CHAPTER 5

Configuring DSL Access with PPPoE

DSL access has become an overwhelmingly popular access methodology for homes and home offices. Along with this surge in popularity comes a host of additional possible application and service offerings. These applications and services may be provided by a service provider or offered by a corporation deploying a teleworker architecture.

This chapter builds upon the topics discussed in Chapter 4, "Using DSL to Connect to a Central Site." Configuring a Cisco router for PPPoE access, like other technologies, is not a difficult process. However, there are some not-so-subtle differences that must be addressed.

"Do I Know This Already?" Quiz

The purpose of the "Do I Know This Already?" quiz is to help you decide whether you really need to read the entire chapter. If you already intend to read the entire chapter, you do not necessarily need to answer these questions now.

The 12-question quiz, derived from the major sections in the "Foundation Topics" portion of the chapter, helps you to determine how to spend your limited study time.

Table 5-1 outlines the major topics discussed in this chapter and the "Do I Know This Already?" quiz questions that correspond to those topics.

Table 5-1 *"Do I Know This Already?" Foundation Topics Section-to-Question Mapping*

Foundation Topics Section	Questions Covered in This Section	Score
Configure a Cisco Router as a PPPoE client	1–2	
Configure an Ethernet/ATM Interface for PPPoE	3–4	
Configure the PPPoE DSL Dialer Interface	5–6	
Configure Port Address Translation (PAT)	7–8	
Configure DHCP for DSL Router Users	9–10	
Configure Static Default Route on a DSL Router	11–12	
Total Score		

CAUTION The goal of self-assessment is to gauge your mastery of the topics in this chapter. If you do not know the answer to a question or are only partially sure of the answer, you should mark this question wrong for purposes of self-assessment. Giving yourself credit for an answer that you correctly guess skews your self-assessment results and might provide you with a false sense of security.

1. DSL operates at which layer of the OSI reference model?
   a. Layer 1
   b. Layer 2
   c. Layer 3
   d. Layer 4
2. Layer 3 connectivity will be established between the CPE and which device in the provider network?
   a. DSLAM
   b. Splitter
   c. Aggregation router
   d. Headend
3. In DSL installations using Ethernet interfaces for both subscriber-facing and provider-facing connectivity, which of the following is true?
   a. The subscriber-facing Ethernet interface is configured with an IP address while the provider-facing Ethernet interface is not. A dialer interface will be configured for IP connectivity.
   b. The provider-facing Ethernet interface is configured with an IP address while the subscriber-facing Ethernet interface is not. A dialer interface will be configured for IP connectivity.
   c. Both the subscriber-facing and provider-facing Ethernet interfaces must have an IP address configured.
   d. Neither the subscriber-facing Ethernet interface nor the provider-facing Ethernet interface needs an IP address. A dialer interface will be configured for IP connectivity.
4. In configuring an ATM interface for PPPoE connectivity, which commands are necessary? Choose all that apply.
   a. **atm pvc 0/32 encapsulation aal5snap**
   b. **dsl operating-mode auto**
   c. **pppoe-client dial-pool-number 1**
   d. **atm map ip 172.16.0.2 pvc 0/32**

5. The dialer interface controls which physical interface? Choose all that apply.
   a. Subscriber-facing Ethernet
   b. Provider-facing Ethernet
   c. Provider-facing ATM
   d. Subscriber-facing ATM
6. A logical dialer interface is bound to a physical interface by what?
   a. Dialer group number on the physical interface that matches the dialer pool number on the dialer interface
   b. Dial pool number on the physical interface that matches the dialer pool number on the dialer interface
   c. DDR interesting traffic
   d. Dialer idle-timeout
7. Port Address Translation is dependent on the configuration of which technology in order to function?
   a. NAT
   b. LAT
   c. DDR
   d. DHCP
8. PAT allows which of the following?
   a. One-to-one IP address translation through the CPE router
   b. Many-to-one IP address translation through the CPE router
   c. Application-specific port numbers to be manually configured for translation
   d. Static IP address translations
9. DHCP configuration must include which of the following? Choose all that apply.
   a. IP address range
   b. DNS server(s)
   c. Subnet mask
   d. WINS server(s)
   e. TFTP server(s)

10. To avoid an address or range of addresses from being assigned to network hosts, which of the following should be configured?

    a. **dhcp reservation**
    b. **ip dhcp excluded-address**
    c. **import all**
    d. **DNS reverse-lookup**

11. Which of the following are good reasons to use a static default route? Choose all that apply.

    a. Decision made to disallow routing protocols at the teleworker sites
    b. Single entry/exit point (stub network) at the CPE site
    c. Limited router resources (CPU/memory)
    d. Desire to avoid full static routing definition

12. Which of the following properly defines a static default route?

    a. **ip route 0.0.0.0 255.255.255.255 dialer0**
    b. **ip route 0.0.0.0 0.0.0.0 dialer0**
    c. **ip default-gateway 0.0.0.0**
    d. **ip default-network 0.0.0.0**

The answers to the "Do I Know This Already?" quiz are found in Appendix A, "Answers to the 'Do I Know This Already?' Quizzes and Q&A Sections." The suggested choices for your next step are as follows:

- **8 or fewer overall score**—Read the entire chapter. This includes the "Foundation Topics," "Foundation Summary," and "Q&A" sections.
- **9 or 10 overall score**—Begin with the "Foundation Summary" section, and then go to the "Q&A" section.
- **11 or more overall score**—If you want more review on these topics, skip to the "Foundation Summary" section, and then go to the "Q&A" section. Otherwise, move to the next chapter.

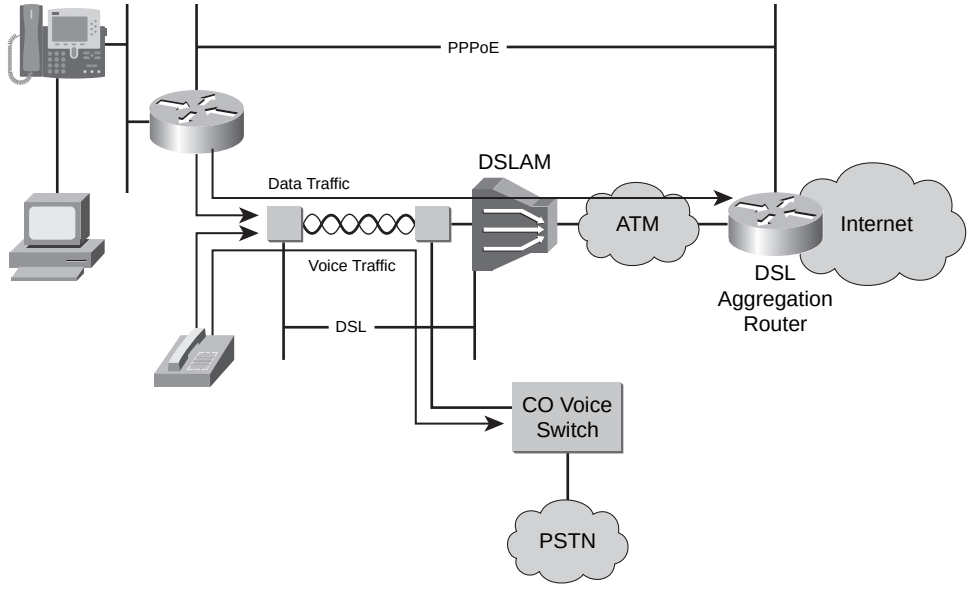
Foundation Topics

Configure a Cisco Router as a PPPoE Client

Configuration of a home router for DSL connectivity includes a number of pieces and parts that must be assembled properly in order for the solution to function properly. As discussed in Chapter 4, Asynchronous Transfer Mode (ATM) is DSL's underlying technology. As the PPPoE name implies, Point-to-Point Protocol (PPP) and Ethernet both play a significant role as well.

DSL is a Layer 1 access methodology that relies on multiple Layer 2 protocols in order to function properly. The Layer 1 connection exists across the local loop between the customer premises equipment (CPE) and the DSL access multiplexer (DSLAM). Layer 3 connectivity is established between the CPE and an aggregation router located somewhere beyond the DSLAM. For purposes of review and to provide a point of reference for discussion topics in this chapter, Figure 5-1 provides a topological view.

Figure 5-1 *DSL Topology*



The figure shows the connectivity between the CPE and the Internet. The data traffic must traverse the local loop to the DSLAM and then go across the ATM network to the aggregation router.

There are multiple ways in which PPPoE can be configured. The configuration options will be decided upon by the provider. The example discussed here will be one using a dial-on-demand configuration option. Among the tasks necessary to configure PPPoE are the following:

- Ethernet/ATM interface configuration
- Dialer interface configuration
- PAT configuration
- DHCP server services configuration
- Static default route configuration

Each of these tasks must be completed before the data connectivity will function properly. Fortunately, they are fairly uncomplicated.

There are basically two relevant physical interfaces on any router, the ingress (inbound) and the egress (outbound). What takes place inside the router is mystical smoke-and-mirrors to the typical user. The definition of ingress and egress are subject to the direction of the traffic flow. So, to avoid confusion, the interfaces on the CPE will be called *subscriber-facing* and *provider-facing*.

A PPPoE session is initiated by the PPPoE client. If the session has a timeout or is disconnected, the PPPoE client immediately attempts to reestablish the session.

There are two configuration options with integrated DSL functionality in the CPE:

- **PPPoE on Ethernet interfaces**—PPPoE functionality is configured on a CPE router with two Ethernet interfaces. One Ethernet interface is subscriber-facing, the other provider-facing.
- **PPPoE on ATM interfaces**—PPPoE functionality is configured on a CPE router with one Ethernet interface and one ATM interface. The Ethernet interface is subscriber-facing whereas the ATM interface is provider-facing.

These options are typically dictated by the provider.

Configure an Ethernet/ATM Interface for PPPoE

The Ethernet interface is the subscriber-facing component of the CPE router. Example 5-1 shows how to configure the PPPoE client on an Ethernet interface.

Example 5-1 *Configuring the PPPoE Client on an Ethernet Interface*

```
!
interface Ethernet0/0
 ip address 172.16.0.1 255.255.0.0
!
interface Ethernet0/1
 no ip address
 pppoe enable
 pppoe-client dial-pool-number 1
!
```

This portion of the configuration enables the PPPoE functionality on the interface as well as assigning it to a dialer pool. This configuration element is required when using PPPoE over an Ethernet interface. Interface Ethernet 0/1 is bound to the logical dialer interface and an ATM permanent virtual circuit (PVC) is automatically provisioned across it.

NOTE As of Cisco IOS Software Release 12.2(13)T and later, the PPPoE client functionality was separated from the VPDN functionality, resulting in changes to the PPPoE client configuration. The configuration examples in this chapter are post-12.2(13)T examples.

For cases in which an ATM interface (ATM0/0 in this case) is used rather than the Ethernet 0/1 interface, you would use the configuration in Example 5-2.

Example 5-2 *Configuring the PPPoE Client on an ATM Interface*

```
!
interface Ethernet0/0
 ip address 172.16.0.1 255.255.0.0
!
interface ATM0/0
 no ip address
 dsl operating-mode auto
 pvc 8/35
 pppoe-client dial-pool-number 1
!
```

Configure the PPPoE DSL Dialer Interface

The dialer interface is the DSL provider-facing component of the CPE router. Example 5-3 demonstrates how to configure the basic elements of the dialer interface.

Example 5-3 *Configuring the Dialer Interface*

```
!
interface Dialer0
 ip address negotiated
 ip mtu 1492
 encapsulation ppp
 dialer pool 1
!
```

This configuration specifies that the dialer interface should get its IP address from the provider's DHCP server while specifying the upstream MTU and setting the interface encapsulation to PPP. Finally, the **dialer pool** command associates the dialer back to the **pppoe-client** command issued on the Ethernet interface. The pool numbers must match on the dialer and Ethernet interfaces in order for the configuration to function.

If PPP negotiation fails or the PPP line protocol is brought down for any reason, the PPPoE session and the virtual access will be brought down. When the PPPoE session is brought down, the client waits for a predetermined number of seconds before trying again to establish a PPPoE.

Configure Port Address Translation

Port Address Translation (PAT) is an extension of Network Address Translation (NAT). PAT adds a unique identifier to the outside translation entry of each inside host. Using PAT allows many inside IP addresses to use a single outside IP address because the outside address has a unique port number mapped to each inside host. NAT allows IP addresses to be changed as they pass through a router in order to be properly routed on another network. For NAT to work properly, some additional information and planning is necessary. Inside and outside interfaces must be defined.

Inside interfaces are those that exist on the internal, private network. In this case, inside interfaces are those with IP addresses on the subscriber's home network. This is typically a nonroutable address as defined by RFC 1918:

- **Inside local**—Configured IP address assigned to a host on the inside network
- **Inside global**—The IP address of an inside host as it appears to the outside network

Outside interfaces are those that exist on the external provider network and/or public Internet. Depending on the implementation, this may be a nonroutable RFC 1918 address or a public routable address:

- **Outside local**—The IP address of an outside host as it appears to the inside network
- **Outside global**—The configured IP address assigned to a host in the outside network

Figure 5-2 illustrates the concepts of NAT with PAT.

Figure 5-2 *NAT with PAT*

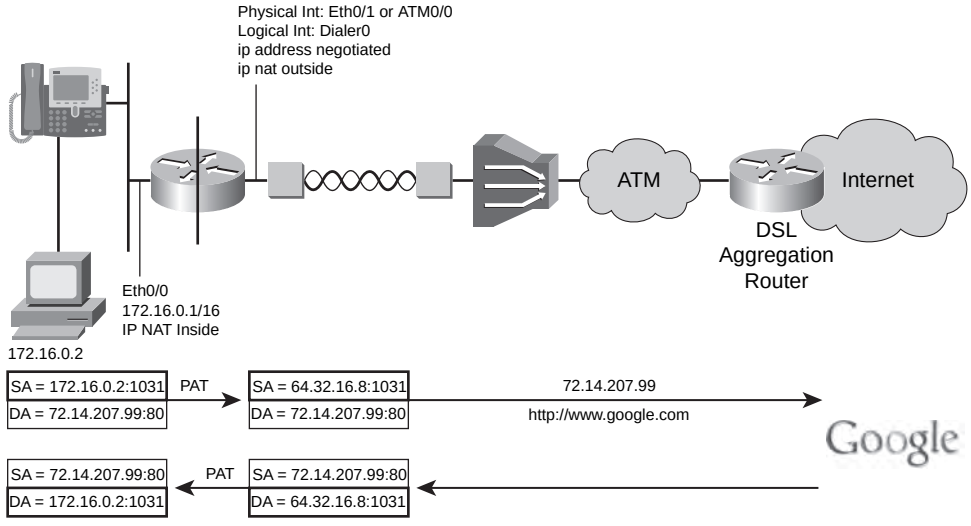


Figure 5-2 shows the subscriber host (inside local address) sending a web request to www.google.com. A DNS lookup resolves the host name in the URL to its public IP address. The resolved address is then placed in the Destination IP Address field (inside global address). In this example, NAT is performed in only one direction. Additional subscriber hosts would have a unique inside local address but be assigned the same inside global address and a unique port number. The coupling of an IP address with a port number is known as a *socket*.

NOTE The process can be performed bidirectionally to translate addresses inbound and outbound. This is one method for dealing with overlapping address space in merged, acquired, or mismanaged networks by effectively concealing outside addresses from inside hosts.

For bidirectional NAT to work, DNS must be configured internally to map outside hosts to the proper inside addresses (that is, outside local addresses). The NAT process will translate the outside local address to its actual address (that is, the outside global address).

With NAT alone, each subscriber host inside local address would be translated to an individual, unique inside global address (one-to-one). With PAT, each subscriber inside local address is translated to a single inside global address (many-to-one) to conserve IP address space utilization. To keep the individual hosts organized and pass the proper traffic flows to and from each host, the source port number is attached to the IP address. In theory, up to 65,535 inside addresses can be translated to a single outside address. However, in practice, this might not be the best theory to test on a router not designed for very high user density.

PAT uses unique source port numbers on the inside global IP address to distinguish between translations. PAT attempts to preserve the original source port. If the source port is already in use, PAT attempts to use the first available port from the appropriate port group 0–5111, 5112–1023, or 1024–65535. If there is still no port available from the appropriate group and more than one IP address is configured, PAT moves to the next IP address and tries to allocate the original source port again. This continues until PAT runs out of available ports and IP addresses.

Example 5-4 shows the NAT/PAT portion of the configuration. Note that there is no configuration on the Interface Ethernet0/1 (or ATM0/0 as the case may be). This is intentional, because the logical dialer0 interface represents the physical Ethernet0/1 or ATM0/0 interface configuration.

Example 5-4 *NAT/PAT Configuration*

```
!
interface Ethernet0/0
 ip nat inside
!
interface Dialer0
 ip nat outside
!
ip nat inside source list 100 interface dialer0 overload
access-list 100 permit ip 172.16.0.0 0.0.255.255 any
!
```

This configuration is added to the examples presented to this point, so the IP addresses and so on are not shown. In the example, the Ethernet interface is defined as *inside* while the dialer interface is *outside*. The access list defines hosts that are eligible for translation, in this case all 172.16.X.X source addresses. The NAT definition uses access-list 100 as the "inside source" list and maps it to dialer0. The **overload** parameter enables PAT on the interface. The configuration then uses the provider-assigned address of dialer0 as the outside address for traffic flow. For this reason, no NAT pool is necessary. Without the **overload** parameter, a NAT pool would be defined for one-to-one translations.

Configure DHCP for DSL Router Users

The CPE router can function as a Cisco IOS–based DHCP server for subscriber network hosts. Address pools are configured for each subnet to be serviced. The address of the Ethernet interface should be excluded from the address range defined for the DHCP server. This is also the case for any other statically assigned host addresses on the subscriber's network such as print servers. The Cisco IOS DHCP functionality has been enhanced to support centralized DHCP services and administration. The pool definition(s) can be imported from centralized servers if desired.

Example 5-5 can be added to the CPE router configuration discussed up to this point to enable DHCP services for the subscriber network.

Example 5-5 *DHCP Services Configuration*

```
!
ip dhcp excluded-address 172.16.0.1 172.16.0.9
!
ip dhcp pool PCLAN
   import all
   network 172.16.0.0 255.255.0.0
   default-router 172.16.0.1
!
```

The **dhcp excluded-address** command specifies that no addresses in the defined range should be allocated. Because of this, the first address available for host allocation is 172.16.0.10. Technically, the 172.16.0.1 address need not be included in the exclusion because the local router already has this address assigned, but it was included for clarity's sake. The **import all** option will dynamically populate any DNS server, WINS server, or other options, such as TFTP server, into the database so that they can be provided to hosts on the subscriber network.

If multiple VLANs are defined, each VLAN interface will provide addresses from the pool that shares its IP subnet. When a router receives a DHCP request, it checks all configured DHCP pools for a network match. If a match is found, an address will be assigned from the appropriate pool. If no match is found, no DHCP offer is made. To service the request, the router would require an additional pool configuration matching the network in question. Alternatively, if no pool is sharing its subnet, an IP helper address must be configured to forward the DHCP request to the appropriate server or no address will be allocated.

Configure Static Default Route on a DSL Router

Because the teleworker home network is typically a stub network, there is no need to enable routing protocols to maintain connectivity. This simply adds unneeded overhead to the router and WAN link. A static default route will suffice to send all nonlocal traffic to the next logical hop router and out to the Internet or enterprise network, as the case may be. Example 5-6 shows the configuration of the static default route.

Example 5-6 *Static Default Route Configuration*

```
!
ip route 0.0.0.0 0.0.0.0 interface dialer0
!
```

Any traffic destined for non-172.16.0.0 addresses will be sent via dialer0 to the next-hop router where another routing decision will be made based on the destination IP address.

The Overall CPE Router Configuration

Overall, the configuration of the CPE router is relatively uncomplicated, although the preceding sections have discussed the interface-specific and routing-specific dependencies. Example 5-7 assembles the configuration options detailed in this chapter to render the basic CPE router configuration.

Example 5-7 *CPE Router Configuration*

```
no service pad
service timestamps debug datetime msec localtime show-timezone
service timestamps log datetime msec localtime show-timezone
service password-encryption
!
hostname PPPoE-CPE
!
memory-size iomem 5
enable secret 5 [removed]
!
username Emma privilege 15 secret 5 [removed]
username Amanda privilege 15 secret 5 [removed]
clock timezone est -6
clock summer-time cdt recurring
no aaa new-model
ip subnet-zero
no ip domain lookup
ip domain name mydomain.com
ip name-server 4.2.2.1
!
ip dhcp excluded-address 172.16.0.1 172.16.0.9
! Configures DHCP Exclusions
!
ip dhcp pool PCLAN
! Creates DHCP Pool
   import all
   network 172.16.0.0 255.255.0.0
   default-router 172.16.0.1
!
interface Ethernet0/0
 description ***Internal Private Network***
 ip address 172.16.0.1 255.255.0.0
 ip nat inside
! Specifies NAT role
!
```

Example 5-7 *CPE Router Configuration (Continued)*

```
interface ATM0/0
 description ***physical interface bound to dialer0***
 no ip address
 dsl operating-mode auto
 pvc 8/35
! Creates ATM PVC
 pppoe-client dial-pool-number 1
! Assigns dial pool
!
interface Dialer0
 description ***External Provider Network***
 ip address negotiated
 ip mtu 1492
! Configures MTU
 ip nat outside
! Specifies NAT role
 encapsulation ppp
 dialer pool 1
! Dialer association
!
ip classless
ip route 0.0.0.0 0.0.0.0 interface dialer0
! Sets static default
no ip http server
no ip http secure-server
ip nat inside source list 100 interface dialer0 overload
! Configures NAT/PAT
!
access-list 100 permit ip 172.16.0.0 0.0.255.255 any
! Specifies addresses to NAT
!
line con 0
 exec-timeout 0 0
 login local
line aux 0
line vty 0 4
 exec-timeout 240 0
 login local
!
scheduler max-task-time 5000
ntp peer 172.16.1.50
ntp server XXX.118.25.3 prefer
!
End
```

Example 5-8 shows the output confirming a successfully negotiated PPPoE session.

Example 5-8 *Confirming a Successfully Negotiated PPPoE Session*

```
PPPoE-CPE#show pppoe session all
%No active L2TP tunnels
%No active L2F tunnels
PPPoE Session Information Total tunnels 1 sessions 1

Session count: 1

PPPoE Session Information
SID  RemMAC           LocMAC          Intf    Vast   OIntf   VP/VC
1    0050.7359.35b7   0001.96a4.84ac  Vi1     UP     ATM0    8/35
```

In this example, you can see that the SID is a non-zero number, and that both the RemMAC and LocMAC fields are populated. The other field of interest is Vast, which indicates whether PPP has been successfully negotiated and authenticated.

Foundation Summary

Configuration of PPPoE is similar to most other LAN/WAN configurations in that it requires multiple, dependent pieces to be assembled. Only the most basic configuration parameters are discussed in this chapter. Options such as PPP authentication, VPN options, quality of service (QoS), network management, and security are all still on the to-do list with regard to teleworker solution deployments and can be found in detail in the Business Ready Teleworker SRND found at http://www.cisco.com/go/srnd.

Table 5-2 is provided to review the basic configuration elements.

Table 5-2 *PPPoE Configuration Elements*

Element	Description
Ethernet interface	Physical interface, typically subscriber-facing but may be both subscriber- and provider-facing if two exist.
ATM interface	Physical interface, typically provider-facing and carries data traffic to the DSLAM then on to the aggregation router.
Dialer interface	Logical interface bound to a physical interface (usually ATM or second Ethernet) to establish PPPoE session to aggregation router.
NAT/PAT	Services allowing one-to-one and one-to-many IP address translation capabilities in the CPE router. PAT is also known as NAT with Overload.
Inside local address	Configured IP address assigned to a host on the inside network.
Inside global address	The IP address of an inside host as it appears to the outside network.
Outside local address	The IP address of an outside host as it appears to the inside network.
Outside global address	The configured IP address assigned to a host in the outside network.
DHCP server	Service configured to allocate IP address, gateway, and other relevant information to IP hosts on a particular subnet.
Static default route	A route to a gateway of last resort. In teleworker deployments, no routing protocol is necessary because there is typically only a single subnet. The static default route takes any traffic destined to nonlocal destinations and directs it to the aggregation router.

Q&A

The questions and scenarios in this book are designed to be challenging and to make sure that you know the answer. Rather than allowing you to derive the answers from clues hidden inside the questions themselves, the questions challenge your understanding and recall of the subject.

Hopefully, mastering these questions will help you limit the number of exam questions on which you narrow your choices to two options, and then guess.

You can find the answers to these questions in Appendix A. For more practice with exam-like question formats, use the exam engine on the CD-ROM.

1. Which solutions discussed in this chapter would be relevant to the typical teleworker?
2. In a teleworker solution, is there ever a case for using a routing protocol rather than a static default route?
3. Consider a scenario in which NAT is configured at a teleworker site. Are there circumstances that might warrant the use of NAT without PAT?
4. Explain the use of the **import all** parameter in a DHCP pool configuration.
5. When using a dialer interface, how are physical interfaces bound or associated with the dialer interface?
6. List the tasks that must be completed to configure an interface for PPPoE or PPPoA.
7. Which command should be issued to view the status of the PPPoE connection?
8. How does a router determine whether it can service a DHCP request it receives on any given interface?

Exam Topic List

This chapter covers the following topics that you need to master for the CCNP ISCW exam:

- **Configure a Cisco Router as a PPPoA Client**—Describes the requirements of configuring a PPPoA connection
- **Configure an ATM Interface for PPPoA**—Describe the tasks involved in configuring a PPPoA connection
- **Configure the PPPoA Dialer and Virtual-Template Interfaces**—Describes interface-specific requirements for PPPoA
- **Configure Additional PPPoA Elements**—Describes additional configuration requirements for PPPoA

CHAPTER 6

Configuring DSL Access with PPPoA

With the discussion of PPPoE covered in Chapter 5, some of the information presented here is redundant. This is to be expected with two fairly similar technologies. However, in the interest of reducing the amount of page turning, some of the covered information is offered once again as review.

PPPoA is a technology based on the ability of the customer premises equipment (CPE) to offer a native Asynchronous Transfer Mode (ATM)-capable interface as the provider-facing interface. As with PPPoE, the configuration is contingent on a number of additional elements being put in place.

"Do I Know This Already?" Quiz

The purpose of the "Do I Know This Already?" quiz is to help you decide whether you really need to read the entire chapter. If you already intend to read the entire chapter, you do not necessarily need to answer these questions now.

The 7-question quiz, derived from the major sections in the "Foundation Topics" portion of the chapter, helps you to determine how to spend your limited study time.

Table 6-1 outlines the major topics discussed in this chapter and the "Do I Know This Already?" quiz questions that correspond to those topics.

Table 6-1 *"Do I Know This Already?" Foundation Topics Section-to-Question Mapping*

Foundation Topics Section	Questions Covered in This Section	Score
Configure a Cisco Router as a PPPoA Client	1–3	
Configure an ATM Interface for PPPoA	4–5	
Configure the PPPoA DSL Dialer and Virtual-Template Interfaces	6–7	
Total Score		

CAUTION The goal of self-assessment is to gauge your mastery of the topics in this chapter. If you do not know the answer to a question or are only partially sure of the answer, you should mark this question wrong for purposes of self-assessment. Giving yourself credit for an answer that you correctly guess skews your self-assessment results and might provide you with a false sense of security.

1. ATM connections are formed through the use of which of the following?
   a. PVC
   b. SVC
   c. PVP
   d. SVP
2. To configure an ATM interface to carry a single protocol per virtual circuit, which encapsulation should be used?
   a. **aal5snap**
   b. **aal5mux**
   c. **aal5cisco**
   d. **aal1**
3. Which field in the LLC header contains protocol information?
   a. DSAP
   b. SSAP
   c. OUI
   d. NLPID
4. If not specified, what is the default encapsulation used for an ATM PVC?
   a. **aal5mux**
   b. **aal5snap**
   c. **aal5cisco**
   d. **aal34smds**
5. Which two types of logical interfaces may be used in a PPPoA configuration?
   a. Loopback
   b. Dialer
   c. BVI
   d. Virtual-template

6. Which command set is properly associating a logical interface with the interface to be placed under its control?

a.

```
interface Ethernet0/1
 dialer pool 1
!
interface Dialer0
 dialer pool-member 1
```

b.

```
interface Ethernet0/1
 dialer pool-member 1
!
interface dialer0
 dialer pool 1
```

c.

```
interface ATM0/0
 dialer-pool-member 1
!
interface virtual-template 1
 encapsulation ppp
```

d.

```
interface ATM0/0
  pvc 0/35
  dialer pool-member 1
!
interface dialer0
 dialer 1
```

7. To automatically configure the type DSL implementation on the interface, which command is necessary?

   a. **dsl operating-mode auto**

   b. **dialer 1**

   c. **dialer pool-member 1**

   d. **interface virtual-template 1**

The answers to the "Do I Know This Already?" quiz are found in Appendix A, "Answers to the 'Do I Know This Already?' Quizzes and Q&A Sections." The suggested choices for your next step are as follows:

- **3 or fewer overall score**—Read the entire chapter. This includes the "Foundation Topics," "Foundation Summary," and "Q&A" sections.

- **4 or 5 overall score**—Begin with the "Foundation Summary" section, and then go to the "Q&A" section.

- **6 or more overall score**—If you want more review on these topics, skip to the "Foundation Summary" section, and then go to the "Q&A" section. Otherwise, move to the next chapter.

Foundation Topics

Configure a Cisco Router as a PPPoA Client

To clear up a rather widespread misconception, PPPoA is defined in RFC 2364 as *PPP over AAL5*. However, it is commonly referred to simply as *PPP over ATM*. Chapter 5, "Configuring DSL Access with PPPoE," covered the configuration of PPPoE on a home router for DSL connectivity in some detail. The relative technology behind PPPoA is identical in nature to PPPoE. However, there are some significant differences that exist on the provider-facing side of the configuration, primarily:

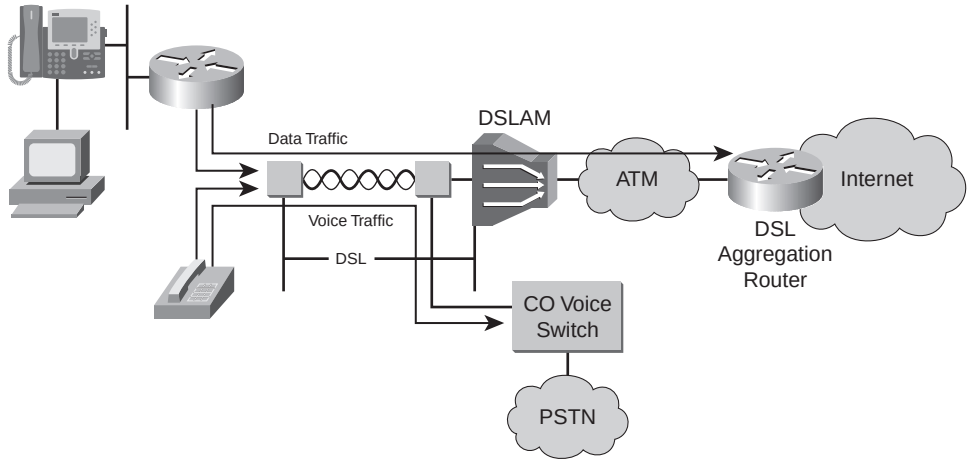
- The handling of the ATM interface
- The configuration of the ATM permanent virtual circuit (PVC) or switched virtual circuit (SVC)

DSL is a Layer 1 access methodology. The Layer 1 connection exists across the local loop between the CPE and the DSL access multiplexer (DSLAM). Layer 2 connectivity is provided by ATM from the CPE to the DSLAM and beyond. Layer 3 connectivity is established between the CPE and an aggregation router located somewhere beyond the DSLAM. For purposes of review and to provide a point of reference for discussion topics in this chapter, Figure 6-1 provides a topological view. It shows the connectivity between the CPE and the Internet. The data traffic must traverse the local loop to the DSLAM and then go across the ATM network to the aggregation router.

Although similar to PPPoE, PPPoA is its own technology. It does present several configuration differences (due to the needs of an ATM interface versus an Ethernet interface) when compared to PPPoE. The principal difference in PPPoA is that the CPE router is now using RFC 1483/2684 encapsulation to transport PPP frames across the local loop inside of ATM cells. In other words, it actually gets to be a router this time, rather than a bridge.

Like PPPoE, a logical interface is used for managing the PPP connection. This interface is known as a virtual access interface. It will be associated with the ATM PVCs configured on the ATM interface. This configuration encapsulates each PPP connection into a separate PVC or SVC to allow each session to appear as if it is being terminated on a traditional PPP serial interface. To facilitate these connections, a virtual interface template is created to provide configuration details when the virtual circuit is created.

Figure 6-1 *PPPoA DSL Topology*



PPP over AAL5 Connections

Three separate types of connectivity options are offered under the PPPoA banner:

- Virtual circuit multiplexed PPP over AAL5 (AAL5VCMUX)
- LLC encapsulated PPP over AAL5 (AAL5SNAP)
- Cisco PPP over ATM (PPPoA)

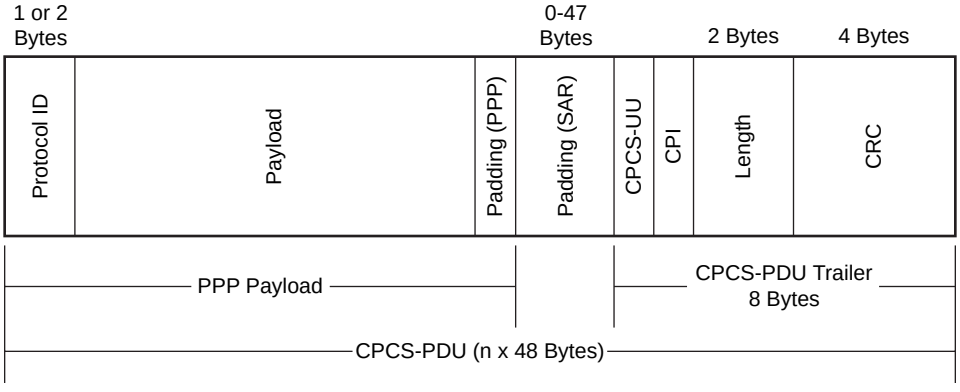
RFC 2364 defines the AAL5VCMUX and AAL5SNAP options. Cisco PPPoA, as the name implies, is a Cisco proprietary implementation. The sections that follow describe these three different connectivity options in greater detail.

NOTE As a general rule, Cisco implements its own proprietary solutions in situations where underlying technologies are not progressing quickly enough to meet market demand. Cisco continues to use the proprietary methodology until a standardized equivalent is made available to the industry. For example, consider Power over Ethernet (PoE). Well ahead of the IEEE 802.3af standard release, Cisco provided PoE capabilities to its customers in March 2000. It came in the form of a proprietary PoE known as "pre-standard power". Even in the absence of a standardized method of providing PoE, an extremely large volume of customers were requesting the capability. In response, Cisco implemented its proprietary solution. This allowed the deployment of PoE switches and technologies well ahead of a published standard. The IEEE standard was finally released in 2003. Cisco quickly converted its products to support both its pre-standard power and the standard 802.3af power.

VCMultiplexed PPP over AAL5

VCMultiplexed PPP over AAL5 (known as VC-MUX or AAL5MUX) specifies the capability to create a per-protocol virtual circuit to transport payloads for differing routed protocols. In a multiprotocol environment, integrated services and applications might not be IP-compatible. With that in mind, it might be necessary to transport IPX or AppleTalk over the network to the teleworker site. This solution allows the use of one virtual circuit per protocol to be transported. Figure 6-2 shows the framing structure for AAL5MUX.

Figure 6-2 *AAL5MUX*



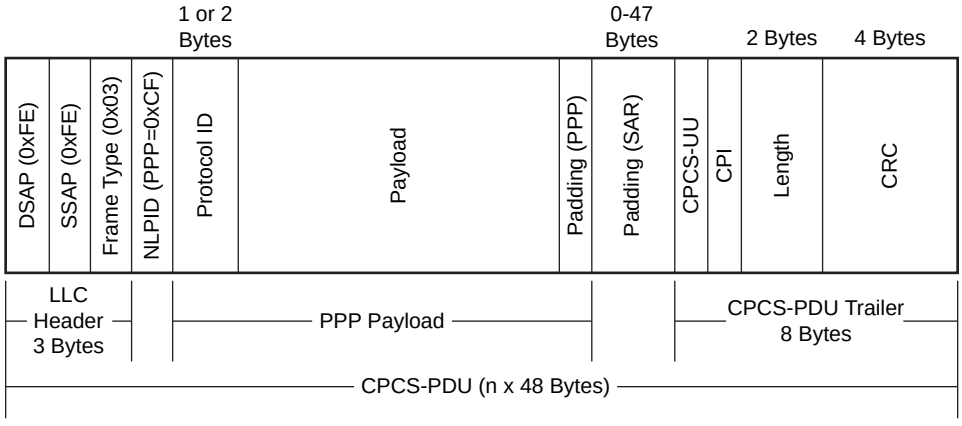
Because there is only one protocol per virtual circuit, the Protocol ID field in the frame suffices to adequately point to the upper-layer protocol encapsulated in the payload. The PPP padding is meant only to maintain the Minimum Transmittable Unit requirements of PPP.

LLC Encapsulated PPP over AAL5

Also defined in RFC 2364, this methodology uses a single virtual circuit to transport all protocols. In support of this, additional information is required to be carried in the ATM Common Part Convergence Sublayer-Protocol Data Unit (CPCS-PDU). To that end, this option specifies the use of Logical Link Control (LLC) encapsulation. Figure 6-3 shows the framing structure for AAL encapsulated PPP.

Within this specification is a detailed structure of an LLC encapsulated PPP frame. When using the LLC encapsulation technique, the payload's protocol type is explicitly identified on a per-Protocol Data Unit (PDU) basis by an in-band LLC header, followed by the payload data.

Figure 6-3 *LLC Encapsulated PPP*



The LLC encapsulation technique provides a means to define a protocol number inside the LLC header, which allows the payload to be identified as containing a particular protocol. The LLC header contains the following information:

- **Destination service access point (DSAP)**—Destination network endpoint identifier used for OSI network layer protocols such as Connectionless Network Service (CLNS). In SNAP encapsulation, it is set to 0xFE.
- **Source service access point (SSAP)**—Source network endpoint identifier used for OSI network layer protocols. In SNAP encapsulation, it is set to 0xFE.
- **Frame Type**—This field denotes the type of frame in use and therefore its structure. This field is also known as Control (Ctrl) and is set to 0x03 (unnumbered information).

The Network Layer Protocol Independent (NLPID) field is not part of the LLC header. Typically, it is associated with the Sub-Network Access Point (SNAP) header. The SNAP Header contains an Organizationally Unique Identifier (OUI) field as well as the NLPID. This is not the case with the LLC Encapsulated PPP frame structure. The NLPID field is set to 0xCF in the LLC encapsulation technique to identify PPP as the encapsulated protocol.

The cell stream is sent from CPE to DSLAM. Once it arrives at the DSLAM, the cells are switched and forwarded across to the aggregation router. With PPPoA, the overhead created by the existence of the Ethernet frame structure is eliminated because the CPE simply uses ATM as the encapsulation rather than bridging the Ethernet frame across the network, as with PPPoE.

Cisco PPPoA

Cisco's proprietary PPP over ATM PVC technology is one dependent on Cisco infrastructure end-to-end. Multiple PVCs can be configured on multiple subinterfaces to significantly increase the maximum number of PPPoA sessions running on a router. Remote sites must have Cisco-proprietary PPPoA configured on PPP-compatible devices interconnected directly to an ATM Switch Interface Shelf, also known as AXIS, via leased-line connectivity. The shelf is installed into a Cisco BPX core prior to connecting to a Cisco 7500 router.

The configuration is performed similarly to other ATM PVCs with the exception of the encapsulation setting of **aal5ciscoppp**.

Configure an ATM Interface for PPPoA

In a PPPoA configuration, there is typically a single Ethernet interface and an ATM interface on the CPE router. The Ethernet interface is the subscriber-facing component of the CPE router. Example 6-1 shows how to configure an Ethernet interface.

Example 6-1 *Subscriber-Facing Ethernet Interface Configuration*

```
!
interface Ethernet0/0
 description ****Inside Private Network****
 ip address 172.16.0.1 255.255.0.0
!
```

Once the Layer 1 connection is established, the router's PPP subsystem will initialize and send PPP configuration requests to the aggregation router. If the router's PPP subsystem does not receive a response, it will fall back into "listen" mode to wait for an inbound configuration request. After a brief timeout period, the router will again attempt to make contact with the aggregation router. Example 6-2 demonstrates an AAL5MUX configuration.

Example 6-2 *AAL5MUX Configuration*

```
!
interface Ethernet0/0
 ip address 172.16.0.1 255.255.0.0
!
interface ATM0/0
 no ip address
 dsl operating-mode auto
 pvc 8/35
  encapsulation aal5mux ppp dialer
  dialer pool-member 1
!
```

Example 6-3 demonstrates a similar configuration but uses the LLC encapsulated PPP technique. Note that this is, in fact, accomplished by using the **encapsulation aal5snap** command. While the **encapsulation aal5snap** command has been included in this example, it is the default setting if no encapsulation is specified.

Also configured on the ATM interface is the **dsl operating-mode auto** command. This sets the interface to auto-detect the DSL modulation method to be used rather than having to define it specifically.

Example 6-3 *AAL5SNAP Configuration*

```
!
interface ATM0/0
 no ip address
 dsl operating-mode auto
interface ATM0/0.1 multipoint
 class-int ppp-default
 pvc 8/35
!
vc-class atm ppp-default
 encapsulation aal5snap
 protocol ppp virtual-template 1
 ubr 256
!
```

This example shows the use of the virtual-template interface rather than the dialer interface. The section that follows discusses the virtual-template configuration in greater detail.

Configure the PPPoA DSL Dialer and Virtual-Template Interfaces

The dialer interface is the DSL provider-facing component of the CPE router. Example 6-4 shows how to configure the basic elements of the dialer interface.

Example 6-4 *Dialer Interface Configuration*

```
!
interface ATM0/0
 no ip address
 dsl operating-mode auto
 pvc 8/35
 pppoe-client dial-pool-number 1
!
interface Dialer0
 ip address negotiated
 ip mtu 1492
 encapsulation ppp
 dialer pool 1
!
```

This configuration specifies that the dialer interface should get its IP address from the provider's DHCP server while specifying the upstream MTU and setting the interface encapsulation to PPP. Finally, the **dialer pool** command associates the dialer back to the ATM interface where the **pppoe-client dial-pool-number** command was issued. This is similar to the PPPoE configuration discussed in Chapter 5, "Configuring DSL Access with PPPoE." The pool numbers must match on the dialer and ATM interfaces in order for the configuration to function.

Virtual templates are logical interfaces that provide characteristics to physical interfaces under their control. This function is similar to the dialer interface in that regard. Like the dialer interface, the virtual-template interface is configured with all relevant PPP characteristics and parameters. Example 6-5 demonstrates the configuration for a virtual template that would function with AAL5SNAP as configured in Example 6-3.

Example 6-5 *Virtual-Template Configuration*

```
!
interface virtual-template1
 encapsulation ppp
 ip address negotiated
 ip nat outside
 ppp authentication chap
 ppp chap hostname cpe_router@cisco.com
 ppp chap password 0 cisco
!
```

The PPP CHAP options in Example 6-5 are simply added for demonstrative purposes. They are required only at the discretion of the provider. Note that NAT has also been included in the configuration. This is for demonstrative purposes to show that the virtual-template interface should be treated like any other outside interface.

Configure Additional PPPoA Elements

The information regarding additional PPPoA elements is identical to that discussed in Chapter 5 with PPPoE. For that reason, as well as to save a tree or two, the information will not be revisited here. Please refer to Chapter 5 for information on NAT/PAT, DHCP, and static default route configuration.

The Overall CPE Router Configuration

The configuration of the CPE router is relatively uncomplicated overall. Example 6-6 assembles the configuration options detailed in this chapter to render the basic CPE router configuration.

Example 6-6 *CPE Router Configuration for DSL Access with PPPoA*

```
no service pad
service timestamps debug datetime msec localtime show-timezone
service timestamps log datetime msec localtime show-timezone
service password-encryption
!
hostname PPPoA-CPE
!
memory-size iomem 5
enable secret 5 [removed]
!
username Emma privilege 15 secret 5 [removed]
username Amanda privilege 15 secret 5 [removed]
clock timezone est -6
clock summer-time cdt recurring
no aaa new-model
ip subnet-zero
no ip domain lookup
ip domain name mydomain.com
ip name-server 4.2.2.1
!
ip dhcp excluded-address 172.16.0.1 172.16.0.9
!
ip dhcp pool PCLAN
   import all
   network 172.16.0.0 255.255.0.0
   default-router 172.16.0.1
!
interface Ethernet0/0
 description ***Internal Private Network***
 ip address 172.16.0.1 255.255.0.0
 ip nat inside
!
interface ATM0/0
 no ip address
 dsl operating-mode auto
! Auto detect Modulation method
!
interface ATM0/0.1 multipoint
 class-int ppp-default
! Configure interface characteristics
 pvc 8/35
!
interface virtual-template1
! Configures virtual-template
 encapsulation ppp
 ip address negotiated
 ip nat outside
```

continues

Example 6-6 *CPE Router Configuration for DSL Access with PPPoA (Continued)*

```
!
vc-class atm ppp-default
! Class sets circuit characteristics
 encapsulation aal5snap
 protocol ppp virtual-template1
! Ties circuit to virtual-template
 ubr 256
!
ip classless
ip route 0.0.0.0 0.0.0.0 interface virtual-template1
no ip http server
no ip http secure-server
ip nat inside source list 100 interface virtual-template1 overload
!
access-list 100 permit ip 172.16.0.0 0.0.255.255 any
!
line con 0
 exec-timeout 0 0
 login local
line aux 0
line vty 0 4
 exec-timeout 240 0
 login local
!
scheduler max-task-time 5000
ntp peer 172.16.1.50
ntp server XXX.118.25.3 prefer
!
End
```

Alternatively, the configuration options may use AAL5MUX and a dialer interface. Example 6-7 illustrates the configuration.

Example 6-7 *AAL5MUX Configuration*

```
no service pad
service timestamps debug datetime msec localtime show-timezone
service timestamps log datetime msec localtime show-timezone
service password-encryption
!
hostname PPPoA-837
!
boot-start-marker
boot-end-marker
!
memory-size iomem 5
```

Example 6-7 *AAL5MUX Configuration (Continued)*

```
logging buffered 65536 debugging
enable secret 5 [removed]
!
username Emma privilege 15 secret 5 [removed]
username Amanada privilege 15 secret 5 [removed]
clock timezone est -6
clock summer-time cdt recurring
no aaa new-model
ip subnet-zero
no ip domain lookup
ip domain name mydomain.com
ip name-server 4.2.2.1
!
ip dhcp excluded-address 172.16.0.1 172.16.0.9
!
ip dhcp pool LAN_HOSTS
 import all
 network 172.16.0.0 255.255.0.0
 default-router 172.16.0.1
 dns-server 4.2.2.1
 domain-name mydomain.com
 option 150 ip xx.xxx.2.93
 netbios-name-server xxx.68.235.228 xxx.68.235.229
!
ip cef
!
interface Ethernet0
 description ****Internal Private Network****
 ip address 172.16.0.1 255.255.0.0
 ip nat inside
!
interface ATM0
 no ip address
 ip route-cache flow
 no ip mroute-cache
 load-interval 30
 no atm ilmi-keepalive
 dsl operating-mode auto
!
interface ATM0.35 point-to-point
 description ****ATM Subinterface for DSL Access****
 no ip mroute-cache
 pvc dsl 0/35
  encapsulation aal5mux ppp dialer
  dialer pool-member 1
!
interface Dialer1
```

continues

Example 6-7 *AAL5MUX Configuration (Continued)*

```
 description ****Logical Outside Interface****
 ip address negotiated
 ip nat outside
 ip mtu 1492
 encapsulation ppp
 ip tcp adjust-mss 542
 dialer pool 1
 ppp authentication pap callin
 ppp chap refuse
 ppp pap sent-username csconerd@mydomain.com password 7 [removed]
!
ip classless
ip route 0.0.0.0 0.0.0.0 Dialer1
no ip http server
no ip http secure-server
ip nat inside source list 100 interface dialer1 overload
!
access-list 100 permit ip 172.16.0.0 0.0.255.255 any
!
control-plane
!
rtr responder
banner motd ^C
C i s c o S y s t e m s

UNAUTHORIZED ACCESS TO THIS NETWORK DEVICE IS PROHIBITED.
You must have explicit permission to access or configure this
device. All activities performed on this device are logged and
violations of this policy may result in disciplinary action.
^C
!
line con 0
 exec-timeout 0 0
 login local
line aux 0
line vty 0 4
 exec-timeout 240 0
 login local
!
exception memory minimum 786432
scheduler max-task-time 5000
sntp server xxx.5.41.41
sntp server xxx.5.41.40
sntp server xxx.210.169.40
!
end
```

Foundation Summary

Configuration of PPPoA is similar to PPPoE. However, the options are somewhat different and admittedly a bit difficult to understand initially. Only the most basic configuration parameters are discussed in this chapter. The AAL5SNAP and AAL5MUX options are the overwhelmingly more dominant choices in the market today. The Cisco-proprietary PPPoA option works very well in "Cisco-on-Cisco" environments.

Table 6-2 provides a review of the basic configuration elements.

Table 6-2 *PPPoA Configuration Elements*

Element	Description
Ethernet interface	Physical interface providing service to the subscriber's home network.
ATM interface	Physical interface, provider-facing and encapsulates PPP frames inside ATM cells via native ATM functionality in the CPE router.
Dialer interface	Logical interface bound to a physical interface (usually ATM) to establish PPPoA session to aggregation router. PPP and NAT options are configured on this interface.
Virtual-template	Logical interface bound to an ATM interface via a vc-class configuration. PPP and NAT options are configured on this interface.
NAT/PAT	Services allowing one-to-one and one-to-many IP address translation capabilities in the CPE router. PAT is also known as NAT with Overload.
Inside local address	Configured IP address assigned to a host on the inside network.
Inside global address	The IP address of an inside host as it appears to the outside network.
Outside local address	The IP address of an outside host as it appears to the inside network.
Outside global address	The configured IP address assigned to a host in the outside network.
DHCP server	Service configured to allocate IP address, gateway, and other relevant information to IP hosts on a particular subnet.
Static default route	A route to a gateway of last resort. The static default route takes any traffic destined to nonlocal destinations and directs it to the aggregation router.

Q&A

The questions and scenarios in this book are designed to be challenging and to make sure that you know the answer. Rather than allowing you to derive the answers from clues hidden inside the questions themselves, the questions challenge your understanding and recall of the subject.

Hopefully, mastering these questions will help you limit the number of exam questions on which you narrow your choices to two options, and then guess.

You can find the answers to these questions in Appendix A. For more practice with exam-like question formats, use the exam engine on the CD-ROM.

1. In ATM interface configurations, what is the first usable VCI available for user-defined virtual circuits?
2. What is the purpose of the **dsl operating-mode auto** command?
3. What purpose does the LLC header serve in the LLC encapsulated technique for PPPoA?
4. Consider a situation in which you want each routed protocol to use a different virtual circuit for transport across the network. Which encapsulation would allow this, and what might be accomplished by such a configuration?
5. In the following example, what is the IP address assigned to the provider-facing interface?

```
interface Ethernet0/0
 ip address 172.16.0.1 255.255.0.0
 ip nat inside
!
interface ATM0/0
 no ip address
 dsl operating-mode auto
!
interface ATM0/0.1 multipoint
 class-int ppp-default
 pvc 8/35
!
interface virtual-template1
 encapsulation ppp
 ip address negotiated
 ip nat outside
!
vc-class atm ppp-default
 encapsulation aal5snap
 protocol ppp virtual-template1
 ubr 256
!
```

6. List one alternative to the use of a static default route.
7. Is there a time when a router using a dynamic routing protocol might also benefit from a static default route? If so, when?
8. If a source address does not match a defined access list for a NAT definition, what is the result?

Exam Topic List

This chapter covers the following topics that you need to master for the CCNP ISCW exam:

- **DSL Connection Troubleshooting**—Describes basic DSL troubleshooting principles
- **Isolating Physical Layer Issues**—Describes how to diagnose Layer 1 issues
- **Isolating Data Link Layer Issues**—Describes how to diagnose Layer 2 issues