



This chapter covers the following topics:

- ADSL Overview
- Cisco 6160 DSLAM Overview
- Cisco 6400 UAC Overview
- DSL Access Architectures and Protocols

Using DSL to Access a Central Site

This chapter focuses on Digital Subscriber Line (DSL) technology. DSL, like cable modem, is one of the most popular broadband access methods and will be a new topic on the CCNP exam.

After completing this chapter, you will understand the basic Asymmetric DSL (ADSL) technology, Cisco 6160 DSL Access Multiplexer (DSLAM) configuration, and Cisco 6400 Universal Access Concentrator (UAC) configuration. You will also understand different access architectures and protocols such as Integrated Routing and Bridging (IRB), Routed Bridge Encapsulation (RBE), Point-to-Point Protocol over ATM (PPPoA), and Point-to-Point Protocol over Ethernet (PPPoE).

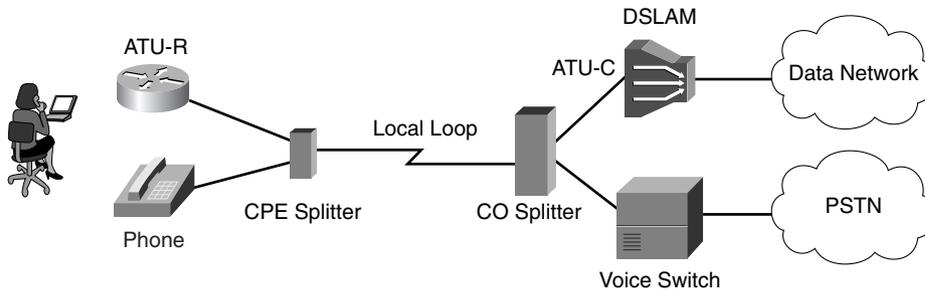
Note that there are different flavors of DSL technologies. This chapter focuses on ADSL technology.

ADSL Overview

DSL technology introduces a new family of products that can provide high-speed data and voice service over existing copper pairs. Several flavors of DSL exist, but each type can be categorized as either SDSL or ADSL. *Symmetric DSL (SDSL)* provides equal bandwidth from the customer premises to the service provider (upstream) and from the service provider to the customer (downstream). *ADSL* provides higher downstream speeds than upstream.

Traditionally, ADSL has been used to provide high-speed data service by encoding data on the local loop by using frequencies (up to 1 MHz) greater than voice (up to 4 kHz) so that existing telephone service would be preserved and would travel simultaneously with the data. At the central office (CO), the voice would be routed to the public switched telephone network (PSTN) using a low-pass frequency filter called a POTS splitter chassis (PSC).

Figure 8-1 depicts a typical end-to-end ADSL system. Beginning at the customer premises, the user's general-purpose computer is connected to the ADSL Terminating Unit-Remote (ATU-R) over an Ethernet connection.

Figure 8-1 *Typical End-to-End ADSL System*

The ATU-R is typically connected to an external splitter device. In some cases, however, the external splitter is eliminated in lieu of an internal filter in the ATU-R and microfilters attached to plain old telephone service (POTS) devices in the home. From the splitter, the loop is wired to a Network Interface Device (NID) that serves as the demarcation point into the customer premises. From the NID, the loop is connected to a splitter device in the central office that splits off voice traffic and routes it to the PSTN. Data is connected to the ADSL Terminating Unit-Central Office (ATU-C). The user's data traffic is then typically routed across the ATM network to an aggregation gateway or router.

Modulation Methods

Three modulation methods for encoding data onto the local loop are Carrierless Amplitude and Phase (CAP), Discrete MultiTone 2 - Issue 2 (DMT2), and G.lite. DMT was selected as the preferred standard for ADSL modulation. CAP technology is cost-effective and readily available. G.lite is a simplified DMT encoding scheme that provides limited features to facilitate interoperability and minimize end-user interaction.

Table 8-1 shows the maximum data rates for downstream and upstream, line-coding technologies, and maximum reach. Note that the maximum-reach number is best-case, assuming "clean copper."

Table 8-1 *ADSL Data Rates*

Maximum Data Rate Downlink/Uplink	Line Coding Technology	Maximum Reach
8 Mbps/1 Mbps	CAP, DMT	18,000 feet/5.5 km
1.5 Mbps/640 kbps	G.lite	18,000 feet/5.5 km

Sources of Interference

Many sources of interference can degrade the quality of DSL. For instance, loading coils are used as a low-frequency (300 to 3300 Hz) filter but cannot be present for ADSL operation.

Other sources of interference include the following:

- Impedance changes
- Bridged taps
- Crosstalk
- Impulse hits

Techniques to Solve Interference

Several techniques exist for adjusting to interference:

- **Rate-Adaptive DSL (RADSL)**—Used to adjust the transmission rate.
- **Reed-Solomon Forward Error Correction (FEC)**—The process of correcting errors mathematically at the receiving end of a transmission path rather than calling for a retransmission.
- **Bit interleaving**—Used to avoid having consecutive errors delivered to the FEC algorithm at the receiving end of the circuit.
- **Trellis coding**—A modulation error-correction technique to improve error performance during reception.

Cisco 6160 DSLAM Overview

This section provides an overview of the Cisco 6160 DSLAM system and hardware components and discusses basic Cisco DSLAM configuration.

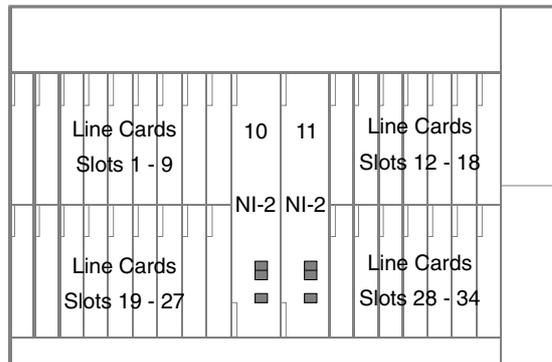
System and Hardware Components

The Cisco 6160 can be operated as a carrier class DSLAM with ADSL, SDSL, and Integrated Services Digital Network DSL (IDSL) interfaces. The Cisco 6160 is intended for use in North American central office facilities. The Cisco 6160 DSLAM can support up to 256 subscribers and concentrate traffic onto a single high-speed WAN trunk.

Examine Figure 8-2. The chassis has 32 short slots for line cards and two double-length slots for Network Interface (NI-2) cards. Slots 10 and 11 hold the NI-2 cards. Slots 1 to 9 and 12 to 34 hold the line cards. Some of the essential functions the NI-2 card provides are ATM switching, WAN interface, and subtending.

WAN interfaces can be either OC-3c or DS3 and can be used for trunking or subtending. Subtending allows up to 12 other chassis to be subtended to a single host DSLAM system, aggregating the subtended systems through a single network uplink.

DSL line cards come in several varieties. In this chapter, the Quad Flexicard is used. It supports four ADSL connections and can be configured with CAP, DMT2, or G.lite line coding.

Figure 8-2 *Cisco 6160 DSLAM Chassis*

NOTE You can install line cards of two or more different types in a single Cisco 6160 chassis. However, mixing different types of cards (Flexi ADSL, SDSL, and/or IDSL) on the same side of the chassis might result in decreased performance.

Basic Cisco 6160 DSLAM Configuration

In this section, you will learn all the necessary information to successfully configure the Cisco 6160 DSLAM.

Interface Numbering

Before you begin the configuration, it is important to know the interface numbering scheme used by the Cisco IOS software in the 6160. Interfaces whose names begin with ATM0 (ATM0/0, ATM0/1, and so forth) are NI-2 card WAN interfaces. ATM0/0 is the ATM switch's interface with the processor. There is no need to configure ATM0/0 unless you plan to use in-band management. ATM0/1 is the trunk port. ATM0/2 and ATM0/3, if present, are subtending interfaces.

Table 8-2 illustrates the interface numbering scheme for Cisco 6160 DSLAM.

Table 8-2 *Cisco 6160 DSLAM Interface Numbering*

Interface	Description
ATM0/0	The ATM switch's interface
ATM0/1	Trunk interface
ATM0/2	Subtend
ATMA/B	A = 1 to 34 (slot); B = 1 to 4 (port)
Ethernet0/0	Management Ethernet port

As shown in Table 8-2, interfaces whose names begin with ATM1 through ATM34 are line card interfaces. Ethernet0/0 is the interface for the LAN that connects the Cisco 6160 to its management system. For line card interfaces, the number before the slash indicates the slot number. The number after the slash indicates the interface or port number. For example, ATM5/4 is port 4 in slot 5.

Configuring Line Cards

Before you can use the Flexicard, you need to configure a slot for a specific card type. Use this command:

```
slot slot# cardtype
```

slot# is the slot number; the range is 1 to 34. *cardtype* is the card type for which you want to configure the slot. You must indicate the type of card. To configure the Quad Flexicard in slot 1 to use DMT modulation, you would enter the following:

```
lab-6160(config)#slot 1 ATUC-4FLEXIDMT
```

NOTE

You can use **show hardware** command to find out which cards are installed in the Cisco 6160 DSLAM.

Creating DSL Profiles

Except for a few dynamic operational modes, port configuration takes place through a configuration profile rather than by direct configuration. A *profile* is a named list of configuration parameters with a value assigned to each parameter. You can change the value of each parameter in the profile. To configure a subscriber, you need only attach the desired profile to that subscriber. When you change a parameter in a profile, you change the value of that parameter on all ports using that profile. If you want to change a single port or a subset of ports, you can copy the profile, change the desired parameters, and then assign the new profile to the desired ports. Multiple ports can share the same profile, but one port cannot have more than one profile. If you modify an existing profile, that change takes effect on every ADSL port linked to that profile.

Every port is attached to a special profile named “default” by default. You can modify the default profile (but not delete it). This is useful when you want to modify one or two default parameters and apply this to every port in the system (rather than creating a new profile with minor changes and attaching it to every port in the system).

When you create a profile, it inherits all the configuration settings of the default profile at the time of creation. If you subsequently modify the special profile default, the new changes to the default do not propagate to the previously created profiles.

To create a DSL profile, or to select an existing profile for modification, use the following command:

```
dsl-profile profile-name
```

To delete a DSL profile, use the following command:

```
no dsl-profile profile-name
```

In both examples, *profile-name* is the name of the profile you want to create, or an existing profile you want to delete or modify. To create a DSL profile called `ccnp`, you would enter the following:

```
lab-6160#configure terminal  
lab-6160(config)#dsl-profile ccnp
```

After the DSL profiles are created, you can customize them with the following parameters:

- Bit rate
- DMT margin
- Check bytes
- Interleaving delay
- Training mode

The following sections discuss these parameters in more detail.

Setting the Bit Rate

To set the maximum and minimum allowed bit rates for the fast-path and interleaved-path profile parameters, use the following command:

```
dmt bitrate max interleaved downstream dmt-bitrate upstream dmt-bitrate
```

dmt-bitrate is a multiple of 32 kbps. If you enter a nonmultiple of 32 kbps, the Cisco IOS software aborts the command.

In Example 8-1, the command sets the maximum interleaved-path bit rate of the `ccnp` profile to 8032 kbps downstream and 832 kbps upstream.

Example 8-1 *Setting the Bit Rate*

```
lab-6160#configure terminal  
lab-6160(config)#dsl-profile ccnp  
lab-6160(config-dsl-prof)#dmt bitrate interleaved-path downstream 8032  
upstream 832
```

Setting the Margins

To set upstream and downstream signal-to-noise ratio (SNR) DMT margins, use the following command:

```
dmt margin downstream dmt-margin upstream dmt-margin
```

dmt-margin is equal to the upstream and downstream SNR margins in decibels. Values must be nonnegative integers. The range is from 0 to 127 dB.

NOTE Research has shown that the optimum margins for DMT service are 6 dB downstream and 6 dB upstream.

In Example 8-2, the command sets the DMT SNR margins of the ccnp profile to 6 dB upstream and 3 dB downstream.

Example 8-2 *Setting the Margin*

```
lab-6160#configure terminal
lab-6160(config)#dsl-profile ccnp
lab-6160(config-dsl-prof)#dmt margin downstream 3 upstream 6
```

Setting Check Bytes

Check bytes are also called *FEC bytes*. They are added to the user data stream to improve error correction, but they slow performance. To set upstream and downstream check bytes, use the following command:

```
dmt check-bytes interleaved downstream bytes upstream bytes
```

bytes values can be 0, 2, 4, 6, 8, 10, 12, 14, and 16. The default is 16 in each direction.

In Example 8-3, the command sets the interleaved check bytes for the ccnp profile to 6 upstream and 12 downstream.

Example 8-3 *Setting the Check Bytes*

```
lab-6160#configure terminal
lab-6160(config)#dsl-profile ccnp
lab-6160(config-dsl-prof)#dmt check-bytes interleaved
downstream 12 upstream 6
```

Setting Interleaving Delay

To set the interleaving delay parameter, use this command:

```
dmt interleaving-delay downstream delay-in-usecs upstream delay-in-usecs
```

delay-in-usecs specifies the interleaving delay in microseconds. The default value is 16000 microseconds in each direction. Allowable values are 0, 500, 1000, 2000, 4000, 8000, and 16000 microseconds.

In Example 8-4, the command sets the interleaving delay of the ccnp profile to 2000 microseconds downstream and 4000 microseconds upstream.

Example 8-4 *Setting the Interleaving Delay*

```
lab-6160#configure terminal
lab-6160(config)#dsl-profile ccnp
lab-6160(config-dsl-prof)#dmt interleaving-delay downstream 2000 upstream 4000
```

Setting the Training Mode

Two training modes are available—standard and quick. Standard train relates to a training procedure specified in ANSI standards document T1.413, which is considered the standards reference for DMT ADSL. *Quick train*, also called *fast train*, uses a vendor-specific training sequence that is shorter than the standard training sequence.

To modify the training mode in a DMT profile, use the following command:

```
dmt training-mode {standard / quick}
```

In Example 8-5, the command sets the ccnp profile’s training mode to quick.

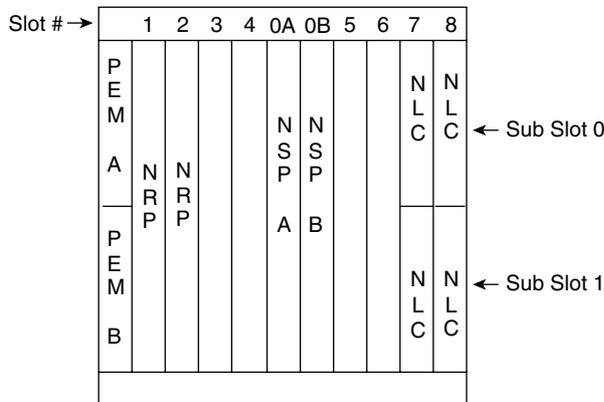
Example 8-5 *Setting the Training Mode*

```
lab-6160#configure terminal
lab-6160(config)#dsl-profile ccnp
lab-6160(config-dsl-prof)#dmt training-mode quick
```

Cisco 6400 UAC Overview

This section provides an overview of 6400 Universal Access Concentrator (UAC) hardware components (see Figure 8-3). Functional descriptions are provided for each component. How all the components work together within the system is also described.

Figure 8-3 *Cisco 6400 UAC Hardware Component*



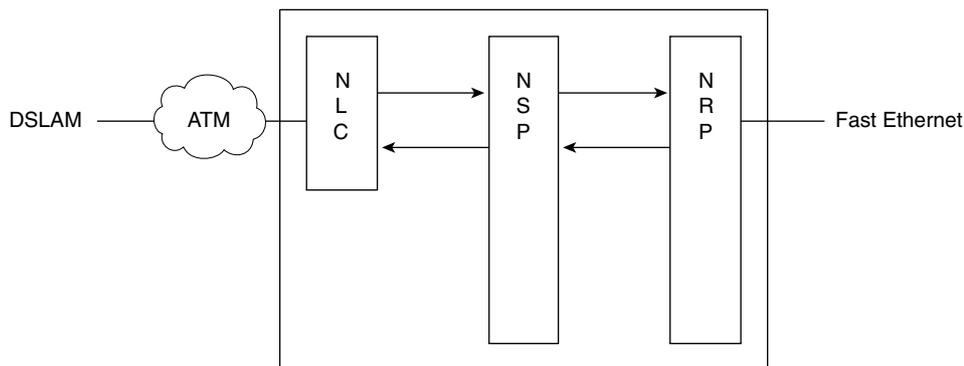
The 6400 is a broadband concentrator that supports Cisco's ATM services, PPP termination, and tunneling. The Cisco 6400 combines ATM switching and routing in a modular and scalable platform.

The 6400 UAC comprises three major functional components:

- **Node Line Card (NLC)**—A half-height line card. It features two OC-3 ATM interfaces and supports SONET APS 1+1 redundancy.
- **Node Switch Processor (NSP)**—The centerpiece of the 6400 system. It performs ATM switching and per-flow queuing for the ATM virtual circuits.
- **Node Route Processor (NRP)**—Based on the Cisco 7200 series router. It supports a variety of configurations, including PPP over ATM and RFC 1483 bridging. It is a full-height line card.

Figure 8-4 illustrates how these components work together.

Figure 8-4 Typical Traffic Flow for the Cisco 6400 UAC



The NLC receives traffic from the DSLAM or other ATM network. The NLC sends this traffic to the NSP. The NSP acts as an ATM switch. The ATM cells must be sent from the NSP to the NRP. The NRP handles routing functions for the 6400. The NRP reassembles the ATM cells into data packets and determines where the data needs to be sent. Direct data connections can be made via a Fast Ethernet port on the NRP. Other data packets are sent back through the NSP to the NLC, where these packets may be routed through the ATM network.

Understanding interface numbering is also important before you configure the 6400. The **interface slot/subslot/port** convention is used for both NLC and NRP. For NLC, the valid subslot and port number are 0 and 1. Because NRP is a full-height card, the subslot and port are always 0. In Example 8-6, NRP is installed in slot 1 and NLC is installed in slot 8, subslot 1.

Example 8-6 Cisco 6400 UAC Interface Numbering

```

interface atm 1/0/0  NRP in slot 1
interface atm 8/1/0  NLC in slot 8, sub-slot 1, port 0
  
```

All line cards are connected to the ATM backplane to the NSP. This interface is known as interface ATM0/0/0 and can be thought of as the interface to the NSP from an NLC or NRP card's perspective. Example 8-7 shows information about the NSP's ATM backplane.

Example 8-7 *Internal Connection to the CPU Card*

```
lab-6400NSP#show interface atm 0/0/0
ATM0/0/0 is up, line protocol is up
  Hardware is CPU card
  MTU 4470 bytes, sub MTU 4470, BW 155520 Kbit, DLY 0 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ATM, loopback not set
  Keepalive not supported
  Encapsulation(s):
  4096 maximum active VCs, 0 current VCCs
  VC idle disconnect time: 300 seconds
  Signalling vc = 35, vpi = 0, vci = 16
  UNI Version = 3.0, Link Side = user
```

To create an ATM PVC on the Cisco 6400, you can use the following command syntax:

```
interface atm slot/subslot/port
atm pvc vpi vci interface atm slot/subslot/port vpi vci
```

Example 8-8 shows you how to create an ATM PVC. From the NSP, to create PVC 1/100 coming from NLC 8/0/0 to NRP 1/0/0, the 6400 commands are as shown.

Example 8-8 *Creating an ATM PVC from the NLC to the NRP*

```
interface atm 8/0/0
atm pvc 1 100 atm1/0/0 1 100
```

DSL Access Architectures and Protocols

The following sections show you the different access architectures and protocols for the DSL service. Four types of access architectures and protocols are covered in this chapter.

- IRB
- RBE
- PPPoA
- PPPoE

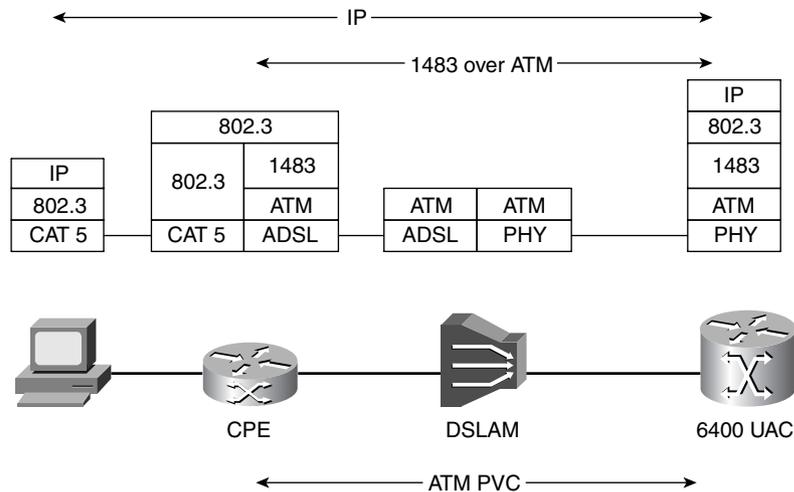
RFC 1483 Bridging and IRB Overview

When configured for RFC 1483 bridging, the ATU-R acts as a half bridge, forwarding all MAC frames not present on the LAN side to the WAN interface. In the case of 1483 bridging, 802.3 MAC frames are encapsulated along with an LLC/SNAP header into cells using AAL5 segmentation. The LLC/SNAP header is used to identify the protocols encapsulated to the

remote end. Bridge groups are defined by associating VCs with each other. Bridge groups can be defined in several ways. Bridge members can communicate only with a network host, between each member and use IRB to route out of the bridge.

Bridge Group Virtual Interface (BVI) is a virtual interface that resides in the Cisco 827 and NRP. It acts as an interface between a bridge group and a routed interface. When configured for IRB, the BVI is assigned a number that corresponds to the bridge group that is used to associate the bridge group with the BVI. BVI is used as routed interface with network-layer attributes such as IP address, filtering, and so on. On BVI, routing is enabled on a per-protocol basis. BVI allows you to route a given protocol between routed interfaces and bridge groups. Figure 8-5 illustrates the RFC 1483 bridging protocol stack.

Figure 8-5 RFC 1483 Bridging Protocol Stack



To configure IRB, follow these steps:

Step 1 Enable IRB with the following code:

```
bridge irb
```

Step 2 Specify the bridge protocol to define the type of Spanning Tree Protocol:

```
bridge bridge-group protocol {ieee | dec}
```

Step 3 Specify a protocol to be routed in a bridge group:

```
bridge bridge-group route protocol
```

Step 4 Configure the ATM subinterface and aal5snap encapsulation:

```
interface atm slot/0.subinterface-number {multipoint | point-to-point}
  pvc [name] vpi/vci
  encapsulation aal5snap
```

Step 5 Assign a network interface to a bridge group:

```
bridge-group bridge-group
```

Step 6 Enables a bridge group virtual interface:

```
interface bvi bridge-group
```

Example 8-9 demonstrates the IRB configuration of the Cisco 6400 NRP.

Example 8-9 *IRB Configuration*

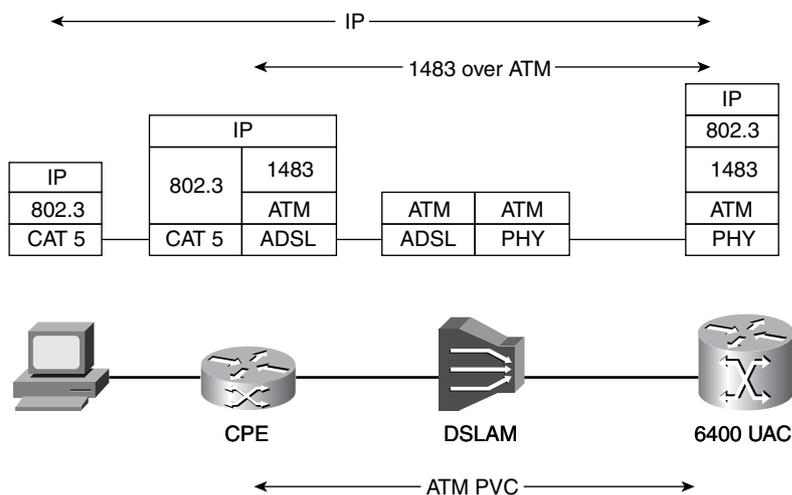
```
bridge irb
bridge 1 protocol ieee
  bridge 1 route ip
!
interface ATM0/0/0.133 point-to-point
  description Integrated
  no ip directed-broadcast
  pvc 1/33
    encapsulation aal5snap
  !
  bridge-group 1
!
interface BVI1
  ip address 10.1.1.1 255.255.255.0
```

RBE Overview

When configured for RBE, the CPE configuration remains the same as that in IRB. RBE is intended to address most of the RFC 1483 bridging issues, such as broadcast storms and security. The ATU-R behaves like the routed-bridge interface that is connected to an Ethernet LAN. For packets sending from the customer side, the destination IP address is examined, and the Ethernet header is skipped. If the destination IP address is in the route cache, the packet is fast-switched to the outbound interface. If the destination IP address is not the route cache, the packet is queued for process switching.

For packets destined for the customer devices, the destination IP address is examined first, and then the destination interface is determined from the IP routing table. To place a destination MAC address in the Ethernet header, the router checks the ARP table for that interface. If the MAC address is not found, the router generates an ARP request for the destination IP address and forwards the ARP request to the destination interface only. If an unnumbered interface is used and multiple subscribers are on the same subnet, the routed-bridge interface uses proxy ARP. All of these can be achieved without using a bridge group or BVI in the aggregation gateway and therefore are more scalable. Figure 8-6 illustrates the RBE protocol stack.

Figure 8-6 RBE Protocol Stack



To configure RBE, follow these steps:

- Step 1** Configure the ATM subinterface, and use `aal5snap` encapsulation. **`ip unnumbered`** is used when subscribers are on the same subnet and to conserve IP address space. You can use the **`ip address`** command if subscribers are on different subnets.

```
interface atm slot/0.subinterface-number {multipoint | point-to-point}
ip unnumbered interface-name-number
pvc [name] vpi/vci
encapsulation aal5snap
```

- Step 2** Associate the RBE command with the ATM subinterface:

```
atm route-bridged ip
```

- Step 3** Define the static host route. It is required if the IP unnumbered configuration is used.

```
ip route network-number [network-mask] {address | interface} [distance]
[name name]
```

Example 8-10 demonstrates the RBE configuration of the Cisco 6400 NRP.

Example 8-10 RBE Configuration

```
interface Loopback0
ip address 192.168.1.1 255.255.255.0
no ip directed-broadcast
!
```

continues

Example 8-10 RBE Configuration (Continued)

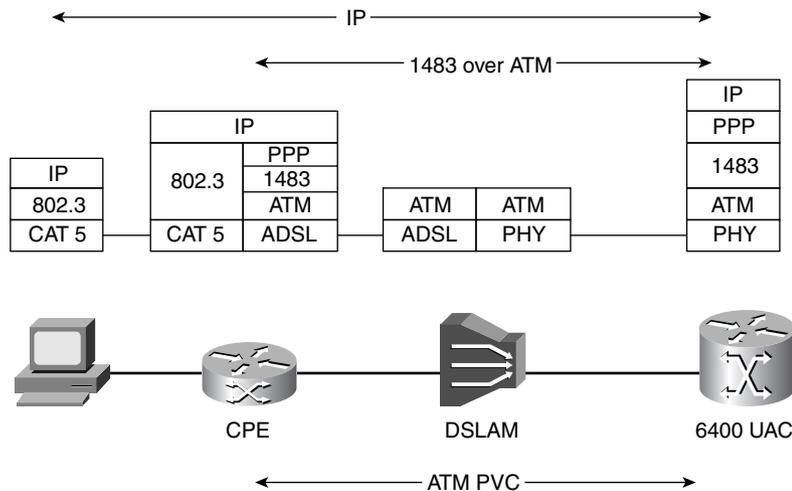
```

interface ATM0/0/0.1 point-to-point
ip unnumbered Loopback0
no ip directed-broadcast
atm route-bridged ip
pvc 1/35
encapsulation aal5snap
!
ip route 192.168.1.2 255.255.255.255 ATM0/0/0.1

```

PPPoA Overview

When configured for PPP over ATM, the ATU-R acts as a router, and additionally provides DHCP and NAT services to the LAN side. In the case of PPP routing, IP packets are encapsulated into a PPP frame and then are segmented into ATM cells through AAL5. The PPP sessions initiated by the subscriber are terminated at the service provider that authenticates users, either using a local database on the router or through a RADIUS server. After the user is authenticated, IPCP negotiation takes place, and then the IP address gets assigned to the CPE. Figure 8-7 illustrates the PPPoA protocol stack.

Figure 8-7 PPPoA Protocol Stack

Follow the next steps to configure PPPoA. (Note that local authentication is used here and that the IP address for the CPE is assigned by the router. RADIUS can be used for these tasks.)

Step 1 Configure a username and password for local authentication:

```
username name password secret
```

Step 2 Create an ATM subinterface and PVC:

```
interface atm slot/0.subinterface-number {multipoint | point-to-point}
  pvc [name] vpi/vci
```

Step 3 Configure PPPoA encapsulation, and associate a virtual template with it:

```
encapsulation aal5mux ppp virtual-template number
```

aal5mux encapsulation is used for the PPPoA configuration. **virtual-template** serves as the template, and the virtual-access interface is cloned from the virtual template.

Step 4 Create a virtual template interface:

```
interface virtual-template number
```

Step 5 Conserve IP addresses by configuring the ATM subinterface as unnumbered, and assign the IP address of the interface type you want to leverage:

```
ip unnumbered interface-name-number
```

Step 6 Create the local IP address pool:

```
ip local pool name begin-ip-address-range [end-ip-address-range]
```

Step 7 Specify the pool for the interface to use:

```
peer default ip address pool poolname
```

Step 8 Enable CHAP or PAP authentication on the interface:

```
ppp authentication {chap | pap | chap pap | pap chap} [if-needed]
  {default | list-name} [callin]
```

Example 8-11 demonstrates the PPPoA configuration of the Cisco 6400 NRP.

Example 8-11 PPPoA Configuration

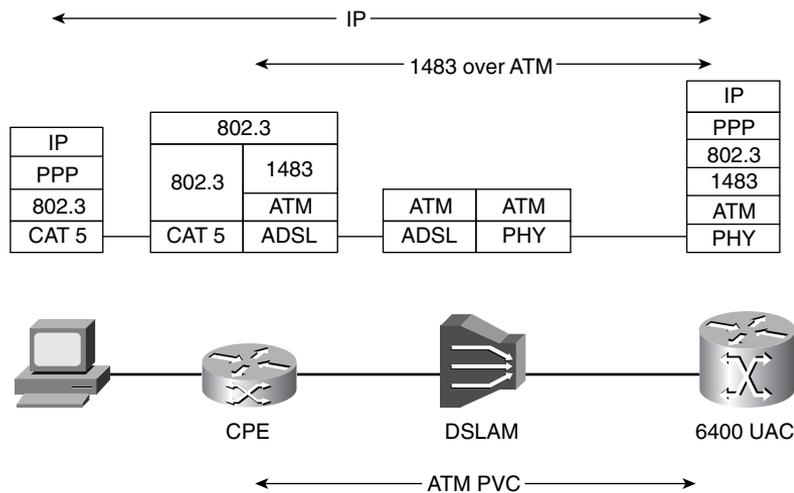
```
username cisco password 0 cisco
!
interface ATM0/0/0.133 point-to-point
  no ip directed-broadcast
  pvc 1/33
    encapsulation aal5mux ppp Virtual-Template1
  !
interface Virtual-Template1
  description PPPoATM
  ip unnumbered FastEthernet0/0/0
  no ip directed-broadcast
  peer default ip address pool ccnp
  ppp authentication chap
  !
ip local pool ccnp 10.1.1.10 10.1.1.50
```

PPPoE Overview

For PPPoE, the ATU-R is transparent to this function, bridging the MAC/PPP frames across the WAN interface. The PPPoE feature allows a PPP session to be initiated on a simple bridging Ethernet-connected client. The session is transported over the ATM link via encapsulated Ethernet-bridged frames. The session can be terminated at either a local exchange carrier central office or an Internet service provider point of presence. The termination device is a Cisco 6400 UAC.

In the PPPoE architecture, the IP address allocation for the individual host running the PPPoE client is based on the same principle of PPP in dial mode—that is, via IPCP negotiation. Where the IP address is allocated from depends on the type of service the subscriber has subscribed to and where the PPP sessions are terminated. The PPPoE uses the dialup networking feature of Microsoft Windows. The IP address assigned is reflected with the PPP adapter. The IP address assignment can be either by the UAC or the home gateways if L2TP is used. The IP address is assigned for each PPPoE session. Figure 8-8 illustrates the PPPoE protocol stack.

Figure 8-8 *PPPoE Protocol Stack*



To configure PPPoE, follow these steps. (Note that local authentication is used here, and the router assigns IP addresses for the hosts. RADIUS can be used for these tasks.)

Step 1 Make sure Cisco Express Forwarding is enabled. If it isn't, use the following command to enable it:

```
ip cef
```

Step 2 Configure the username and password for local authentication:

```
username name password secret
```

Step 3 Enable the virtual private dialup network (VPDN) configuration:

```
vpdn enable
```

Step 4 Configure the VPDN group to accept the dial-in and to be used to establish PPPoE sessions. Also specify the virtual template that will be used to clone virtual-access interfaces:

```
vpdn-group number
  accept-dialin
  protocol pppoe
  virtual-template template-number
```

Step 5 Create the ATM subinterface and PVC. Also configure AAL5SNAP encapsulation and specify the PPPoE protocol that the VPDN group will use:

```
interface atm slot/0.subinterface-number {multipoint | point-to-point}
  pvc [name] vpi/vci
  encapsulation aal5snap
  protocol pppoe
```

Step 6 Create the virtual template interface:

```
interface virtual-template number
```

Step 7 Conserve IP addresses by configuring the ATM subinterface as unnumbered, and assign the IP address of the interface type you want to leverage:

```
ip unnumbered interface-name-number
```

Step 8 Configure the maximum transmission unit (MTU):

```
ip mtu 1492
```

Because Ethernet has a maximum payload size of 1500 bytes, the PPPoE header is 6 bytes and the PPP ID is 2 bytes, so the PPP MTU must not be greater than 1492 bytes.

Step 9 Create a local IP address pool:

```
ip local pool name begin-ip-address-range [end-ip-address-range]
```

Step 10 Specify the IP address pool for the interface to use:

```
peer default ip address pool poolname
```

Step 11 Enable CHAP or PAP authentication on the interface:

```
ppp authentication {chap | pap | chap pap | pap chap} [if-needed]
  {default | list-name} [callin]
```

Example 8-12 demonstrates the PPPoE configuration of the Cisco 6400 NRP.

Example 8-12 PPPoE Configuration

```
username cisco password 0 cisco
!
vpdn enable
!
vpdn-group 1
```

continues

Example 8-12 *PPPoE Configuration (Continued)*

```

accept-dialin
 protocol pppoe
 virtual-template 1
!
ip cef
!
interface ATM0/0/0.133 point-to-point
 no ip directed-broadcast
 pvc 1/33
  encapsulation aal5snap
  protocol pppoe
!
interface Virtual-Template1
 ip unnumbered FastEthernet0/0/0
 no ip directed-broadcast
 ip mtu 1492
 peer default ip address pool ccnp
 ppp authentication chap
!
ip local pool ccnp 10.1.1.10 10.1.1.50

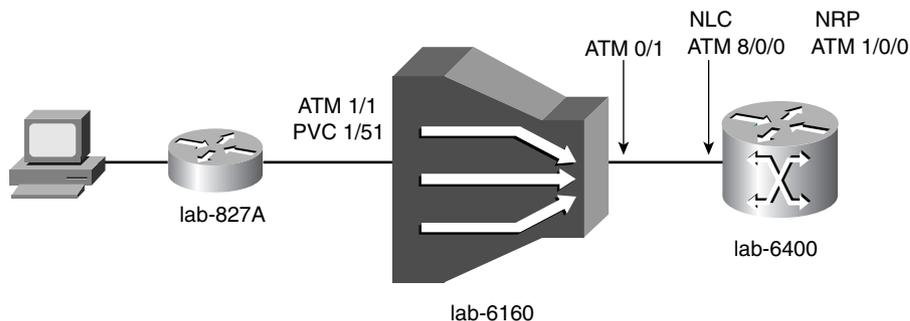
```

Scenarios

This section presents several examples of DSL access configurations. The scenarios cover the configuration for a DSLAM, a Cisco 6400 UAC NSP, a Cisco 6400 UAC NRP, and a DSL CPE - Cisco 827.

Scenario 8-1: Configuring IRB over DSL

In this scenario, you will configure the DSL solution to support data transport using IRB. When completed, the Cisco 827 should train up with the DSLAM, and you should be able to ping and access all normal network services from a client PC attached to the DSL CPE modem. Figure 8-9 illustrates how these devices are interconnected.

Figure 8-9 *IRB Lab Scenario*

In Example 8-13, the PVC is mapped from the Cisco 827 DSL connection (ATM1/1) to the DSLAM trunking port (ATM0/1).

Example 8-13 *ATM PVC Configuration for the Cisco 6160 DSLAM*

```
interface ATM1/1
  description IRB Architecture
  no ip address
  no atm ilmi-keepalive
  atm pvc 1 51 interface ATM0/1 1 51
```

In Example 8-14, the PVC is configured from the DSLAM to the NSP and NRP. Interface ATM8/0/0 is the network line card, and interface ATM1/0/0 is the NRP.

Example 8-14 *ATM PVC Configuration for the NSP*

```
interface ATM8/0/0
  description OC3 connection to lab-6160
  no ip address
  no ip directed-broadcast
  no atm ilmi-keepalive
  atm pvc 1 51 interface ATM1/0/0 1 51
```

A bridge group is configured for IP, and a BVI is created for IRB. The BVI becomes the default gateway for the remote device attached to the CPE equipment (which will be in subnet 10.1.121.0/24). A subinterface is created for a PVC to the NSP. (See the NSP configuration. The NSP maps this PVC to another PVC from the DSLAM, which maps to the subscriber PVC.) In this case, the 1/51 PVC is mapped across the NSP to the 6160. The subinterface is also put in the bridge group. Example 8-15 shows the IRB configuration for the NRP.

Example 8-15 *IRB Configuration for the NRP*

```
bridge irb
!
interface BVI1
ip address 10.1.121.1 255.255.255.0
no ip directed-broadcast
!
bridge 1 protocol ieee
  bridge 1 route ip
!
interface ATM0/0/0
no ip address
no ip directed-broadcast
!
interface ATM0/0/0.51 point-to-point
```

continues

Example 8-15 *IRB Configuration for the NRP (Continued)*

```
description IRB Configuration
no ip directed-broadcast
pvc 1/51
encapsulation aal5snap
!
bridge-group 1
```

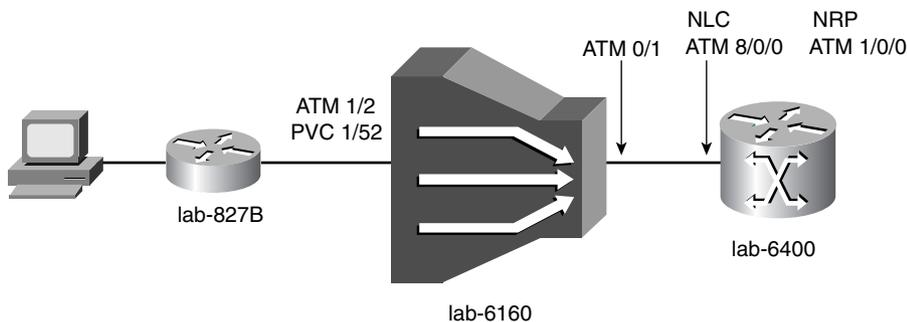
Example 8-16 shows the bridging configuration for the DSL CPE.

Example 8-16 *RFC 1483 Bridging Configuration for the Cisco 827*

```
hostname lab-827A
!
ip subnet-zero
no ip routing
!
interface Ethernet0
ip address 10.1.121.2 255.255.255.0
no ip directed-broadcast
no ip mroute-cache
bridge-group 1
!
interface atm0
mac-address 0001.96a4.8fae <--- MAC Address from Ethernet 0
ip address 10.1.121.2 255.255.255.0
no ip directed-broadcast
no ip mroute-cache
no atm ilmi-keepalive
pvc 1/51
encapsulation aal5snap
!
bundle-enable
bridge-group 1
hold-queue 224 in
!
ip classless
no ip http server
!
bridge 1 protocol ieee
```

Scenario 8-2: Configuring RBE over DSL

In this scenario, you will configure the DSL solution to support data transport using RBE. When completed, the Cisco 827 should train up with the DSLAM, and you should be able to ping and access all normal network services from a client PC attached to the DSL CPE modem. Figure 8-10 illustrates how these devices are interconnected.

Figure 8-10 RBE Scenario

In Example 8-17, the PVC is mapped from the Cisco 827 DSL connection (ATM1/2) to the DSLAM trunking port (ATM0/1).

Example 8-17 ATM PVC Configuration for the Cisco 6160 DSLAM

```
interface ATM1/2
  description RBE Architecture
  no ip address
  no atm ilmi-keepalive
  atm pvc 1 52 interface ATM0/1 1 52
```

In Example 8-18, the PVC is configured from the DSLAM to the NSP and NRP. Interface ATM8/0/0 is the network line card, and interface ATM1/0/0 is the NRP.

Example 8-18 ATM PVC Configuration for the NSP

```
interface ATM8/0/0
  description OC3 connection to lab-6160
  no ip address
  no ip directed-broadcast
  no atm ilmi-keepalive
  atm pvc 1 52 interface ATM1/0/0 1 52
```

Example 8-19 shows the RBE configuration for the NRP. You saw the configuration steps in the previous section.

Example 8-19 RBE Configuration for the NRP

```
interface Loopback1
  ip address 10.1.121.1 255.255.255.0
  no ip directed-broadcast
  !
interface ATM0/0/0
  no ip address
  no ip directed-broadcast
```

continues

Example 8-19 *RBE Configuration for the NRP (Continued)*

```
!  
interface ATM0/0/0.52 point-to-point  
description RBE Configuration  
ip unnumbered Loopback1  
atm route-bridged ip  
pvc 1/52  
encapsulation aal5snap  
!  
ip route 10.1.121.2 255.255.255.255 ATM0/0/0.52
```

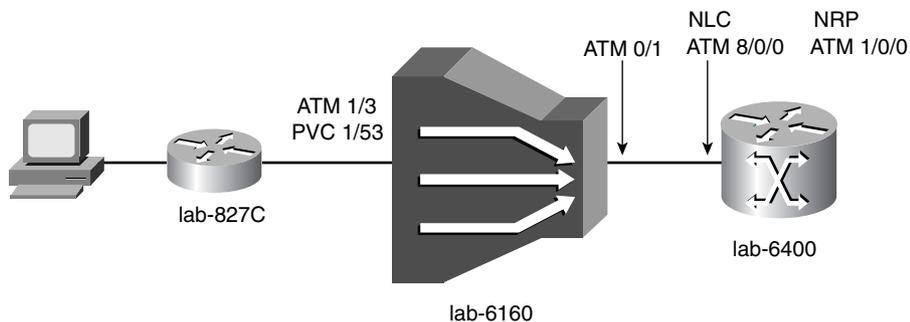
Example 8-20 shows the bridging configuration for the DSL CPE. As you can see, the CPE configuration is the same when you configure the IRB over DSL.

Example 8-20 *RFC 1483 Bridging Configuration for the Cisco 827*

```
hostname lab-827B  
!  
ip subnet-zero  
no ip routing  
!  
interface Ethernet0  
ip address 10.1.121.2 255.255.255.0  
no ip directed-broadcast  
no ip mroute-cache  
bridge-group 1  
!  
interface atm0  
mac-address 0001.96a4.8fae  
ip address 10.1.121.2 255.255.255.0  
no ip directed-broadcast  
no ip mroute-cache  
no atm ilmi-keepalive  
pvc 1/52  
encapsulation aal5snap  
!  
bundle-enable  
bridge-group 1  
hold-queue 224 in  
!  
ip classless  
no ip http server  
!  
bridge 1 protocol ieee
```

Scenario 8-3: Configuring PPPoA over DSL

In this scenario, you will configure the DSL solution to support data transport using PPPoA. When completed, the Cisco 827 should train up with the DSLAM, and you should be able to ping and access all normal network services from a client PC attached to the DSL CPE modem. Figure 8-11 illustrates how these devices are interconnected.

Figure 8-11 *PPPoA Lab Scenario*

In Example 8-21, the PVC is mapped from the Cisco 827 DSL connection (ATM1/3) to the DSLAM trunking port (ATM0/1).

Example 8-21 *ATM PVC Configuration for the Cisco 6160 DSLAM*

```
interface ATM1/3
  description PPPoA Architecture
  no ip address
  no atm ilmi-keepalive
  atm pvc 1 53 interface ATM0/1 1 53
```

In Example 8-22, the PVC is configured from the DSLAM to the NSP and NRP. Interface ATM8/0/0 is the network line card, and interface ATM1/0/0 is the NRP.

Example 8-22 *ATM PVC Configuration for the NSP*

```
interface ATM8/0/0
  description OC3 connection to lab-6160
  no ip address
  no ip directed-broadcast
  no atm ilmi-keepalive
  atm pvc 1 53 interface ATM1/0/0 1 53
```

Example 8-23 shows the PPPoA configuration for the NRP.

Example 8-23 *PPPoA Configuration for the NRP*

```
username cisco password 0 cisco
!
interface ATM0/0/0
  no ip address
  no ip directed-broadcast
!
interface ATM0/0/0.53 point-to-point
  description PPPoA Configuration
  pvc 1/53
```

continues

Example 8-23 *PPPoA Configuration for the NRP (Continued)*

```
    encapsulation aal5mux ppp Virtual-Template1
    !
interface Virtual-Template1
description PPPoA
ip unnumbered Ethernet0/0/0
peer default ip address pool ccnp
ppp authentication chap pap
```

Example 8-24 shows the PPPoA configuration for the DSL CPE.

Example 8-24 *PPPoA Configuration for the Cisco 827*

```
hostname lab-827C
!
ip subnet-zero
!
interface Ethernet0
ip address 10.0.0.1 255.255.255.0
no ip directed-broadcast
no ip mroute-cache
!
interface ATM0
no ip address
no ip directed-broadcast
no ip mroute-cache
no atm ilmi-keepalive
pvc 1/53
encapsulation aal5mux ppp dialer
dialer pool-member 1
!
!
interface Dialer1
ip address negotiated
no ip directed-broadcast
encapsulation ppp
dialer pool 1
dialer-group 1
ppp authentication chap callin
ppp chap hostname cisco
ppp chap password cisco
!
ip classless
!
dialer-list 1 protocol ip permit
```

When a PPP connection is made, a virtual interface is created, as shown in Example 8-25. The connection is authenticated with PAP/CHAP (using username “cisco” and password “cisco”). IP addresses are negotiated and handed out from the address pool named ccnp.

Example 8-25 *Verifying the Virtual Interface*

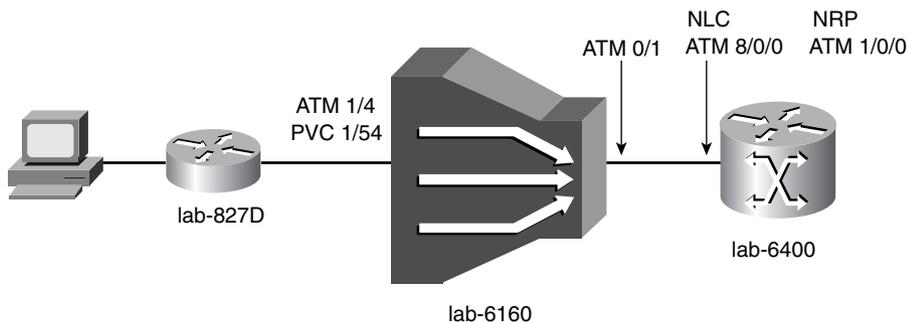
```

lab-6400NRP#show interface virtual-access 1
Virtual-Access1 is up, line protocol is up
  Hardware is Virtual Access interface
  Description: PPPoA
  Interface is unnumbered. Using address of Ethernet0/0/0 (10.1.1.190)
  MTU 1500 bytes, BW 100000 Kbit, DLY 100000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation PPP, loopback not set
  Keepalive set (10 sec)
  DTR is pulsed for 5 seconds on reset
  LCP Open
  Open: IPCP
  Bound to ATM0/0/0.53 VCD: 3, VPI: 1, VCI: 53
  Cloned from virtual-template: 1
  Last input 00:00:03, output never, output hang never
  Last clearing of "show interface" counters 14:05:57
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
    10239 packets input, 141642 bytes, 0 no buffer
    Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
    21626 packets output, 852074 bytes, 0 underruns
    0 output errors, 0 collisions, 0 interface resets
    0 output buffer failures, 0 output buffers swapped out
    0 carrier transitions

```

Scenario 8-4: Configuring PPPoE over DSL

In this scenario, you will configure the DSL solution to support data transport using PPPoE. When completed, the Cisco 827 should train up with the DSLAM, and you should be able to ping and access all normal network services from a client PC attached to the DSL CPE modem. Figure 8-12 illustrates how these devices are interconnected.

Figure 8-12 *PPPoE Lab Scenario*

In Example 8-26, the PVC is mapped from the Cisco 827 DSL connection (ATM1/4) to the DSLAM trunking port (ATM0/1).

Example 8-26 *ATM PVC Configuration for the Cisco 6160 DSLAM*

```
interface ATM1/4
  description PPPoE Architecture
  no ip address
  no atm ilmi-keepalive
  atm pvc 1 54 interface ATM0/1 1 54
```

In Example 8-27, the PVC is configured from the DSLAM to the NSP and NRP. Interface ATM8/0/0 is the network line card, and interface ATM1/0/0 is the NRP.

Example 8-27 *ATM PVC Configuration for the NSP*

```
interface ATM8/0/0
  description OC3 connection to lab-6160
  no ip address
  no ip directed-broadcast
  no atm ilmi-keepalive
  atm pvc 1 54 interface ATM1/0/0 1 54
```

Example 8-28 shows the PPPoE configuration for the NRP.

Example 8-28 *PPPoE Configuration for the NRP*

```
username cisco password 0 cisco
!
vpdn enable
!
vpdn-group 1
  accept-dialin
  protocol pppoe
  virtual-template 1
interface ATM0/0/0
  no ip address
  no ip directed-broadcast
!
interface ATM0/0/0.54 point-to-point
  description LAB PPPoE Configuration
  pvc 1/54
  encapsulation aal5snap
  protocol pppoe
!
interface Virtual-Template1
  description PPPoE
  ip unnumbered Ethernet0/0/0
  ip mtu 1492
  peer default ip address pool ccnp
  ppp authentication chap pap
```

For PPPoE over DSL, the DSL CPE is also configured for pure RFC 1483 bridging, as shown in Example 8-29.

Example 8-29 *RFC 1483 Bridging Configuration for the Cisco 827*

```
hostname lab-827D
!
ip subnet-zero
no ip routing
!
interface Ethernet0
  no ip address
  no ip directed-broadcast
  no ip mroute-cache
  bridge-group 1
!
interface atm0
  mac-address 0001.96a4.8fae
  ip address 10.1.121.2 255.255.255.0
  no ip directed-broadcast
  no ip mroute-cache
  no atm ilmi-keepalive
  pvc 1/52
    encapsulation aal5snap
  !
  bundle-enable
  bridge-group 1
  hold-queue 224 in
!
ip classless
no ip http server
!
bridge 1 protocol ieee
```

When a PPP connection is made, a virtual interface is created, as shown in Example 8-30. The connection is authenticated with PAP/CHAP (using username “cisco” and password “cisco”). IP addresses are negotiated and handed out from the address pool named ccnp.

Example 8-30 *Verifying the Virtual Interface*

```
lab-6400NRP#show int Virtual-Access3
Virtual-Access3 is up, line protocol is up
  Hardware is Virtual Access interface
  Description: PPPoE
  Interface is unnumbered. Using address of Ethernet0/0/0 (10.1.1.190)
  MTU 1492 bytes, BW 100000 Kbit, DLY 100000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation PPP, loopback not set
  Keepalive set (10 sec)
  DTR is pulsed for 5 seconds on reset
  LCP Open
  Open: IPCP
```

continues

Example 8-30 *Verifying the Virtual Interface (Continued)*

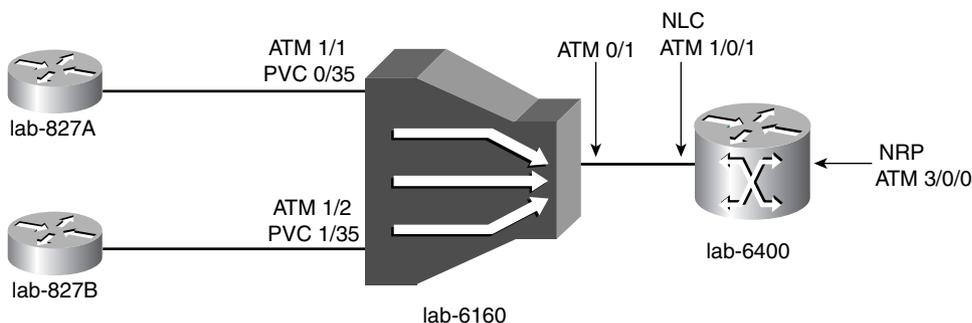
```

Bound to ATM0/0/0.54 VCD: 4, VPI: 1, VCI: 54
Cloned from virtual-template: 1
Last input 00:00:04, output never, output hang never
Last clearing of "show interface" counters 00:01:34
Queueing strategy: fifo
Output queue 0/40, 0 drops; input queue 0/75, 0 drops
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
 40 packets input, 2923 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
 0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
 78 packets output, 6071 bytes, 0 underruns
 0 output errors, 0 collisions, 0 interface resets
 0 output buffer failures, 0 output buffers swapped out
 0 carrier transitions

```

Practical Exercise 8-1: PPPoA over DSL

In this practical exercise, both lab-827A and lab-827B are connected to the DSLAM, as shown in Figure 8-13. You need to create two different DSL profiles—premium and standard. Each of them has a different downstream and upstream speed. Assign a premium DSL profile to lab-827A and a standard DSL profile to lab-827B. In this exercise, you will configure local authentication. IP addresses are assigned to the DSL CPEs from the IP pool configured in the Cisco 6400.

Figure 8-13 *Practical Exercise: PPPoA over DSL*

Practical Exercise 8-1 Solution

Examples 8-31 through 8-35 show the PPPoA configurations for the DSL CPEs, Cisco 6160 DSLAM, and Cisco 6400.

Example 8-31 Configuration Output for lab-827A

```
lab-827A#show running-config
version 12.2
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname lab-827A
!
ip subnet-zero
!
interface Ethernet0
  no ip address
  shutdown
  hold-queue 100 out
!
interface ATM0
  no ip address
  no atm ilmi-keepalive
  pvc 0/35
    encapsulation aal5mux ppp dialer
    dialer pool-member 1
  !
  dsl operating-mode auto
  dsl power-cutback 0
!
interface Dialer1
  ip address negotiated
  encapsulation ppp
  dialer pool 1
  ppp chap hostname cisco
  ppp chap password 0 cisco
!
ip classless
ip route 0.0.0.0 0.0.0.0 Dialer1
ip http server
!
!
!
call rsvp-sync
!
voice-port 1
!
voice-port 2
!
voice-port 3
!
voice-port 4
!
!
```

continues

Example 8-31 *Configuration Output for lab-827A (Continued)*

```
line con 0
  stopbits 1
line vty 0 4
  login
!
scheduler max-task-time 5000
end
```

Example 8-32 *Configuration Output for lab-827B*

```
lab-827B#show running-config
version 12.2
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname lab-827B
!
!
ip subnet-zero
!
!
!
!
interface Ethernet0
  no ip address
  shutdown
  hold-queue 100 out
!
interface ATM0
  no ip address
  no atm ilmi-keepalive
  pvc 0/35
    encapsulation aal5mux ppp dialer
    dialer pool-member 1
  !
  dsl operating-mode auto
!
interface Dialer1
  ip address negotiated
  encapsulation ppp
  dialer pool 1
  ppp chap hostname cisco
  ppp chap password 0 cisco
!
ip classless
ip route 0.0.0.0 0.0.0.0 Dialer1
ip http server
ip pim bidir-enable
```

Example 8-32 Configuration Output for lab-827B (Continued)

```

!
!
!
!
line con 0
  stopbits 1
line vty 0 4
  login
!
scheduler max-task-time 5000
end

```

In Example 8-33, two DSL profiles, premium and standard, are defined. As you can see, each of them is configured with different downstream and upstream speeds.

Example 8-33 Configuration Output for lab-6160

```

lab-6160#show running-config
version 12.2
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname lab-6160
!
slot 1 ATUC-4FLEXIDMT
slot 10 NI-2-155SM-DS3
!
!
dsl-profile default
!
dsl-profile premium
  dmt bitrate maximum fast downstream 8064 upstream 864
  dmt bitrate maximum interleaved downstream 0 upstream 0
!
dsl-profile standard
  dmt bitrate maximum fast downstream 6400 upstream 640
  dmt bitrate maximum interleaved downstream 0 upstream 0
!
network-clock-select 1 ATM0/1
redundancy
ip subnet-zero
!
!
no atm oam intercept end-to-end
atm address 47.0091.8100.0000.0030.96fe.db01.0030.96fe.db01.00
atm router pnni
  no aesa embedded-number left-justified
node 1 level 56 lowest
  redistribute atm-static

```

continues

Example 8-33 *Configuration Output for lab-6160 (Continued)*

```
!  
!  
!  
!  
interface ATM0/0  
  no ip address  
  atm maxvp-number 0  
  atm maxvc-number 4096  
  atm maxvci-bits 12  
!  
interface Ethernet0/0  
  no ip address  
  shutdown  
!  
interface ATM0/1  
  no ip address  
  no atm ilmi-keepalive  
!  
interface ATM0/2  
  no ip address  
  no atm ilmi-keepalive  
!  
interface ATM0/3  
  no ip address  
  no atm ilmi-keepalive  
!  
interface ATM1/1  
  no ip address  
  dsl profile premium  
  no atm ilmi-keepalive  
  atm pvc 0 35 interface ATM0/1 1 35  
!  
interface ATM1/2  
  no ip address  
  dsl profile standard  
  no atm ilmi-keepalive  
  atm pvc 0 35 interface ATM0/1 2 35  
!  
interface ATM1/3  
  no ip address  
  no atm ilmi-keepalive  
!  
interface ATM1/4  
  no ip address  
  no atm ilmi-keepalive  
!  
ip classless  
no ip http server  
ip pim bidir-enable  
!  
!  
!
```

Example 8-33 Configuration Output for lab-6160 (Continued)

```
line con 0
line aux 0
line vty 0 4
!
end
```

Example 8-34 Configuration Output for lab-6400NSP

```
lab-6400NSP#show running-config
version 12.2
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname lab-6400NSP
!
facility-alarm intake-temperature major 49
facility-alarm intake-temperature minor 40
facility-alarm core-temperature major 53
facility-alarm core-temperature minor 45
ip subnet-zero
!
ip cef
!
atm address 47.0091.8100.0000.0050.7359.3581.0050.7359.3581.00
atm router pnni
no aesa embedded-number left-justified
node 1 level 56 lowest
redistribute atm-static
!
interface ATM0/0/0
no ip address
atm maxvp-number 0
!
interface Ethernet0/0/0
no ip address
bridge-group 1
!
interface ATM1/0/0
no ip address
no atm ilmi-keepalive
!
interface ATM1/0/1
no ip address
no atm ilmi-keepalive
!
interface ATM2/0/0
no ip address
no atm ilmi-keepalive
!
```

continues

Example 8-34 *Configuration Output for lab-6400NSP (Continued)*

```
interface ATM2/0/1
  no ip address
  no atm ilmi-keepalive
  !
interface ATM3/0/0
  no ip address
  no atm ilmi-keepalive
  atm pvc 1 35 interface ATM1/0/1 1 35
  atm pvc 2 35 interface ATM1/0/1 2 35
  !
  !
  !
ip classless
ip http server
ip pim bidir-enable
!
line con 0
line 1 16
line aux 0
line vty 0 4
!
end
```

Example 8-35 *Configuration Output for lab-6400NRP*

```
lab-6400NRP#show running-config
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname lab-6400NRP
!
logging rate-limit console 10 except errors
no logging console
!
username cisco password 0 cisco
redundancy
  main-cpu
  auto-sync standard
  no secondary console enable
ip subnet-zero
!
!
!
!
!
interface Loopback1
  ip address 20.1.1.1 255.255.255.255
  !
```

Example 8-35 Configuration Output for lab-6400NRP (Continued)

```
interface ATM0/0/0
  no ip address
  no atm ilmi-keepalive
  hold-queue 500 in
  !
interface ATM0/0/0.135 point-to-point
  pvc 1/35
  encapsulation aal5mux ppp Virtual-Template1
  !
!
interface ATM0/0/0.235 point-to-point
  pvc 2/35
  encapsulation aal5mux ppp Virtual-Template1
  !
!
interface Ethernet0/0/1
  ip address negotiated
  !
interface Ethernet0/0/0
  no ip address
  shutdown
  !
interface FastEthernet0/0/0
  no ip address
  half-duplex
  !
interface Virtual-Template1
  mtu 1460
  ip unnumbered Loopback1
  peer default ip address pool ccnp
  ppp authentication chap
  !
ip local pool ccnp 20.1.1.2 20.1.1.10
ip classless
ip http server
!
!
!
!
!
line con 0
line aux 0
line vty 0 4
  login
!
end
```

Example 8-36 shows that lab-827A has successfully passed the PPP negotiation and authentication. An IP address is assigned to the DSL connection.

Example 8-36 *Output of show ip interface brief for lab-827A*

```
lab-827A#show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
Ethernet0	unassigned	YES	NVRAM	administratively down	down
ATM0	unassigned	YES	NVRAM	up	up
Dialer1	20.1.1.3	YES	BOOTP	up	up
Virtual-Access1	unassigned	YES	unset	up	up
Virtual-Access2	unassigned	YES	unset	up	up
Virtual-Access3	unassigned	YES	unset	up	up

Example 8-37 shows that lab-827B has successfully passed the PPP negotiation and authentication. An IP address is assigned to the DSL connection.

Example 8-37 *Output of show ip interface brief for lab-827B*

```
lab-827B#show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
Ethernet0	unassigned	YES	NVRAM	administratively down	down
ATM0	unassigned	YES	NVRAM	up	up
Dialer1	20.1.1.2	YES	BOOTP	up	up
Virtual-Access1	unassigned	YES	unset	up	up
Virtual-Access2	unassigned	YES	unset	up	up
Virtual-Access3	unassigned	YES	unset	up	up

In Example 8-38, two virtual interfaces are cloned from the virtual template. They are served as Layer 3 termination for the DSL CPEs—lab-827A and lab-827B. Examples 8-39 and 8-40 show the details of two virtual interfaces.

Example 8-38 *Output of show ip interface brief for lab-6400NRP*

```
lab-6400NRP#show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
ATM0/0/0	unassigned	YES	NVRAM	up	up
ATM0/0/0.135	unassigned	YES	unset	up	up
ATM0/0/0.235	unassigned	YES	unset	up	up
Ethernet0/0/1	unassigned	YES	NVRAM	up	up
Ethernet0/0/0	unassigned	YES	NVRAM	administratively down	down
FastEthernet0/0/0	unassigned	YES	NVRAM	up	up
Virtual-Access1	20.1.1.1	YES	TFTP	up	up
Virtual-Template1	20.1.1.1	YES	TFTP	down	down
Virtual-Access2	20.1.1.1	YES	TFTP	up	up
Loopback1	20.1.1.1	YES	NVRAM	up	up

Example 8-39 *Verifying the Virtual Interface for lab-827A*

```
lab-6400NRP#show interface virtual-access1
```

```
Virtual-Access1 is up, line protocol is up
Hardware is Virtual Access interface
Interface is unnumbered. Using address of Loopback1 (20.1.1.1)
MTU 1460 bytes, BW 100000 Kbit, DLY 100000 usec,
reliability 255/255, txload 1/255, rxload 1/255
```

Example 8-39 *Verifying the Virtual Interface for lab-827A (Continued)*

```

Encapsulation PPP, loopback not set
Keepalive set (10 sec)
DTR is pulsed for 5 seconds on reset
LCP Open
Open: IPCP
Bound to ATM0/0/0.135 VCD: 1, VPI: 1, VCI: 35
Cloned from virtual-template: 1
Last input 00:00:03, output never, output hang never
Last clearing of "show interface" counters 00:12:13
Queueing strategy: fifo
Output queue 0/40, 0 drops; input queue 0/75, 0 drops
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
  100 packets input, 1841 bytes, 0 no buffer
  Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
  200 packets output, 49806 bytes, 0 underruns
  0 output errors, 0 collisions, 0 interface resets
  0 output buffer failures, 0 output buffers swapped out
  0 carrier transitions

```

Example 8-40 *Verifying the Virtual Interface for lab-827B*

```

lab-6400NRP#show interface virtual-access2
Virtual-Access2 is up, line protocol is up
  Hardware is Virtual Access interface
  Interface is unnumbered. Using address of Loopback1 (20.1.1.1)
  MTU 1460 bytes, BW 100000 Kbit, DLY 100000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation PPP, loopback not set
  Keepalive set (10 sec)
  DTR is pulsed for 5 seconds on reset
  LCP Open
  Open: IPCP
  Bound to ATM0/0/0.235 VCD: 2, VPI: 2, VCI: 35
  Cloned from virtual-template: 1
  Last input 00:00:00, output never, output hang never
  Last clearing of "show interface" counters 00:12:51
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
    107 packets input, 1499 bytes, 0 no buffer
    Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
    210 packets output, 53645 bytes, 0 underruns
    0 output errors, 0 collisions, 0 interface resets
    0 output buffer failures, 0 output buffers swapped out
    0 carrier transitions

```

Example 8-41 displays the DSL profile status for the default profile, premium profile, and standard profile. Keep in mind that the premium and standard profiles are created in this exercise. You can use **show dsl profile** [*profile-name*] to display a specific profile, all ports to which the profile is currently attached, and those port settings.

Example 8-41 *Output of show dsl profile*

```

lab-6160#show dsl profile
dsl profile default:
  Link Traps Enabled: NO
  Alarms Enabled: NO
  ATM Payload Scrambling: Enabled

DMT profile parameters
Maximum Bitrates:
  Interleave Path:  downstream:  640 kb/s,  upstream:  128 kb/s
  Fast Path:       downstream:   0 kb/s,   upstream:   0 kb/s
Minimum Bitrates:
  Interleave Path:  downstream:   0 kb/s,  upstream:   0 kb/s
  Fast Path:       downstream:   0 kb/s,  upstream:   0 kb/s
Margin:            downstream:   6 dB,    upstream:   6 dB
Interleaving Delay: downstream: 16000 usecs, upstream: 16000 usecs
Check Bytes (FEC):
  Interleave Path:  downstream:  16,      upstream:  16
  Fast Path:       downstream:   0,      upstream:   0
R-S Codeword Size: downstream:  auto,    upstream:  auto
Trellis Coding:    Disabled
Overhead Framing:  Mode 3
Operating Mode:    Automatic
Training Mode:     Quick
Minrate blocking:  Disabled
SNR Monitoring:    Disabled
Power Management Additional Margin:
  downstream:      0 dB,    upstream:   0 dB

dsl profile premium:
  Link Traps Enabled: NO
  Alarms Enabled: NO
  ATM Payload Scrambling: Enabled

DMT profile parameters
Maximum Bitrates:
  Interleave Path:  downstream:   0 kb/s,  upstream:   0 kb/s
  Fast Path:       downstream: 8064 kb/s,  upstream:  864 kb/s
Minimum Bitrates:
  Interleave Path:  downstream:   0 kb/s,  upstream:   0 kb/s
  Fast Path:       downstream:   0 kb/s,  upstream:   0 kb/s
Margin:            downstream:   6 dB,    upstream:   6 dB
Interleaving Delay: downstream: 16000 usecs, upstream: 16000 usecs
Check Bytes (FEC):
  Interleave Path:  downstream:  16,      upstream:  16
  Fast Path:       downstream:   0,      upstream:   0

```

Example 8-41 *Output of show dsl profile (Continued)*

```

R-S Codeword Size:   downstream: auto,      upstream: auto
Trellis Coding:     Disabled
Overhead Framing:   Mode 3
Operating Mode:     Automatic
Training Mode:      Quick
Minrate blocking:   Disabled
SNR Monitoring:     Disabled
Power Management Additional Margin:
                    downstream:  0 dB,      upstream:  0 dB

dsl profile standard:
Link Traps Enabled: NO
Alarms Enabled: NO
ATM Payload Scrambling: Enabled

DMT profile parameters
Maximum Bitrates:
  Interleave Path:  downstream:  0 kb/s,   upstream:  0 kb/s
  Fast Path:        downstream: 6400 kb/s,  upstream:  640 kb/s
Minimum Bitrates:
  Interleave Path:  downstream:  0 kb/s,   upstream:  0 kb/s
  Fast Path:        downstream:  0 kb/s,   upstream:  0 kb/s
Margin:             downstream:  6 dB,     upstream:  6 dB
Interleaving Delay: downstream: 16000 usecs, upstream: 16000 usecs
Check Bytes (FEC):
  Interleave Path:  downstream:  16,       upstream:  16
  Fast Path:        downstream:  0,       upstream:  0
R-S Codeword Size:  downstream: auto,      upstream: auto
Trellis Coding:     Disabled
Overhead Framing:   Mode 3
Operating Mode:     Automatic
Training Mode:      Quick
Minrate blocking:   Disabled
SNR Monitoring:     Disabled
Power Management Additional Margin:
                    downstream:  0 dB,      upstream:  0 dB

```

lab-827A is patched to port 1/1, and lab-827B is patched to port 1/2. Example 8-42 displays the status of the DSL subscriber ports on a 6160 chassis.

Example 8-42 *Using the show dsl status Command to Display the Status of DSL Ports*

```

lab-6160#show dsl status

Subtend Node ID: 0

      NAME      ADMIN/OPER      DOWNSTREAM      UPSTREAM      SUBSCRIBER      CIRCUIT ID
      -----      -      (Kb)      (Kb)      (truncated)      (truncated)
      -----      -      -----      -----      -----      -----
ATM1/1      UP/  UP      8064      864
ATM1/2      UP/  UP      6400      640
ATM1/3      UP/DOWN      0      0
ATM1/4      UP/DOWN      0      0

```

The **show dsl interface atm slot#/port#** command allows you to display DSL, DMT, and ATM status for a port, as shown in Example 8-43.

Example 8-43 *Displaying DSL, DMT, and ATM Status for Port 1/1*

```

lab-6160#show dsl interface atm 1/1
Port Status:
  Subscriber Name:          Circuit ID:
  IOS admin: UP      oper: UP      Card status: ATUC-4FLEXIDMT
  Last Change: 00 days, 00 hrs, 50 min, 28 sec No. of changes: 12
  Line Status: TRAINED
  Test Mode: NONE

ADSL Chipset Self-Test: NONE
CO Modem Firmware Version: 5.38
Configured:
  DMT Profile Name: premium
  Link Traps Enabled: NO
  Alarms Enabled: NO
  ATM Payload Scrambling: Enabled

DMT profile parameters
Maximum Bitrates:
  Interleave Path:  downstream:  0 kb/s,  upstream:  0 kb/s
  Fast Path:       downstream: 8064 kb/s, upstream: 864 kb/s
Minimum Bitrates:
  Interleave Path:  downstream:  0 kb/s,  upstream:  0 kb/s
  Fast Path:       downstream:  0 kb/s,  upstream:  0 kb/s
Margin:            downstream:  6 dB,    upstream:  6 dB
Interleaving Delay: downstream: 16000 usecs, upstream: 16000 usecs
Check Bytes (FEC):
  Interleave Path:  downstream:  16,      upstream:  16
  Fast Path:       downstream:  0,      upstream:  0
R-S Codeword Size: downstream:  auto,    upstream:  auto
Trellis Coding:   Disabled
Overhead Framing: Mode 3
Operating Mode:   Automatic
Training Mode:    Quick
Minrate blocking: Disabled
SNR Monitoring:   Disabled
Power Management Additional Margin:
                                downstream:  0 dB,    upstream:  0 dB

Status:
  Bitrates:
    Interleave Path:  downstream:  0 kb/s,  upstream:  0 kb/s
    Fast Path:       downstream: 8064 kb/s, upstream: 864 kb/s
  Attainable Aggregate
  Bitrates:
                                downstream: 9440 kb/s, upstream: 928 kb/s
  Margin:
                                downstream: 12 dB,    upstream: 11 dB
  Attenuation:
                                downstream: 1 dB,     upstream: 2 dB
  Interleave Delay:
                                downstream: 0 usecs,   upstream: 0 usecs
  Transmit Power:
                                downstream: 9.5 dB,    upstream: 12.1 dB

```

Example 8-43 *Displaying DSL, DMT, and ATM Status for Port 1/1 (Continued)*

```

Check Bytes (FEC):
  Interleave Path:  downstream:  0,      upstream:  0
                    Fast Path:   downstream: 0,      upstream:  0
R-S Codeword Size: downstream:  1,      upstream:  1
Trellis Coding:   In Use
Overhead Framing: Mode 3
Line Fault:       NONE
Operating Mode:   ITU G dmt Issue 1
Line Type:        Fast Only
Alarms:
  status:         NONE
ATM Statistics:
  Interleaved-Path Counters:
    Cells:         downstream:  20      upstream:  154
    HEC errors:    downstream:  0       upstream:  2
    LOCD events:   near end:     1       far end:   0
  Fast-Path Counters:
    Cells:         downstream:  1729    upstream:  660
    HEC errors:    downstream:  1       upstream:  1
    LOCD events:   near end:     1       far end:   0
DSL Statistics:
  Init Events:     4
  Far End LPR Events: 0
  Transmitted Superframes: near end: 161749170 far end: 0
  Received Superframes:  near end: 161748691 far end: 0
  Corrected Superframes: near end: 176 far end: 0
  Uncorrected Superframes: near end: 369 far end: 1
  LOS Events:      near end: 2 far end: 0
  LOF/RFI Events: near end: 0 far end: 0
  ES Events:       near end: 10 far end: 1
CPE Info:
  Version Number:  0
  Vendor ID:       34

```

Practical Exercise 8-2: RFC 1483 Bridging over DSL

In this practical exercise, lab-827A and lab-827B are connected to the DSLAM and will be configured using RFC 1483 bridging, as shown in Figure 8-13. DSLAM and NSP configuration remain the same as in the previous exercise. For this exercise, you will assign the ATM interface of the CPEs and subinterfaces of the NRP to Bridge group 1. You will see the configuration output as well as some useful commands to verify the bridging configuration.

Practical Exercise 8-2 Solution

Examples 8-44 and 8-45 show the bridging configurations of both DSL CPE devices.

Example 8-44 *Configuration Output for lab-827A*

```
lab-827A#show running-config
Building configuration...
Current configuration : 763 bytes
!
version 12.2
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname lab-827A
!
ip subnet-zero
no ip routing
!
interface Ethernet0
 ip address 10.2.2.2 255.255.255.0
 no ip route-cache
 bridge-group 1
 hold-queue 100 out
!
interface ATM0
 mac-address 0001.96a4.84ac
 ip address 10.2.2.2 255.255.255.0
 no ip route-cache
 no atm ilmi-keepalive
 pvc 0/35
  encapsulation aal5snap
!
dsl operating-mode auto
dsl power-cutback 0
bridge-group 1
!
ip classless
ip http server
!
bridge 1 protocol ieee
call rsvp-sync
!
line con 0
 stopbits 1
line vty 0 4
!
scheduler max-task-time 5000
end
```

Example 8-45 Configuration Output for lab-827B

```
lab-827B#show running-config
Building configuration...
Current configuration : 670 bytes
!
version 12.2
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname lab-827B
!
no logging console
!
ip subnet-zero
no ip routing
!
interface Ethernet0
 ip address 10.2.2.3 255.255.255.0
 no ip route-cache
 bridge-group 1
 hold-queue 100 out
!
interface ATM0
 mac-address 0001.96a4.8fae
 ip address 10.2.2.3 255.255.255.0
 no ip route-cache
 no atm ilmi-keepalive
 pvc 0/35
  encapsulation aal5snap
!
 dsl operating-mode auto
 bridge-group 1
!
ip classless
ip http server
ip pim bidir-enable
!
bridge 1 protocol ieee
!
line con 0
 stopbits 1
line vty 0 4
!
scheduler max-task-time 5000
end
```

Example 8-46 shows the bridging configuration of the Cisco 6400.

Example 8-46 *Configuration Output for lab-6400NRP*

```
lab-6400NRP#show running-config
Building configuration...
Current configuration : 907 bytes
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname lab-6400NRP
!
logging rate-limit console 10 except errors
no logging console
!
redundancy
main-cpu
  auto-sync standard
no secondary console enable
ip subnet-zero
!
bridge irb
!
interface ATM0/0/0
no ip address
no atm ilmi-keepalive
hold-queue 500 in
!
interface ATM0/0/0.135 point-to-point
pvc 1/35
  encapsulation aal5snap
!
  bridge-group 1
!
interface ATM0/0/0.235 point-to-point
pvc 2/35
  encapsulation aal5snap
!
  bridge-group 1
!
interface Ethernet0/0/1
ip address negotiated
!
interface Ethernet0/0/0
no ip address
shutdown
!
interface FastEthernet0/0/0
no ip address
half-duplex
!
```

Example 8-46 Configuration Output for lab-6400NRP (Continued)

```

interface BVI1
  ip address 10.2.2.1 255.255.255.0
  !
ip classless
ip http server
!
!
!
!
bridge 1 protocol ieee
  bridge 1 route ip
!
line con 0
line aux 0
line vty 0 4
!
end

```

Example 8-47 shows that Bridge group 1 is running the IEEE Spanning Tree Protocol.

Example 8-47 Displaying the Spanning Tree Protocol (IEEE)

```

lab-6400NRP#show spanning-tree 1
Bridge group 1 is executing the ieee compatible Spanning Tree protocol
Bridge Identifier has priority 32768, address 0000.0c7f.70fc
Configured hello time 2, max age 20, forward delay 15
We are the root of the spanning tree
Topology change flag not set, detected flag not set
Number of topology changes 4 last change occurred 00:35:16 ago
    from ATM0/0/0.235
Times: hold 1, topology change 35, notification 2
    hello 2, max age 20, forward delay 15
Timers: hello 0, topology change 0, notification 0, aging 300
Port 6 (ATM0/0/0.135) of Bridge group 1 is forwarding
Port path cost 14, Port priority 128, Port Identifier 128.6.
Designated root has priority 32768, address 0000.0c7f.70fc
Designated bridge has priority 32768, address 0000.0c7f.70fc
Designated port id is 128.6, designated path cost 0
Timers: message age 0, forward delay 0, hold 0
Number of transitions to forwarding state: 1
BPDU: sent 1663, received 2
Port 8 (ATM0/0/0.235) of Bridge group 1 is forwarding
Port path cost 14, Port priority 128, Port Identifier 128.8.
Designated root has priority 32768, address 0000.0c7f.70fc
Designated bridge has priority 32768, address 0000.0c7f.70fc
Designated port id is 128.8, designated path cost 0
Timers: message age 0, forward delay 0, hold 0
Number of transitions to forwarding state: 1
BPDU: sent 1527, received 1

```

Example 8-48 shows the IP and MAC addresses of lab-827A and lab-827B. **show arp** is a useful command to verify whether bridging is configured properly.

Example 8-48 *Displaying ARP Information*

```
lab-6400NRP#show arp
```

Protocol	Address	Age (min)	Hardware Addr	Type	Interface
Internet	10.2.2.2	31	0001.96a4.84ac	ARPA	BVI1
Internet	10.2.2.3	31	0001.96a4.8fae	ARPA	BVI1
Internet	10.2.2.1	-	0050.7359.35a6	ARPA	BVI1

Example 8-49 illustrates that both subinterfaces are in the same bridge group (Bridge group 1), and traffic is passed among them. **show bridge** is another useful command to debug RFC 1483 bridging.

Example 8-49 *Displaying Classes of Entries in the Bridge Forwarding Database*

```
lab-6400NRP#show bridge verbose
```

Total of 300 station blocks, 298 free
Codes: P - permanent, S - self

BG Hash	Address	Action	Interface	VC	Age	RX count	TX count
1 21/0	0001.96a4.8fae	forward	ATM0/0/0.235	2	0	5	5
1 28/0	0001.96a4.84ac	forward	ATM0/0/0.135	1	0	100	100

Flood ports (BG 1)

	RX count	TX count
ATM0/0/0.135	0	0
ATM0/0/0.235	0	0

Summary

This chapter covered ADSL technology, Cisco DSL hardware components, and the configuration of various DSL access architectures, such as IRB, RBE, PPPoA, and PPPoE. Keep in mind that each DSL access architecture has its advantages and disadvantages. You should further research these architectures to discover the best implementation for your DSL network environment.

Table 8-3 summarizes the commands used in this chapter.

Table 8-3 *Summary of Commands Used in This Chapter*

Command	Description
slot <i>slot# cardtype</i>	Configures a slot for a specific card type.
dsl-profile <i>profile-name</i>	Creates a DSL profile.
dmt bitrate max interleaved downstream <i>dmt-bitrate upstream dmt-bitrate</i>	Sets the maximum and minimum allowed bit rates for the fast-path and interleaved-path profile parameters.
dmt margin downstream <i>dmt-margin</i> upstream <i>dmt-margin</i>	Sets the upstream and downstream SNR DMT margins.
dmt check-bytes interleaved downstream <i>bytes upstream bytes</i>	Sets the upstream and downstream check bytes.

Table 8-3 Summary of Commands Used in This Chapter (Continued)

Command	Description
dmt interleaving-delay downstream <i>delay-in-μsecs upstream delay-in-μsecs</i>	Sets the interleaving delay parameter.
dmt training-mode { <i>standard</i> <i>quick</i> }	Sets the training mode in a DMT profile.
bridge irb	Enables IRB.
bridge bridge-group protocol { <i>ieee</i> <i>dec</i> }	Specifies the bridge protocol to define the type of Spanning Tree Protocol.
bridge bridge-group route protocol	Specifies a protocol to be routed in a bridge group.
bridge-group <i>bridge-group</i>	Assigns a network interface to a bridge group.
interface bvi <i>bridge-group</i>	Enables a bridge group virtual interface.
atm route-bridged ip	RBE command. Typically used to associate with an interface.
username name password <i>secret</i>	Configures a username and password for local authentication.
encapsulation aal5mux ppp Virtual-Template <i>number</i>	Configures PPPoA encapsulation and associates a virtual template with it.
interface virtual-template <i>number</i>	Creates a virtual template interface.
ip unnumbered <i>interface-name-number</i>	Conserves IP addresses by configuring the interface as unnumbered, and assigns the IP address of the interface type you want to leverage.
ip local pool name <i>begin-ip-address-range</i> <i>[end-ip-address-range]</i>	Creates the local IP address pool.
peer default ip address pool <i>poolname</i>	Specifies the pool for the interface to use.
ppp authentication { <i>chap</i> <i>pap</i> <i>chap pap</i> <i>pap chap</i> } [<i>if-needed</i>] { <i>default</i> <i>list-name</i> } [<i>callin</i>]	Enables CHAP or PAP authentication on the interface.
ip cef	Enables Cisco Express Forwarding switching.
vpdn enable	Enables VPDN configuration.
vpdn-group <i>number</i> accept-dialin protocol pppoe virtual-template <i>template-number</i>	Configures a VPDN group to accept the dial-in and to be used to establish PPPoE sessions. Specifies the virtual template that will be used to clone virtual-access interfaces.
ip mtu <i>bytes</i>	Sets the MTU size of IP packets sent on an interface.
show dsl profile	Displays the DSL profile you changed.

continues

Table 8-3 *Summary of Commands Used in This Chapter (Continued)*

Command	Description
show dsl status	Displays the status of the DSL subscriber ports on a chassis.
show dsl interface atm slot/port	Shows the status of a DSL port.
show spanning-tree bridge-group	Displays information on which Spanning Tree Protocol is running.
show arp	Displays the entries in the ARP table.
show bridge group [verbose]	Displays the status of each bridge group in detail.

Review Questions

- Which of the following modulation methods is not used for ADSL technology?
 - CAP
 - 2B1Q
 - DMT-2
 - G.lite
- RFC 1483 when implemented is _____.
 - Bridged
 - Routed
 - Decrypted
 - Encrypted
- PPPoA when implemented is _____.
 - Bridged
 - Routed
 - Decrypted
 - Encrypted
- Which of the following interferences degrades DSL services?
 - Impedance changes
 - Bridged taps
 - Crosstalk
 - Impulse hits
 - All of the above

- 5 What is the function of the POTS splitter?
- A. It separates low and high frequencies.
 - B. It manages ADSL signaling.
 - C. It generates ringing voltage.
 - D. It boosts the ADSL signal.
- 6 The DSL interface on a Cisco 827 is _____.
- A. An FDDI interface
 - B. A Frame Relay interface
 - C. A serial interface
 - D. An ATM interface
- 7 With PPP over ATM, _____. (Choose all that apply.)
- A. MAC frames are encapsulated into ATM cells
 - B. UDP frames are encapsulated using RFC 1483
 - C. IP packets are encapsulated into PPP frames and then into ATM cells
 - D. IP packets are encrypted
- 8 With RFC 1483 bridging, _____.
- A. MAC frames are passed across the bridge after LLC/SNAP information is appended
 - B. IP frames are passed across the bridge unchanged
 - C. MAC frames are passed across the bridge unchanged
 - D. IP packets are encrypted
- 9 Which of the following cards in the Cisco 6400 can be used for Layer 3 packet services?
- A. NSP
 - B. NLC
 - C. NRP
 - D. NI-2
- 10 Which of the following is part of PPPoA configuration?
- A. **encapsulation aal5mux ppp Virtual-Template 1**
 - B. **encapsulation aal5snap**
 - C. **atm route-bridged ip**
 - D. **bridge 1 protocol ieee**