for early identification and correction of problems.

The budget can be set based on time connected or charge units. A circuit level budget can be set as a percentage of the overall router budget. The budget can be applied to incoming calls, outgoing calls, or both. An overdraft budget can be set as a percentage of the overall budget. A Refresh period set by time of year resets the budget at appropriate intervals. When a set percentage (threshold) of the budget is used, the router can be configured to log an event or send an SNMP trap. Likewise, when the entire budget is used, the router can log an event, send an SNMP trap, apply the overdraft, block charged calls, or block all calls.

Initial Minimum Call Timer: Many ISDN service providers impose a minimum call charge that often varies depending on the time of week—for example 30 seconds on week days and 90 seconds on weekends. It makes sense to keep the call up for this prepaid initial minimum period in case there is more data to send and to avoid making back-to-back minimum duration calls. The Initial Minimum Call Timer function sets the time that the router will keep a call open, based on a time of week profile stored in the RouteAbout Central. This function interworks with the Idle Timer and the Bandwidth on Demand Monitor.

Call Blocking by Time of Week: The Call Blocking function controls when the RouteAbout Central allows inbound calls, outbound calls, or all calls based on a time of week profile. Possible actions include logging an event, sending an SNMP trap, or blocking the call.

An optional feature clears appropriate calls upon entering a blocking period. For example, if outbound calls are blocked starting Saturday at 5:00 PM, the router clears any existing outbound calls and prevents new ones from being established.

Call Back by Time of Week: The Call Back function controls when the RouteAbout Central will call back incoming calls, based on a time of week profile stored in the router. This function allows centralizing call charges at the central site to take advantage of volume discounts offered by some service providers. The Call Back function controls the location that is billed, allowing you to take advantage of geographical differences in tariffs. The Time of Week profile takes advantage of different tariff zones in different regions.

The RouteAbout Central uses the Calling Line Identifier (CLI) facility to implement one-call call back. This facility is compatible with PPP LCP call back. Most service providers charge for the CLI facility, so it makes sense to centralize CLI at the central site.

Other Connection Management Functions: Other telesavings connection management functions in Distributed Routing Software include the Idle Timer, Bandwidth on Demand, and WAN Restoral/Reroute. The Idle Timer closes a dial circuit after a configurable interval of inactivity, eliminating charges for inactive lines. Bandwidth on Demand is a cost effective way of adding additional bandwidth for peak usage periods, avoiding the cost of having higher capacity permanent leased lines. (Refer to the PPP Data Link section for more information.) WAN Restoral and Reroute ensure connectivity without the cost of having permanent redundant lines. (Refer to the Serial Line Interface section for more information.)

Data Management: Distributed Routing Software includes many features that reduce the amount of data sent across expensive WAN lines. These features also ensure that dial circuits are brought up only when there is real data to send.

Compression reduces the amount of data sent over WAN lines, allowing the use of lower capacity leased lines or reducing the amount of time that dial circuits are kept open. All of the RouteAbout models described in this SPD support the PPP Compression Control Protocol (CCP) and STAC LZS V5.0 software compression. They also support TCP/IP header compression and X.25 data compression. The RouteAbout Central EP also has a hardware compression co-processor. (For more information on compression, see the PPP data link section.)

The TCP/IP protocol includes many data management features including triggered RIP, static routes, TCP keepalive spoofing, IP filtering, and PIM timers. (For more information on these features, see the TCP/IP Routing section.)

The Novell IPX protocol also provides many features that control the amount of data sent out on the WAN. These data management features include IPX filtering, NetBIOS over IPX filtering, Server keepalive spoofing, RIP/SAP route and service filtering, and RIP/SAP broadcast timers. (For more information on these features, see the Novell Netware Routing section.)

Filtering is provided for AppleTalk as detailed in the AppleTalk section. The bridging function supports MAC address and protocol filtering as described in the Bridging section of this SPD.

Service Installation Cost Reduction: X.25 over ISDN and Frame Relay over ISDN reduce the cost of installing these services for a location, as well as eliminating the need for a dedicated access line. (For more information, see the ISDN section.)

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 can be either local or remote.

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 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 itself. The setup port on the DEChub ONE takes the user directly to the RouteAbout Central setup menu.

The RouteAbout Access products also support setup through a direct connection to the Router console port.

The RouteAbout 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. The Quickconfig utility or the *clear*VISN Router Configurator can also be used to complete the configuration.

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 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. Version 3.0 of the utility configures IP, IPX, DECnet, OSI, bridging, PPP, Multilink PPP, V.25 *bis* and DTR dial circuits, ISDN, Frame Relay, WAN Restoral, and Telesavings features. Router configurations either can be generated live or generated off line for downline loading at a convenient time. Router Configurator loads the configuration files using BOOTP and the Trivial File Transfer Protocol (TFTP). The tool also supports dump file configuration. The DECNIS configuration can be installed on the same system as the Router Configurator, allowing the user to share the browser by showing DECNIS and RouteAbout configurations in the same display.

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 RouteAbout Central products 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 Intranet Manager:** The *clear*VISN Intranet Manager manages multivendor networks comprised of RouteAbout, DECswitch, DECNIS, DECbrouter, Cisco Systems, Bay Networks, 3Com, and Novell routers and switches. The application also supports other routers and switches to the extent that they support MIB-II and other standard MIBs. For RouteAbout 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. Intranet Manager includes WAN Services Management, which manages WAN services such as Frame Relay, ISDN, and X.25.

Telesavings Monitor: The Telesavings monitor is a web-based tool that uses the Telesavings SNMP MIB objects and other MIB objects to gauge the effects of Telesavings controls. The tool also dynamically resets budget controls. A bar in the initial screen shows the percentage of the budget remaining. The Box screen shows data for the router as a whole. The Circuit screen details individual ISDN or Frame Relay SVC circuits.

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. UNIX and VMS versions of this application are available, as well as Windows 95 and Windows NT versions that have a graphical user interface. The DTF application supports in-depth tracing of data moving through the Router for troubleshooting and analysis. Distributed Routing Software V3.0 includes DTF tracepoints for X.25, Frame Relay, and ISDN D channel.

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. All of the private MIBs listed below are freely available to the public.

- 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 1243—AppleTalk MIB
- RFC 1253—OSPF Version 2 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 1493—Bridge MIB Objects
- 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)
- LLC MIB (Internet Draft Version 01)
- Novell IPX MIB
- Novell RIP-SAP MIB
- Telesavings Private MIB

SNMP LAN Support: Error statistics are collected on a node and port basis for Ethernet. System delta events are captured in an event log for retrieval by an SNMP network management system.

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 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. 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 Central 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 products, a 10Base-T (RJ45) Ethernet connection is required for each Ethernet interface on the front panel.

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 three-meter cable is provided for connecting the RouteAbout ISDN port to the NT 1. (Two of these cables are shipped with the RouteAbout Central EI.) To purchase additional cables for the other ISDN ports on the RouteAbout Central EI, order part number BN25G-03.

For the RouteAbout Central EP E1 variant, two three-meter cables are provided for connecting the RouteAbout Primary Rate ISDN ports to the carrier equipment or CSUs. This cable has a Modular Plug 8 (MP8) connection on the RouteAbout side and is unterminated on the CSU side. The unterminated end can be attached to screw-type connectors or to Insulation Displacement Connector (IDC) punchdown blocks.

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, DTR dialing modem, CSU/DSU, or terminal adapter (for ISDN services). V.25bis 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 Basic Rate ISDN Lines: In North America, an NT 1 Network Termination is required for connecting the RouteAbout Access EI or RouteAbout Central EI Basic Rate ISDN line to the ISDN carrier local loop. Elsewhere in the world, the carrier provides the NT 1.

CSU for Primary Rate ISDN Lines: A CSU is required for connecting each Primary Rate ISDN interface on the RouteAbout Central EP to the ISDN carrier local loop.

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 MultiChassis Manager:** The *clear*VISN MultiChassis Manager Version 5.0 or later is required for configuring the hub backplane channel attachment of modules in DEChub configurations. Version 6.3 is required for the RouteAbout Central EP.

***clear*VISN Stack Manager:** The *clear*VISN Stack Manager Version 1.0 or later can be used to manage the RouteAbout Access EW and RouteAbout Access EI in DIGITAL MultiStack systems.

***clear*VISN Intranet Manager:** The *clear*VISN Intranet Manager Version 2.0 can be used to monitor performance, trace network paths, generate events, and produce reports. Intranet Manager also manages WAN services such as ISDN, X.25, and Frame Relay.

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.

Year 2000 Compliance

Distributed Routing Software is compliant with Year 2000 requirements.

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 an Adobe Acrobat Reader. This reader runs on Windows 3.1, Windows 95, and Windows NT systems.

ORDERING INFORMATION

For initial purchase of a Router, use the DE***-** option number shown in Table 8. 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 an Adobe Acrobat documentation reader. A hardware installation manual and a Software Quick Reference Guide are also included. To purchase a complete hardcopy documentation set, use the GZ kit part number listed in Table 8.

Table 8
Distributed Routing Software V3.0 Ordering Information

	RouteAbout Access EW	RouteAbout Access EI	RouteAbout Central EW	RouteAbout Central EI	RouteAbout Central EP
Initial Ordering					
Router Unit with IP Software					
Standalone	DEX2R-F*	DEXBR-F*	N/A	N/A	N/A
Hub	DEX2R-MB	DEXBR-MB	DEZ8R-SB	DEZBR-SB	N/A
MultiStack	DEX2R-T*	DEXBR-T*	N/A	N/A	N/A
Router Unit with MP Software					
Standalone	DEX2R-D*	DEXBR-D*	N/A	N/A	N/A
Hub	DEX2R-MA	DEXBR-MA	DEZ8R-RB	DEZBR-RB	DEZPR-RB (T1) DEZPR-RC (E1)
MultiStack	DEX2R-S*	DEXBR-S*	N/A	N/A	N/A
Updates and Upgrades					
IP Software Update License	QL-4C1A9-RA	QL-4SQA9-RA	QL-4P2A9-RA	QL-5FAA9-RA	N/A
Multiprotocol Software Update License	QL-4C2A9-RA	QL-4SRA9-RA	QL-4P3A9-RA	QL-5FBA9-RA	QL-5LHA9-RA
IP to Multiprotocol Upgrade License	QL-4C3A9-AA	QL-4SSA9-AA	QL-4P4A9-RA	QL-5FCA9-RA	N/A
IP Software Media and Documentation	QA-4C1AA-H8	QA-4SQAA-H8	QA-4P2AA-H8	QA-5FAAA-H8	N/A
MP Software Media and Documentation	QA-4C2AA-H8	QA-4SRAA-H8	QA-4P3AA-H8	QA-5FBAA-H8	QA-5LHAA-H8
Hardcopy Documentation and Services					
Hardcopy Software Documentation	QA-4P3AA-GZ	QA-4P3AA-GZ	QA-4P3AA-GZ	QA-4P3AA-GZ	QA-4P3AA-GZ
IP Software Product Services	QT-4C1A*-**	QT-4SQA*-**	QT-4P2A*-**	QT-5FAA*-**	N/A
MP Software Product Services	QT-4C2A*-**	QT-4SRA*-**	QT-4P3A*-**	QT-5FBA*-**	QT-5LHA*-**

*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, 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.

This software is furnished under the licensing provisions of DIGITAL's Standard Terms and Conditions. For more information about DIGITAL's licensing terms and policies, contact your local DIGITAL office.

SOFTWARE PRODUCT SERVICES

A variety of service options are available from DIGITAL. For more information, contact your local DIGITAL office.

SOFTWARE WARRANTY

Warranty for this software product is provided by DIGITAL with the purchase of a license for the product as defined in the Software Warranty Addendum of this SPD.

The above information is valid at time of release. Please contact your local DIGITAL office for the most up-to-date information.