# Planning Your Network 1

This chapter describes planning steps that will make it easier to configure the physical interfaces, logical interfaces, and routing protocols for the ERX system in:

- A new network that you are creating and implementing
- An existing network that you are expanding

## Applications Overview

The system can be used for a number of edge aggregation applications. Two of the most common are:

- Private line aggregation
- xDSL session termination

### *Private Line Aggregation*

A major application for the ERX edge router is for private line aggregation—the consolidation of multiple high-speed access lines into one access point. See Figure 1-1.

In this application, the service provider can use a single system to offer high-speed access (FT1/FE1 through T3/E3) to thousands of subscribers. The individual subscriber lines can be multiplexed into T3 lines by the service provider and fed into the system. (The system can also accept unchannelized T3 or E3 connections from high-speed users and channelized E1 connections directly into the unit.) Once the traffic is received, the system then handles all IP packet processing, including the assignment of QoS and routing policies. The packets are then routed into the backbone network.

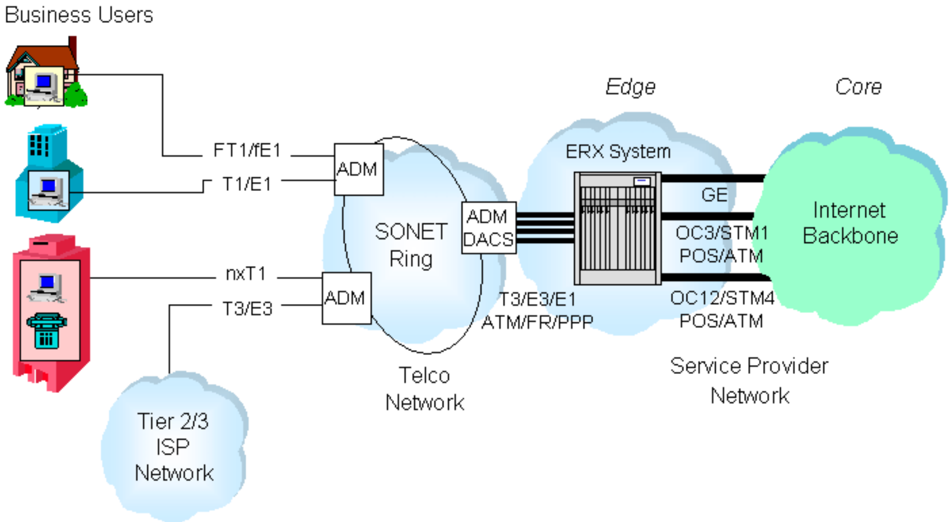


**Figure 1-1** Private line aggregation with the ERX system

The system supports a number of access and uplink methods; the most common pairings are listed in Table 1-1.

**Table 1-1** Common access/uplink pairings

| Access | Uplink |
|---|---|
| PPP | ATM, Fast Ethernet, Gigabit Ethernet, or POS |
| Frame Relay | |
| ATM | |

*xDSL Session Termination*

The system supports Broadband Remote Access Server (B-RAS) applications, as shown in Figure 1-2. In this application, the system handles the aggregated output from the digital subscriber line access multiplexers (DSLAMs). Directly connected to the subscriber premises, the DSLAMs handle the copper termination and aggregate the traffic into a higher-speed uplink. The output from the DSLAM is fed into the system through a DS3 or OC3 link.

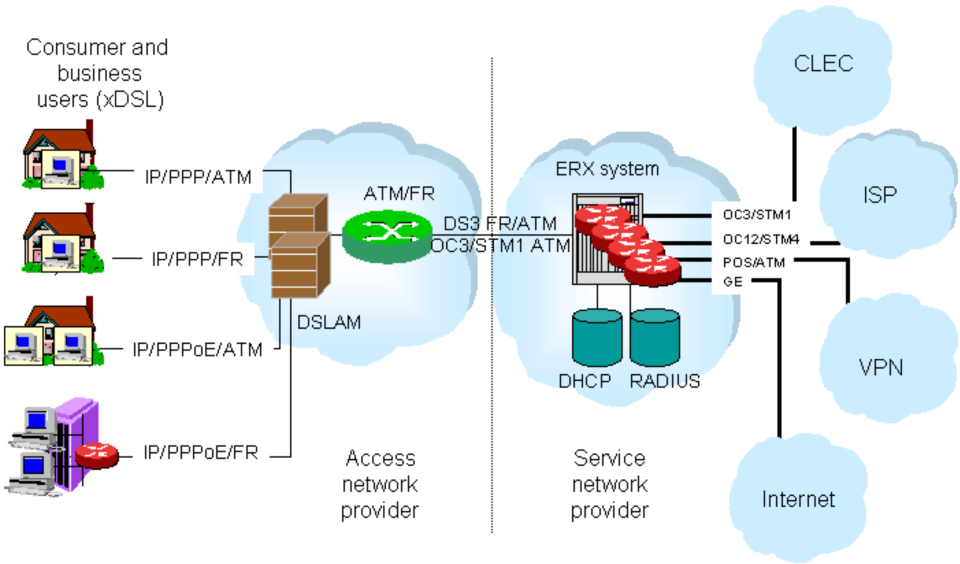


**Figure 1-2** B-RAS application

The system then performs several functions:

- PPP session termination and authentication checking through PAP or CHAP
- Coordination with DHCP servers and local IP pools to assign IP addresses
- Connection to RADIUS servers or use of domain names to associate subscribers with user profile information
- Support for RADIUS accounting to gather detailed billing information
- Application of the user profile to the user traffic flow, which could include QoS, VPN, and routing profiles

The output of the system is typically a high-speed link, such as OC3/STM1 to feed a core backbone router. Virtual routers can also be used to keep the traffic logically separate and to direct packets to different destinations. As shown in Figure 1-2, the packets can be directed to a CLEC, ISP, corporate VPN, or the Internet.

A large number of xDSL protocols are supported, including:

- IP/PPP/ATM
- IP/PPP/Ethernet/ATM
- IP/bridged Ethernet/ATM

See *ERX Broadband Access Configuration Guide, Chapter 1, Configuring Remote Access to the ERX System*, for information on configuring B-RAS.

## Layered Approach

The *ERX Configuration Guides* use a bottom-up approach to describe the configuration process. Figure 1-3 shows the relationship of layers, protocols, and interfaces to the configuration process. Software functions are layered on top of physical (copper or optical) interfaces. The system supports a number of access protocols (PPP/POS, Frame Relay, ATM) that allow service providers to offer a number of access methods and line speeds to their subscribers. The system is optimized to handle IP connections regardless of the access protocol used. The system also supports a number of protocols that are specific to the B-RAS application. These are shown in Figure 1-3, and include IP/PPP/ATM and IP/PPP/Ethernet/ATM.

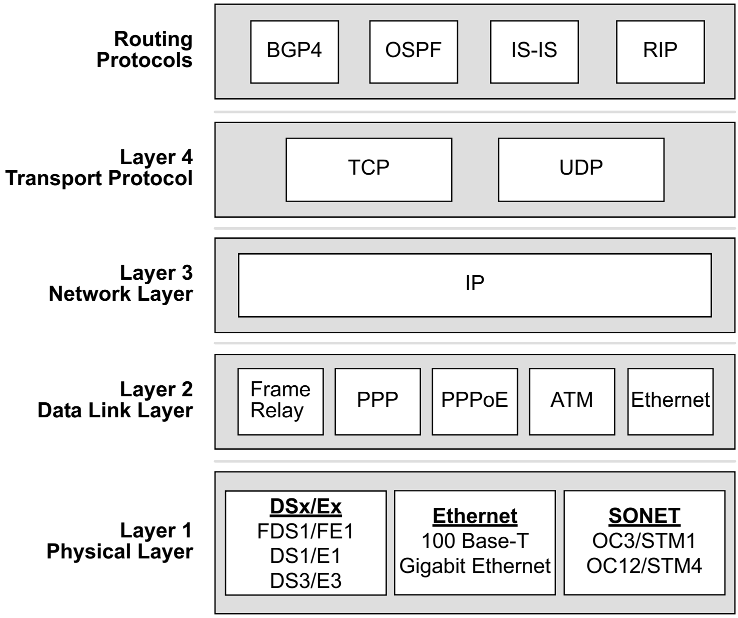


**Figure 1-3** Network configuration using a bottom-up approach

Layer 2 (data link) defines how the data is packaged and sent to an IP data connection point in layer 3 (IP interfaces). In layer 3, you define the global attributes for IP services that serve as a platform from which you add routing information.

## Line Modules and I/O Modules

A range of line modules and input/output (I/O) modules is available for the system. With the exception of the IPSec Service line module and Tunnel Service line module (TSM), each line module pairs with a corresponding I/O module.

I/O modules provide the input and output connections from the network to the system. Line modules connect to their corresponding I/O modules through a passive midplane. A line module receives packets through its I/O module, and processes those packets. The system then routes the packets out to the network through the designated I/O module.

Each line module and I/O module has a label on its faceplate. In this documentation, line modules and I/O modules are identified by that label. For example, the 3-port CT3 line module is called the CT3 line module, and its corresponding I/O module is the CT3/T3 I/O module.

When referring to a related set of line modules or I/O modules, the generic information from the module labels is used in this documentation. For example, the term “OCx/STMx line modules” refers to both the OCx/STMx ATM and the OCx/STMx POS line modules. Similarly, the term “GE I/O modules” refers to both the GE Multimode I/O module and the GE Single Mode I/O module.

For a complete list of the line modules and I/O modules available, see *ERX Installation and User Guide*, *Appendix B, Module Specifications*.

## Interfaces

The term *interfaces* is used in a very specific way in this documentation. Interfaces are both physical and logical channels on the system that define how data is transmitted to and received from lower layers in the protocol stack. Conceptually, you configure an interface as part of the physical layer, layer 1.

You configure the physical and logical characteristics of T3 and T1 lines coming directly from your customer’s premises or from a central office switch and OC3 lines going out to the core of your network infrastructure. These physical and logical characteristics define an interface.

Interface layering must always be configured in order from the lowest layer to the highest layer. For example, if you have already configured IP to run over ATM and you want to reconfigure the interface to run IP over PPP over ATM, you must first remove the IP interface, apply PPP, and then reapply IP.

### *Subinterfaces*

A subinterface is a mechanism that allows a single physical interface to support multiple logical interfaces or networks. Several logical interfaces or networks can be associated with a single physical interface. Configuring multiple virtual interfaces, or subinterfaces, on a single physical interface allows greater flexibility and connectivity on the network.

Protocols such as Frame Relay and ATM require that you create one or more virtual circuits over which your data traffic is transmitted to higher layers in the protocol stack. The system requires that you define a subinterface on top of a physical interface as a platform for a virtual circuit, such as a permanent virtual circuit (PVC).

Once you have defined the underlying characteristics of an interface, use the **interface** command to:

1. Assign an *interface type*, such as POS or ATM.
2. Assign the associated *interface specifier* to the interface, such as the slot/port and channel/subchannel.
3. Assign one or more subinterfaces.

### *interface Command*

The **interface** command has the following format:

**interface** *interfaceType interfaceSpecifier*

Each interface type has an interface specifier associated with it. The interface specifier identifies the physical location of the interface on the system, such as the chassis slot and port number, and logical interface information, such as an T1 channel on an Channelized T3 interface.

The system supports the interface types shown in Table 1-2.

**Table 1-2** Interface types

| Interface Type Variable | Interface Specifier Variable | To configure, see … |
|---|---|---|
| atm | slot/port[.subinterface] | *ERX Physical and Link Layers Configuration Guide, Chapter 10, Configuring ATM* |
| ethernet | slot/port.subinterface | *ERX Physical and Link Layers Configuration Guide, Chapter 6, Configuring Ethernet Interfaces* |
| hssi | slot/port | *ERX Physical and Link Layers Configuration Guide, Chapter 7, Configuring HSSIs* |
| loopback | loopback number | *ERX Command Reference Guide* |
| mlframe-relay | bundle-name [.subinterface ] | *ERX Physical and Link Layers Configuration Guide, Chapter 12, Configuring Multilink Frame Relay* |
| mlppp | bundle-name | *ERX Physical and Link Layers Configuration Guide, Chapter 14, Configuring Multilink PPP* |
| pos | slot/port | *ERX Physical and Link Layers Configuration Guide, Chapter 15, Configuring Packet over SONET* |

**Table 1-2** Interface types (continued)

| Interface Type Variable | Interface Specifier Variable | To configure, see … |
|---|---|---|
| serial | Depends on type of interface | *ERX Physical and Link Layers Configuration Guide, Chapter 1, Configuring Channelized T3 Interfaces*<br>*ERX Physical and Link Layers Configuration Guide, Chapter 2, Configuring T3 and E3 Interfaces*<br>*ERX Physical and Link Layers Configuration Guide, Chapter 3, Configuring CT1 and CE1 Interfaces*<br>*ERX Physical and Link Layers Configuration Guide, Chapter 5, Configuring Channelized OCx/STMx Interfaces*<br>*ERX Physical and Link Layers Configuration Guide, Chapter 8, Configuring X.21/V.35 Interfaces* |
| tunnel | tunnel-type:tunnel-name | *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 4, Configuring IP Tunnels*<br>*ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 10, Configuring IPSec*<br>*ERX Broadband Access Configuration Guide, Chapter 4, Configuring L2TP*<br>*ERX Broadband Access Configuration Guide, Chapter 5, Configuring L2F* |
| null | 0 | *ERX Command Reference Guide* and *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 1, Configuring Routing Policy*. |

For detailed information about interface types and specifiers and for specific syntax for the **interface** command, see the *ERX Command Reference Guide.*

## General Configuration Tasks

The configuration process involves the following general tasks:

1. Determine information about physical and logical characteristics and IP-addressing information of the various interfaces you want to configure.
2. Determine information about the link layer protocols.
3. Determine how to organize virtual routers on the system.
4. Determine how IPSec will be used to provide security.
5. Determine routing information that defines all or part of the network.
6. Create the virtual routers.

7. Configure the interfaces and subinterfaces (such as CT3, OCx/STMx, and HDLC data channels) over which the higher-layer protocols run.
8. Configure the data link layer protocols, such as Frame Relay, PPP, and ATM, that run over these physical interfaces.
9. Configure the general IP information from which the other routing protocols will operate.
10. Configure IP tunnels, shared interfaces, and subscriber interfaces.
11. Configure IPSec.
12. Configure the routing protocols that will run on the system, such as IP multicasting, OSPF, IS-IS, RIP, BGP-4, and MPLS.
13. Configure Virtual Router Redundancy Protocol (VRRP) on IP/Ethernet interfaces.
14. Configure QoS and policy management.
15. Configure the system for remote access.
16. Use the appropriate **show** commands to display network activity on each of the interfaces that you have configured. Do this to verify that they are operating as you expect and to help improve the management of your network.

## Configuring Virtual Routers

Multiple distinct routers are supported within a single system, which allows service providers to configure multiple, separate, secure routers within a single chassis. These routers are identified as *virtual routers (VRs)*. Applications for this function include the creation of individual routers dedicated to wholesale customers, corporate virtual private network (VPN) users, or a specific traffic type.

The system implements the virtual routers by maintaining a separate instance of each data structure for each virtual router and allowing each protocol to be enabled on a case-by-case basis. Virtual routers provide full support for all supported routing protocols (unicast, multicast, and MPLS).

For information on configuring virtual routers, see *Chapter 10, Configuring Virtual Routers*.

## Configuring IPSec

IPSec provides security to IP flows through the use of authentication and encryption.

- Authentication verifies that data is not altered during transmission and ensures that users are communicating with the individual or organization that they believe they are communicating with.
- Encryption makes data confidential by making it unreadable to everyone except the sender and intended recipient.

IPSec comprises two encapsulating protocols:

- Encapsulating Security Payload (ESP) provides confidentiality and authentication functions to every data packet.
- Authentication Header (AH) provides authentication to every data packet.

For information about configuring IPSec, see *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 10, Configuring IPSec*.

## Configuring Physical Layer Interfaces

The system supports a number of line rates; some of these are listed per line module below.

- E3 line module and COCX-F3 line module support unchannelized E3.
- CE1 module supports E1 and fractional E1.
- Channelized OCx/STMx (cOCx/STMx) line module supports DS3 channelized to DS1, fractional DS1, or the DS0 level; unchannelized DS3; E1/T1 channelized to fractional DS1; unframed E1.
- CT1 line module supports T1 and fractional T1.
- CT3 and CT3 12-FO line modules support DS3 channelized to DS1, fractional DS1, or the DS0 level. CT3 12-FO line modules also support unchannelized T3.
- FE-2 line module supports Fast Ethernet.
- HSSI line module supports high-speed serial interfaces.
- IPSec Service module provides tunnel service for secure tunnels.
- GE/FE line module supports Gigabit Ethernet and Fast Ethernet.
- OC3/STM1 (dual-port) line module supports OC3/STM1.

- OCx/STMx ATM line module supports OC3/STM1 ATM, OC12/STM4 ATM and unchannelized T3.
- OCx/STMx POS line module supports OC3/STM1 POS and OC12/STM4 POS.
- OC48 line module supports OC48/STM16 POS.
- T3 line module and COCX-F3 line module support unchannelized T3.
- TSM provides tunnel service for IP tunnels, L2F tunnels, and LNS termination.
- X.21/V.35 line module supports X.21/V.35 serial interfaces.

A variety of protocols are supported over these interfaces, including IP/Frame Relay, IP/ATM, IP/PPP, as well as the protocols to enable B-RAS services. The system's DSx and E1/E3 implementations support termination, statistics gathering, alarm surveillance, and performance monitoring. These links can be used for either network ingress or network egress.

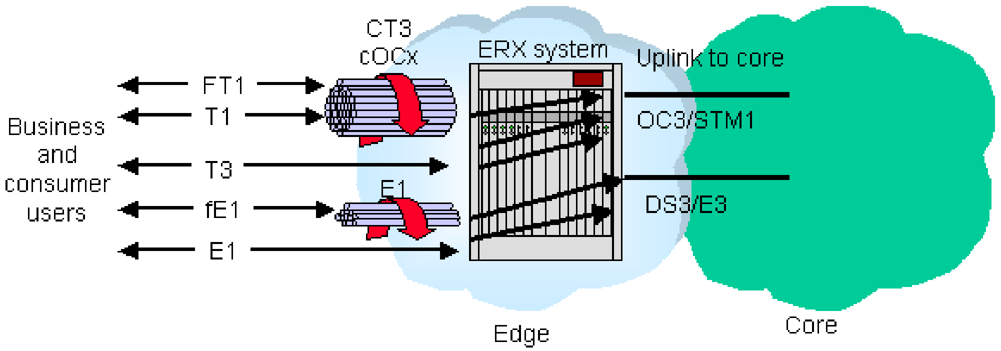


**Figure 1-4** ERX system support for fractional T1/E1 through T3/E3 interfaces

As shown in Figure 1-4, the system can support fractional, full, and channelized interfaces.

***Note:*** *See ERX Installation and User Guide, Chapter 3, Installing ERX Modules, for a discussion of slot groups and the combination of line modules allowed in the ERX system.*

### *Line Module Features*

The following features are supported by the system line modules:

- Three different clocking options: internal timing, loop timing, and chassis timing
- DS3 framing type – both M23 framing and C-bit parity
- DS1 framing type – both D4 framing mode and ESF framing mode
- DS3 loopback – for line, payload, diagnostic, and DS1 loopbacks (see *Diagnostics* in *ERX Product Overview Guide, Chapter 5, Statistics, Accounting, and Diagnostics*, for more information)
- DS1 loopback – for line, payload, and diagnostic loopbacks (see *Diagnostics* in *ERX Product Overview Guide, Chapter 5, Statistics, Accounting, and Diagnostics*, for more information)
- DS3/DS1 line status/alarm monitoring
- DS1 line coding type – both AMI line encoding and B8ZS line encoding
- Unique IP interface support – for each PPP or Frame Relay PVC interface

### *Configurable HDLC Parameters*

The following HDLC parameters are configurable:

- Mapping of DS0 timeslots for T1/FT1 DS0 mapping
- Setting the speed of the DS0 to Nx56 or Nx64
- HDLC CRC checking (enable/disable)
- HDLC CRC algorithm (CRC16 or CRC32)
- Channel data inversion (enable/disable)
- Maximum receive unit (MRU)
- Maximum transmit unit (MTU)

Statistics are also gathered per line module.

### *Configuring CT3 Interfaces*

There are three T3 controllers available on each CT3 line module and 12 T3 controllers available on each CT3 12-FO line module. When you configure these T3 controllers, you are actually configuring T3 (DS3) lines. Each T3 controller has, by definition, 28 T1 controllers representing T1 (DS1) lines.

Use the T3 and T1 commands described in *ERX Physical and Link Layers Configuration Guide, Chapter 1, Configuring Channelized T3 Interfaces*, to:

- Specify the line characteristics, such as framing format and clock source, for T3s and associated T1s.
- Assign full and fractional T1 channels (DS0) to a virtual channel.

Figure 1-5 shows sample parameters for a CT3 interface configuration.

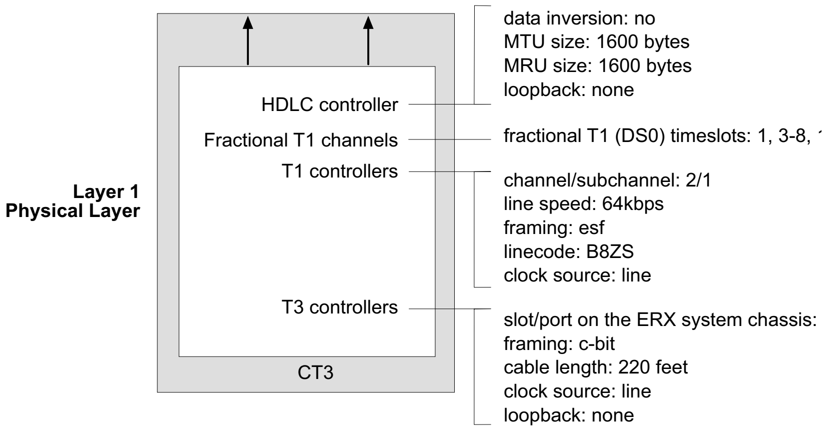


**Figure 1-5** CT3 interface configuration parameters

The following sample command sequence configures a serial interface for a CT3 module. See *ERX Physical and Link Layers Configuration Guide, Chapter 1, Configuring Channelized T3 Interfaces*, for details.

```
host1(config)#controller t3 0/1
host1(config-controll)#framing c-bit
host1(config-controll)#clock source line
host1(config-controll)#cablelength 220
host1(config-controll)#t1 2/1
host1(config-controll)#t1 2 framing esf
host1(config-controll)#t1 lineCoding b8zs
host1(config-controll)#t1 timeslots 2/1 1,3-8,10-12
host1(config-controll)#interface serial 0/1:2/1
```

*Configuring T3 and E3 Interfaces*

The T3 and E3 line modules support the following wide-area network (WAN) protocol encapsulations:

- IP over PPP
- IP over ATM
- IP over PPP over ATM
- IP over PPP over PPPoE over ATM

The T3 and E3 modules support the following WAN protocol encapsulations:

- IP over PPP
- IP over Frame Relay

Figure 1-6 shows sample configuration parameters for a T3 interface configuration.

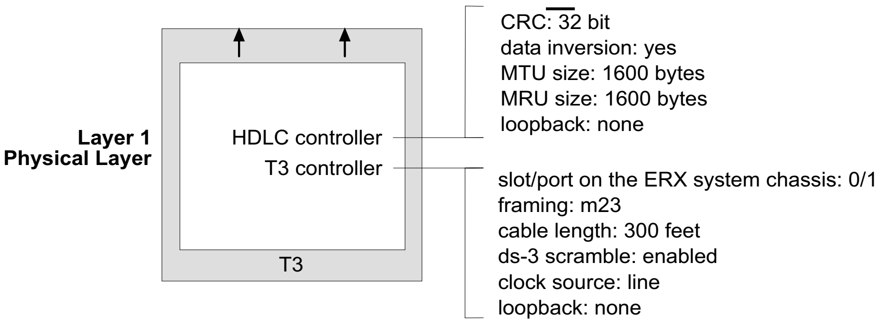


**Figure 1-6** T3 interface configuration parameters

The following sample command sequence configures a serial interface for a T3 module. See *ERX Physical and Link Layers Configuration Guide, Chapter 2, Configuring T3 and E3 Interfaces*, for details.

```
host1(config)#controller t3 0/1
host1(config-controll)#framing m23
host1(config-controll)#cablelength 300
host1(config-if)#ds3-scramble
host1(config)#interface serial 0/1
host1(config-if)#invert data
host1(config-if)#mtu 1600
host1(config-if)#mru 1600
```

*Configuring CT1 and CE1 Line Interfaces*

Figure 1-7 shows the configuration parameters for a sample T1 interface configuration on a CT1 line module.

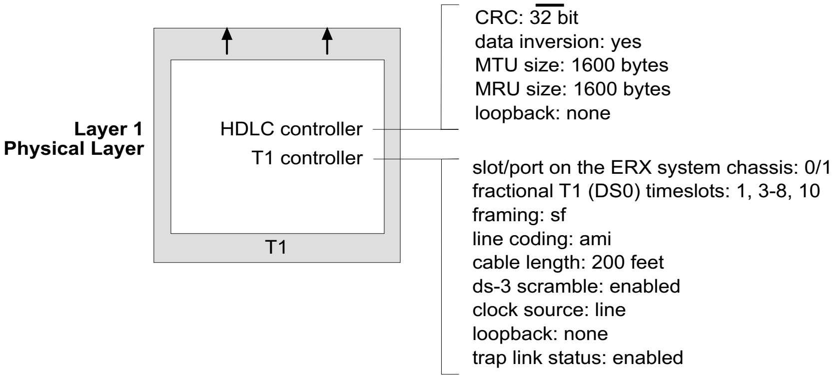


**Figure 1-7** T1 Interface configuration parameters

The following sample command sequence configures a serial interface for a T1 module. See *ERX Physical and Link Layers Configuration Guide, Chapter 3, Configuring CT1 and CE1 Interfaces*, for details.

```
host1(config)#controller t1 0/1
host1(config-controll)#channel group 2 timeslots 1,3-8,10
host1(config-controll)#framing sf
host1(config-controll)#lineCoding ami
host1(config-controll)#cablength short 200
host1(config-controll)#channel-group 2 trap link-status
host1(config)#interface serial 0/1:2
host1(config-controll)#crc 32
host1(config-if)#invert data
host1(config-if)#mtu 1600
host1(config-if)#mru 1600
```

*Configuring OC3 (Dual-Port), OCx/STMx, and OC48 Interfaces*

The system supports IP/ATM and IP/PPP over SONET on the OC3 (dual-port) and OCx/STMx interfaces. OC48 interfaces support IP/PPP over SONET, and do not support ATM operation. This interface support allows service providers to accept incoming optical connections or connect the system to the backbone network through optical connections. The system's SONET implementation supports termination, statistic gathering, and alarm surveillance at the section, line, and path layers of a SONET interface.

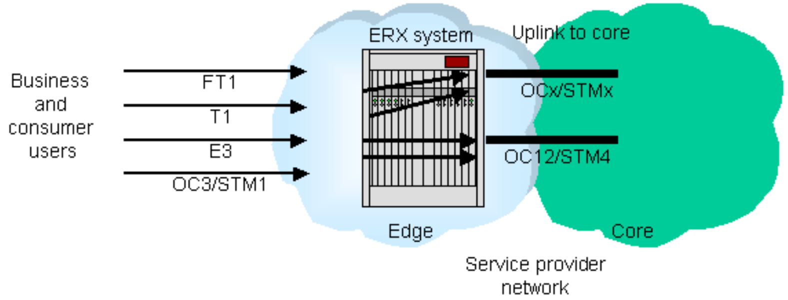


**Figure 1-8** SONET interfaces

The following sample command sequence configures POS for an OC3 interface. See *ERX Physical and Link Layers Configuration Guide, Chapter 15, Configuring Packet over SONET*, for details.

```
host1(config)#interface pos 0/1
host1(config-if)#encapsulation ppp
host1(config-controll)#clock source internal module
host1(config-controll)#loopback line
host1(config-controll)#pos framing sdh
host1(config-controll)#mtu 1600
host1(config-controll)#mru 1600
host1(config-controll)#pos scramble-atm
```

### *Configuring Channelized OCx/STMx Line Interfaces*

The cOCx/STMx modules are generally used for circuit aggregration on the system. This line module supports the following controllers over OC3/STM1 or OC12/STM4, depending on the I/O module used with the line module:

- Fractional T1/E1 over SONET/SDH virtual tributaries or T3
- Unframed E1
- Unchannelized DS3

Figure 1-9 shows the configuration parameters for a sample T1 over DS3 interface configuration.

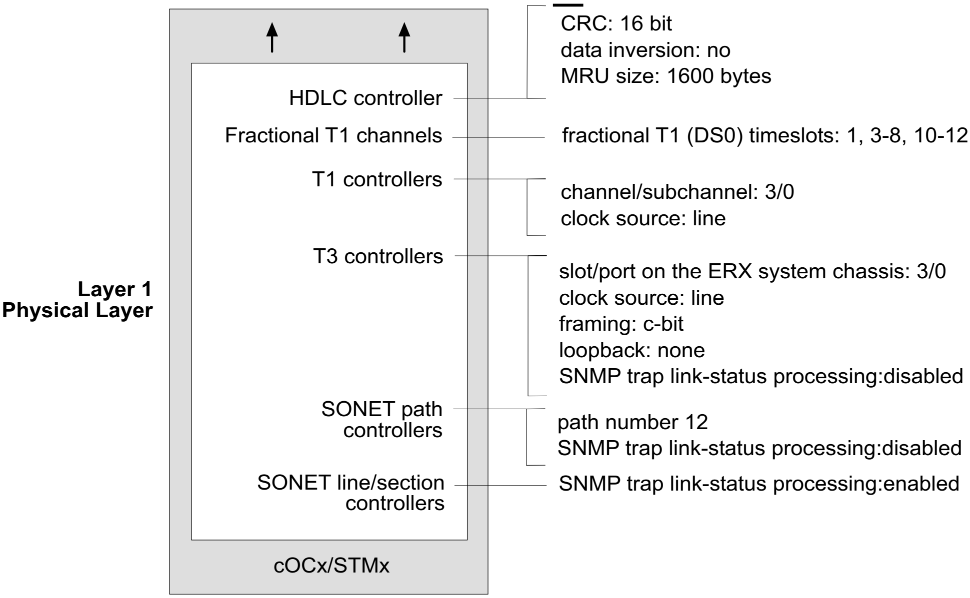


**Figure 1-9** Parameters for cOCx/STMx interface configuration

The following sample command sequence configures T1 over DS3 on a channelized SONET interface. See *ERX Physical and Link Layers Configuration Guide, Chapter 5, Configuring Channelized OCx/STMx Interfaces,* for details.

```
host1(config)#controller sonet 3/0
host1(config-controller)#path 12 oc1 4/1
host1(config-controller)#path 12 ds3 1 channelized
host1(config-controller)#path 12 ds3 1 t1 4
host1(config-controller)#path 12 ds3 1 t1 4/2 timeslots 1,
  3-8, 10-12
host1(config)#interface serial 3/0:12/1/4/2
```

*Configuring Ethernet Interfaces*

Ethernet interfaces support IP, PPPoE, multinetting (multiple IP addresses), and VLANs (subinterfaces). Ethernet modules use the Address Resolution Protocol (ARP) to obtain MAC addresses for outgoing Ethernet frames and support quality of service (QoS) classification. See *ERX Physical and Link Layers Configuration Guide, Chapter 6, Configuring Ethernet Interfaces,* for a description of limitations for individual modules.

Use the FE and GE commands described in *Configuring Ethernet Interfaces* to:

- Configure with IP only, with PPPoE only, with both IP and PPPoE, and with or without VLANs.
- Specify the line speed and duplex mode.
- Specify the MTU.
- Set the time interval at which the ERX system calculates bit and packet rate counters.

The following sample command sequence configures an IP interface on a VLAN on an Ethernet interface:

```
host1(config)#interface fastethernet 2/0.1
host1(config-if)#vlan id 100
host1(config-if)#interface fastethernet 2/0.1.1
host1(config-if)#ip address 192.1.1.1 255.255.255.0
```

The following sample command sequence adds an IP interface over PPPoE to the same VLAN:

```
host1(config)#interface fastethernet 2/0.1.2
host1(config-if)#encapsulation pppoe
host1(config-if)#interface fastethernet 2/0.1.2.1
host1(config)#encapsulation ppp
host1(config-if)#ip address 192.2.2.1 255.255.255.0
```

### *Configuring HSSI Interfaces*

High-speed serial interfaces (HSSIs) support high-speed WAN switching services such as Frame Relay and SMDS (SMDS trunk encapsulation). You can configure an interface to act as data communication equipment (DCE) or data terminal equipment (DTE).

Figure 1-10 shows sample configuration parameters for a HSSI configuration.

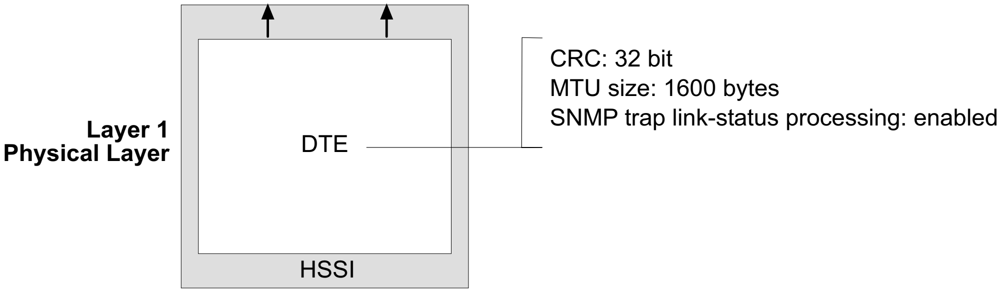


**Figure 1-10** Parameters for HSSI configuration

The following sample configuration shows how to use the HSSI as a DTE. See *ERX Physical and Link Layers Configuration Guide, Chapter 7, Configuring HSSIs*, for details.

```
host1(config)#interface hssi 3/0
host1(config-if)#crc 32
host1(config-if)#mtu 1200
host1(config-if)#snmp trap link-status
```

*Configuring X.21/V.35 Interfaces*

X.21/V.35 interfaces are serial interfaces that support the following:

- Data communications equipment (DCE) or data terminal equipment (DTE) operation
- Maximum data rate of 10 Mbps per port, 50 Mbps across all ports

Figure 1-11 shows sample configuration parameters for an X.21/V.35 interface configuration.

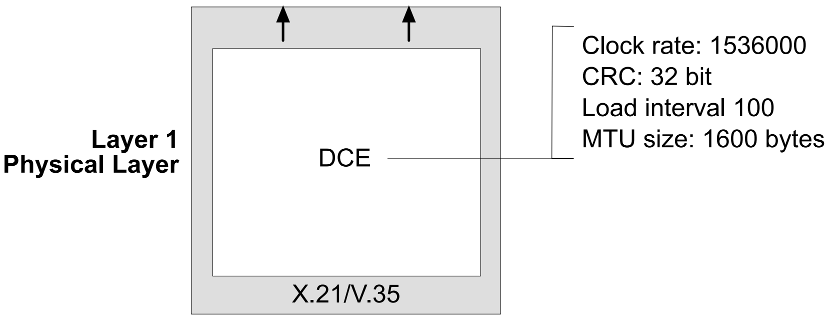


**Figure 1-11** Parameters for X.21/V.35 configuration

The following example shows how to configure the X.21/V.35 interface as a DCE. See *ERX Physical and Link Layers Configuration Guide, Chapter 8, Configuring X.21/V.35 Interfaces*, for details.

```
host1(config)#interface serial 3/1
host1(config-if)#clock rate 1536000
host1(config-if)#crc 32
host1(config-if)#mtu 1200
host1(config-if)#nrzi-encoding
```

### *Configuring IPSec Service Interfaces*

IPSec Service modules support interfaces associated with secure IP tunnels. You configure and delete these interfaces statically; however, the system assigns tunnels to the interfaces dynamically. This mechanism means that you must manage the interfaces for tunnels manually; however, the system will add and remove tunnels when required.

For information on configuring secure IP interfaces, see *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 10, Configuring IPSec.* For information about managing IPSec service interfaces, see *ERX Physical and Link Layers Configuration Guide, Chapter 9, Managing Tunnel Service and IPSec Service Interfaces*.

### *Configuring TSM Interfaces*

You can configure both dynamic tunnels associated with L2TP and L2F and static IP tunnels on your ERX system; however, you must first install a TSM. Dynamic tunnels, which are not associated with a particular interface, are described in *ERX Broadband Access Configuration Guide, Chapter 4, Configuring L2TP*. Static tunnels, in which the tunnel is assigned to a particular interface and specified in slot/port format, are described in *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 4, Configuring IP Tunnels*.

For information about managing these types of tunnels on the system, see *ERX Physical and Link Layers Configuration Guide, Chapter 9, Managing Tunnel Service and IPSec Service Interfaces*.

## Configuring Data Link Layer Interfaces

You can configure the following data link layer interfaces:

- IP/ATM
- IP/Cisco HDLC
- IP/Ethernet
- IP/Frame Relay or multilink Frame Relay
- IP/PPP or multilink PPP

### *Configuring IP/Frame Relay*

The system supports IP over Frame Relay PVCs on the CT3, CT1, CE1, T3, and E3 modules. The interface presented to the incoming traffic is an IP/Frame Relay router. In addition, IP/PPP/Frame Relay is supported on the T3 and E3 modules. With this interface, the service provider can:

- Receive traffic from subscribers that have CPE equipment, such as routers with Frame Relay interfaces
- Take in traffic from other network devices that use Frame Relay, such as DSLAMs and Frame Relay switches
- Use Frame Relay as an uplink technology on an unchannelized T3 or E3 link

Figure 1-12 shows the structure of the system Frame Relay interface. Each system Frame Relay major interface sits on top of an HDLC interface. The Frame Relay implementation is divided into two levels: a major interface and one or more subinterfaces. This division allows a single physical interface to support multiple logical interfaces. Multiple IP interfaces can also be assigned to each Frame Relay major interface through the subinterfaces.

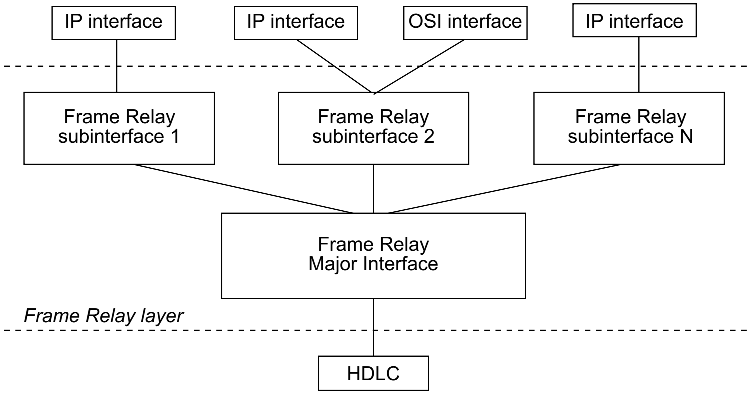


**Figure 1-12** Frame Relay interface design

Figure 1-13 shows the structure of the Frame Relay protocols with the physical layer as the foundation. For Frame Relay, the physical layer can be CE1, E3, CT1, T3, or a fractional service, as supported by the different line module ports. The HDLC layer is on top of the physical layer and can support flexible assignment of physical resources.

For example, an HDLC channel can support one DS0, fractional T1s, or an entire T1. The major Frame Relay interface sits on top of the HDLC resource, and the subinterfaces sit on top of the major interface. The Frame Relay subinterfaces connect to the IP interface layer.

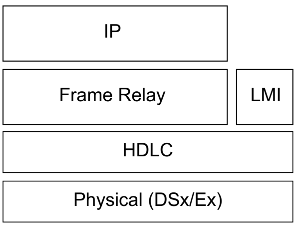


**Figure 1-13** Structure of Frame Relay protocols

The system supports Frame Relay LMI (local management interface) to provide the operator with configuration and status information relating to the Frame Relay VCs in operation. LMI specifies a polling mechanism to receive incremental and full-status updates from the network. The system can represent either side of the User-to-Network Interface (UNI) and supports unidirectional LMI. Bidirectional support for Network-to-Network Interface (NNI) is also supported.

Figure 1-14 shows sample configuration parameters for Frame Relay on a serial interface.

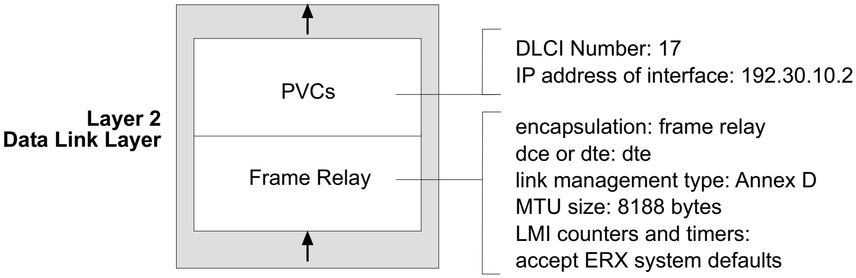


**Figure 1-14** Serial interface configuration parameters for a Frame Relay connection

The following sample command sequence configures a serial interface for Frame Relay. See *ERX Physical and Link Layers Configuration Guide, Chapter 11, Configuring Frame Relay*, for information.

```
host1(config-if)#interface serial 0/1:1/5
host1(config-if)#encapsulation frame-relay ietf
host1(config-if)#frame-relay intf-type dte
host1(config-if)#frame-relay lmi-type ansi
host1(config-if)#interface serial 0/1:1/5.1
host1(config-subif)#frame-relay interface-dlci 17 ietf
host1(config-subif)#ip address 192.32.10.2 255.255.255.0
```

## *Configuring IP/ATM*

The system supports IP over ATM PVCs on the T3 ATM, E3 ATM, OC3 (dual-port), and OCx/STMx ATM line modules. This support allows service providers to receive traffic from subscribers who have CPE equipment, such as routers with ATM interfaces, to take in traffic from other network devices that use ATM, such as DSLAMs, and to connect to service providers with ATM backbone structures. See Figure 1-15.

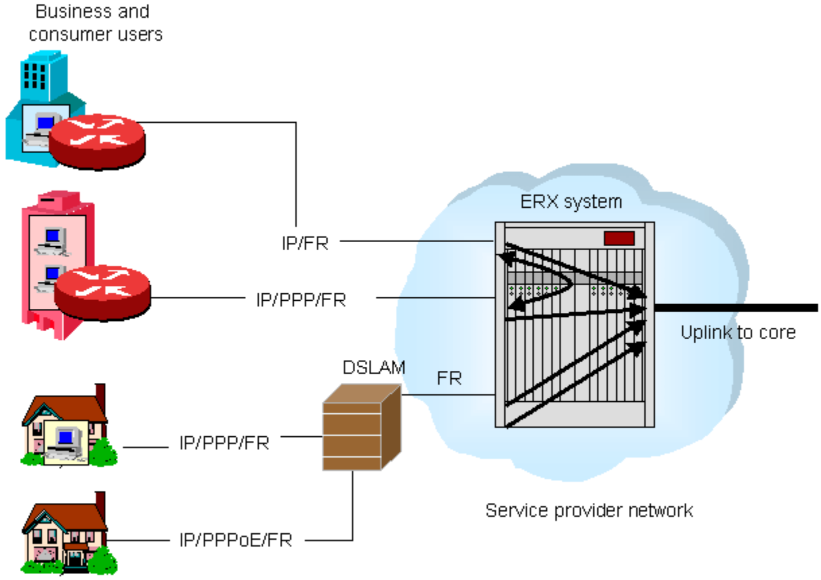


**Figure 1-15** ERX system IP/ATM access connection

Figure 1-16 shows the structure of the ATM interface. For ATM, this can be SONET, DS3, or E3 as supported by the different line modules. The major ATM interface sits on top of the SONET/DS3/E3 resource, and the subinterfaces sit on top of the major interface. The ATM subinterfaces connect to the IP interface layer.

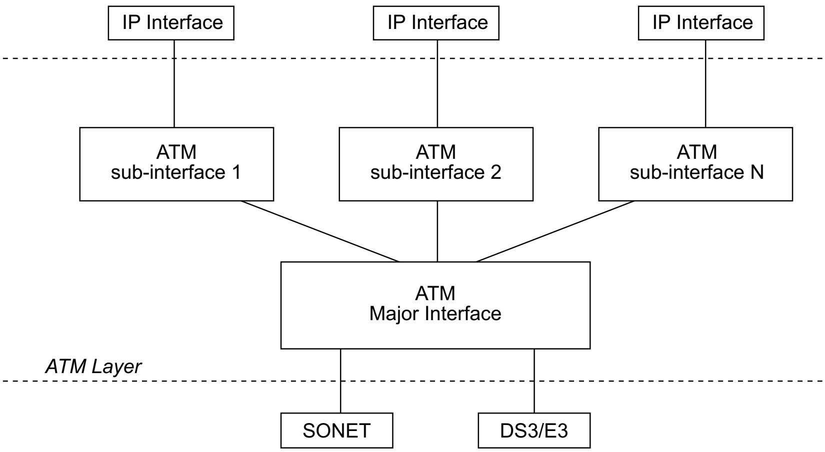


**Figure 1-16** Structure of the ATM interface design

Figure 1-17 shows the structure of the ATM protocols. The physical layer (SONET and/or DSx/Ex) is the foundation and provider of layer 1 framing service. The ATM layer is on top and provides cell, circuit, and OAM services. The AAL5 layer provides a frame-oriented interface to the ATM layer. The integrated local management interface (ILMI) provides local management across the UNI.

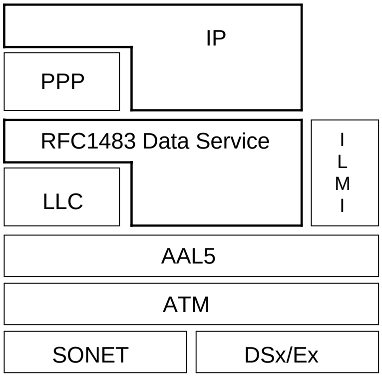


**Figure 1-17** Structure of ATM protocol

Figure 1-18 shows sample configuration parameters for a typical ATM interface configuration.

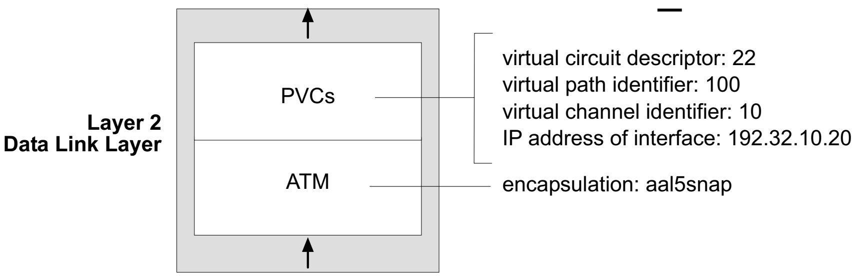


**Figure 1-18** ATM interface configuration parameters

The following sample command sequence configures an ATM interface on port 0 of the line module in slot 1. See *ERX Physical and Link Layers Configuration Guide, Chapter 10, Configuring ATM*, for information on how to configure an ATM interface.

```
host1(config)#interface atm 0/1
host1(config-if)#interface atm 0/1.20
host1(config-if)#atm pvc 10 22 100 aal5snap
host1(config-subif)#ip address 192.32.10.20 255.255.255.0
```

*Configuring IP/PPP*

The system supports IP/PPP on the CT3, E1, and T3/E3 interfaces and IP/PPP/SONET on the OC3/STM1 and OC12/STM4 interfaces. This support allows service providers to accept traffic from subscribers who have CPE equipment, such as routers with PPP interfaces, and to transmit traffic in PPP format to other network devices.

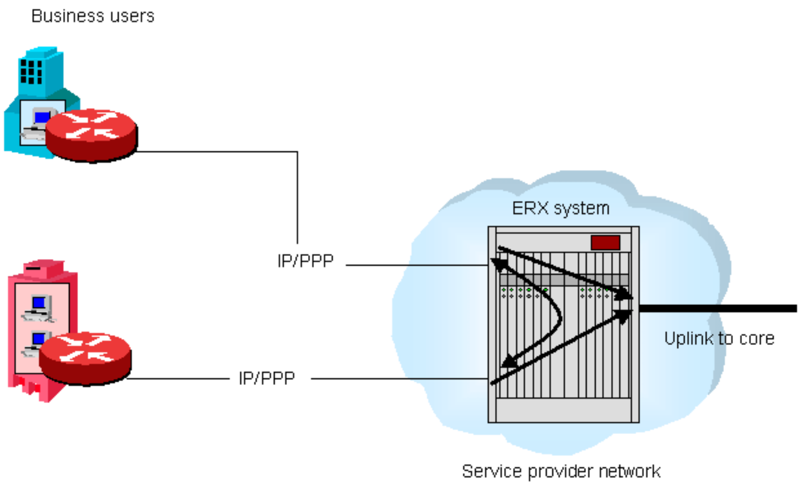


**Figure 1-19** The ERX system supports IP/PPP connections from the CPE

Figure 1-19 shows that the system supports the incoming IP/PPP traffic from the CPE. This traffic can then be routed to the uplink(s) attached to the system or to other CPEs that are attached to the system.

As shown in Figure 1-20, the PPP protocol can exist directly on top of the HDLC layer or on top of a layer 2 Frame Relay or ATM interface. In either case, IP rides on top of PPP, providing support for IP/PPP/ATM, IP/PPP/HDLC, and IP/PPP/Frame Relay. Both SONET and DSx/Ex interfaces are supported at the physical layer.

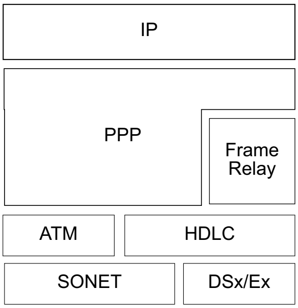


**Figure 1-20** Structure of PPP

Figure 1-21 shows sample configuration parameters for PPP on a serial interface.

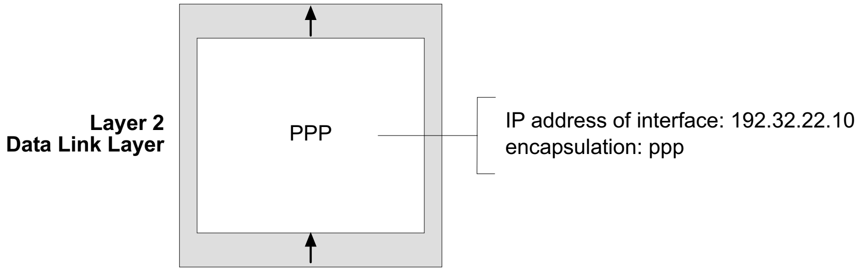


**Figure 1-21** ATM interface configuration parameters

The following sample command sequence configures PPP on a serial interface. See *ERX Physical and Link Layers Configuration Guide, Chapter 13, Configuring Point-to-Point Protocol*, for details.

```
host1(config)#interface serial 3/0:2/5
host1(config-if)#encapsulation ppp
host1(config-if)#ip address 192.32.22.10 255.255.255.0
```

*Configuring IP/HDLC*

The ERX system supports IP over Cisco HDLC on many types of serial interfaces. Cisco HDLC monitors line status on a serial interface by exchanging keepalive request messages with peer network devices. It also allows routers to discover IP addresses of neighbors by exchanging Serial Link Address Resolution Protocol (SLARP) address request and address response messages with peer network devices.

The system Cisco HDLC is compatible with Cisco Systems Cisco-HDLC protocol, the default protocol for all Cisco serial interfaces.

The system supports the following framing features:

- HDLC for data-link framing
- 18,000-byte information field size

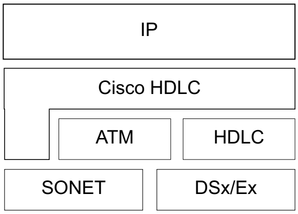


**Figure 1-22** Structure of Cisco HDLC protocol

As shown in Figure 1-22, the Cisco HDLC protocol can exist directly on top of the HDLC layer or ATM or SONET interface. Both SONET and DSx/Ex interfaces are supported at the physical layer.

### *Configuring IP over Ethernet*

The ERX system supports IP/Ethernet. When you select an Ethernet interface, you can assign an IP address to it, as the following example shows:

```
host1(config)#interface fastethernet 4/1
host1(config-if)#ip address 192.5.127.8 255.255.255.0
```

Figure 1-23 shows the IP/Ethernet interface stack.

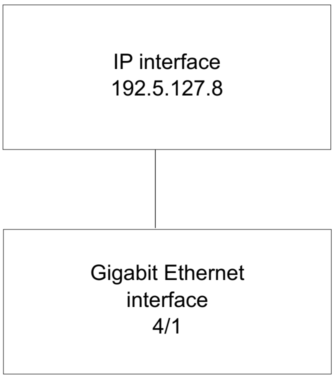


**Figure 1-23** Example of IP over Ethernet stacking configuration steps

## Configuring IP Tunnels, Shared IP Interfaces, and Subscriber Interfaces

The ERX system supports IP tunnels, shared IP interfaces, and subscriber interfaces.

### *Configuring IP Tunnels*

IP tunnels provide a way of transporting datagrams between routers separated by networks that do not support all the protocols that those routers support. To configure an IP tunnel, you must first configure a TSM interface (see *Configuring TSM Interfaces*, earlier in this chapter.)

When you have configured a TSM interface, treat it in the same way as any IP interface on the router. For example, you can configure static IP routes or enable routing protocols on the tunnel interface. The IP configurations you apply to the tunnels control how traffic travels through the network.

### *Configuring Shared Interfaces and Subscriber Interfaces*

A shared IP interface is one of a group of IP interfaces that use the same layer 2 interface. Shared IP interfaces are unidirectional–they can transmit but not receive traffic. A subscriber interface is an extension of a shared IP interface. Subscriber interfaces are bidirectional–they can both receive and transmit traffic.

You can create multiple shared IP interfaces over the same layer 2 logical interface—for example, atm 5/3.101—enabling more than one IP interface to share the same logical resources. This capability is useful, for example, when data received in one VRF needs to be forwarded out an interface in another VRF, such as for BGP/MPLS VPNs (see *ERX Routing Protocols Configuration Guide, Vol. 2, Chapter 3, Configuring BGP/MPLS VPNs*, for more information). You can configure one or more shared IP interfaces. Data sent over shared interfaces use the same layer 2 interface. You can configure shared interfaces as you would other IP interfaces. Each shared interface has its own statistics.

The ERX system supports subscriber interfaces on a particular type of layer 2 interface, Ethernet. In the absence of VLANS, Ethernet does not have a demultiplexing layer. A subscriber interface adds a demultiplexing layer for an Ethernet interface that is configured without VLANs. Using subscriber interfaces, the system can demultiplex or separate the traffic associated with different subscribers. You can use subscriber interfaces to separate traffic for cable modem subscribers with different levels of service and to separate traffic for VPNs.

For information about configuring shared interfaces and subscriber interfaces, see *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 2, Configuring IP*.

## Configuring Routing Protocols

After you have set up the interfaces on which IP traffic flows, you can configure the following routing protocols:

- IP Multicast – IP multicasting allows a device to send packets to a group of hosts, rather than to a list of individual hosts. Routers use multicast routing algorithms to determine the best route and transmit datagrams throughout the network. See *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 3, Configuring IP Multicasting,* for information on how to configure IP Multicast.
- Open Shortest Path First (OSPF) – This interior gateway protocol (IGP) advertises the states of network links within an autonomous system. An autonomous system is a set of routers having a single routing policy running under a single technical administration. See *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 7, Configuring OSPF*, for information on how to configure OSPF.
- Integrated Intermediate System–to–Intermediate System (integrated IS-IS) – The integrated IS-IS protocol provides routing for IP networks and is an extension of the original IS-IS protocol, which provides routing for pure Open Systems Interconnection (OSI) environments. This link state protocol builds a complete and consistent picture of a network’s topology by sharing link state information across network devices in a routing domain. A routing domain is a collection of contiguous networks that provide full connectivity to all end systems located within them. See *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 8, Configuring IS-IS,* for information on how to configure IS-IS.
- Border Gateway Protocol (BGP) – An external gateway protocol (EGP) that provides loop-free interdomain routing between autonomous systems. See *ERX Routing Protocols Configuration Guide, Vol. 2, Chapter 1, Configuring BGP Routing,* for information on how to configure BGP.
- Routing Information Protocol (RIP) – An IGP created for use in small, homogeneous networks. RIP uses distance-vector routing to route information through IP networks. See *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 6, Configuring RIP,* for information on how to configure RIP.

- Multiprotocol Label Switching (MPLS) – A hybrid protocol that integrates network layer routing with label switching to provide a layer 3 network with traffic management capability. Traffic engineering enables more effective use of network resources while maintaining high bandwidth and stability. MPLS enables service providers to offer their customers the best service available given the provider's resources. There are two fundamental aspects to MPLS:
  - Label distribution – The set of actions MPLS performs to establish and maintain a label-switched path (LSP), also known as an MPLS tunnel.
  - Data mapping – The process of getting data packets onto an established LSP.
    See *ERX Routing Protocols Configuration Guide, Vol. 2, Chapter 2, Configuring MPLS*, for information about configuring MPLS.

In addition, if you want to make configuration adjustments to IP, see *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 2, Configuring IP*, for details.

## Configuring VRRP

The Virtual Router Redundancy Protocol (VRRP) can prevent loss of network connectivity to end hosts if the static default IP gateway fails. By implementing VRRP, you can designate a number of routers as "backup" routers in the event that the default "master" router fails. You can configure VRRP on IP/Ethernet interfaces.

For information on configuring VRRP, see *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 9, Configuring VRRP*.

## Configuring Routing Policy

The system supports a number of features that allow the service provider to control the exchange of routing information between virtual routers in the system, between routers in the network, and between protocols within a router:

- Access lists – Provide filters that can be applied to route maps or distribution lists. They allow policies to be created, such as a policy to prevent forwarding of specified routes between the BGP-4 and IS-IS routing tables.
- Route maps – Modify the characteristics of a route (generally to set its metric or to specify additional attributes) as it is transmitted or

accepted by a router. Route maps may use access lists to identify the set of routes to modify.

- Distribution lists – Control the routing information that is accepted or transmitted to peer routers. Distribution lists always use access lists to identify routes for distribution. For example, distribution lists could use access lists to specify routes to advertise.
- Redistribute routes – Allow routes to be shared between routing protocols and routing domains. For example, a subset of BGP-4 routes could be leaked into the IS-IS routing tables.

See *ERX Routing Protocols Configuration Guide, Vol. 1, Chapter 1, Configuring Routing Policy*, for details.

## QoS

QoS is a suite of features that configure queuing and scheduling on the forwarding path of your ERX system. QoS provides a level of predictability and control beyond the current *best-effort* service. Your ERX system provides best-effort data delivery by default. Packets not assigned to a specific traffic class are carried in the best-effort traffic class. Best-effort service provides packet transmission with no guarantee of results.

The major QoS features that the ERX system provides are:

- Multiple traffic classes
- Configurable scheduling
- Configurable buffer management

For information on configuring QoS, see *ERX Policy Management and QoS Configuration Guide, Chapter 2, Configuring Quality of Service*.

## Policy Management

Policy management allows network service providers to implement packet forwarding and routing specifically tailored to their customer's requirements. Using policy management, customers can implement policies that selectively cause packets to take different paths. Policy management provides several types of services:

- Policy routing – Predefines packet flow to a destination port or IP address
- QoS classification and marking – Marks packets of a packet flow.
- Packet forwarding – Allows forwarding of a packet flow.
- Packet filtering – Drops packets of a packet flow.
- Packet logging – Logs packets of a packet flow.
- Rate limiting – Enforces line rates below the physical line rate of the port and sets limits on packet flows.
- RADIUS policy support – Allows you to attached a preconfigured policy to an interface through RADIUS.

See *ERX Policy Management and QoS Configuration Guide, Chapter 1, Configuring Policy Management,* for details about configuring policy management.

## Configuring Remote Access

The ERX system supports the following remote access functionality:

- Broadband Remote Access Server (B-RAS) – This application runs on the system and is responsible for:
  - Aggregating the output from DSLAMs
  - Providing user PPP sessions and PPP session termination
  - Enforcing QoS policies
  - Routing traffic into an ISP's backbone network

  See *ERX Broadband Access Configuration Guide, Chapter 1, Configuring Remote Access to the ERX System*.

- Layer 2 Tunneling Protocol (L2TP) – A method of encapsulating layer 2 packets, such as PPP, for transmission across a network. In an L2TP relationship, an L2TP Access Concentrator (LAC) forms a client-server relationship with a destination, known as an L2TP Network Server (LNS), on a remote network.

  You can configure the system to act as an LAC in PPP pass-through mode. The system creates tunnels dynamically by using AAA authentication parameters and transmits L2TP packets to the LNS through IP/UDP. See *ERX Broadband Access Configuration Guide, Chapter 4, Configuring L2TP*.

- Layer Two Forwarding (L2F) – A method that provides virtual dial-up service over the Internet. The traditional method for a remote user to access a company's network is through remote access equipment that is directly attached to the corporate network. This method requires a significant investment in equipment and support in addition to the cost of telephone charges for remote workers calling into the access equipment.

  By employing L2F, an ISP can provide local access for the remote worker and forward the data traffic through a tunnel to the corporate network. This method allows a company to outsource the investment in remote access equipment to the ISP, while retaining full control over access to the corporate network. In particular, L2F allows leveraging multiple protocols and private addressing across the existing Internet infrastructure. See *ERX Broadband Access Configuration Guide, Chapter 5, Configuring L2F*.

- Non-PPP equal access – A method of allowing remote access in which the system provides IP addresses to subscribers' computers through Dynamic Host Configuration Protocol (DHCP). This method is particularly convenient for broadband (cable and DSL) environments or environments that use bridged Ethernet over ATM, because network operators can support one central system rather than an individual PPPoE client on each subscriber's computer. See *ERX Broadband Access Configuration Guide, Chapter 6, Configuring DHCP Local Server*.