SYBEX Sample Chapter

CCNP™: Advanced Cisco® Router Configuration Study Guide

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WAN Scalability

This chapter's focus is the strategies for scaling WANs with Cisco routers. The packet switching protocols covered in this chapter include Frame Relay, X.25, SMDS, and ATM.

We will cover the basic WAN connection considerations and talk about the different Cisco connection services. We'll then cover the details of configuring and monitoring the Cisco packet switched networks.

The CCNP test objectives covered in this chapter are as follows:

- Compare the differences between WAN connection types: dedicated, asynchronous dial-in, dial-on-demand, and packet switched services
- List at least four common issues to be considered when evaluating WAN services

WAN Scalability

LANs are defined as a network that is restricted to a floor or building. LAN users often rely on asynchronous connections to access the remote services available outside the confines of their local LAN.

However, as organizations evolve and expand, they're often faced with the need to make their networks efficiently support WAN services to the Internet and remote divisions at LAN-type speeds. Achieving that is simply beyond the capabilities of asynchronous connections.

Because it just isn't always feasible for an organization to create its very own private, dedicated WAN connection, alternative approaches to forging connections across public networks have been sought and expansively developed.

Connection Considerations

When a company grows, it's imperative that its internetwork grows with it. The network's administrator must not only understand the various user-group differences regarding their specialized needs for the mélange of LAN and WAN resources, they must find a way to meet—or better yet—exceed these requirements, while planning for growth as well. Below, we've listed important factors to consider when defining and researching business requirements for the purposes of internetwork design or refinement.

Availability Because networks are so heavily relied upon—they're ideally up and running 24 hours a day, 365 days a year—failures and downtime must be minimized. It's also vital that when a failure does occur, it's easy to isolate so that the time needed to troubleshoot the problem is reduced.

Bandwidth Accurately determining the actual and eventual bandwidth requirements with information gathered from both users and management is crucial. It can be advantageous to contract with a service provider to establish connectivity between remote sites. Bandwidth considerations are also an important element for the next consideration—cost.

Cost In a perfect world, we could just install nothing but Cisco Catalyst 5000 series switches that provide switched 100Mbps to each desktop with gigabit speeds between data closets and remote offices. However, since the world's not perfect, and often budget constraints simply won't allow for doing that, Cisco offers an abundance of switches and routers tailored to many wallet sizes. This is one very big reason why it's so important to accurately assess actual needs. A budget must be carefully delimited when designing an internetwork.

Ease of management The ramifications such as the degree of difficulty associated with creating any network connections must be understood and regarded carefully. Factors associated with configuration management include analyses of both the initial configuration and the ongoing configuration tasks related to running and maintaining the entire internetwork. Traffic management issues—the ability to adjust to different traffic rates, especially in bursty networks—also apply here.

Type of application traffic This can be typically comprised of small to very large packets, and the internetwork design must reflect and regard the typical traffic type to meet business requirements.

Routing protocols The characteristics of these protocols can cause some ugly problems and steal a lot of precious bandwidth in networks where they're either not understood or not configured properly.

Cisco Connection Services

Cisco supports many different types of services, providing ample flexibility and many options for meeting internetworking business requirements. These services include:

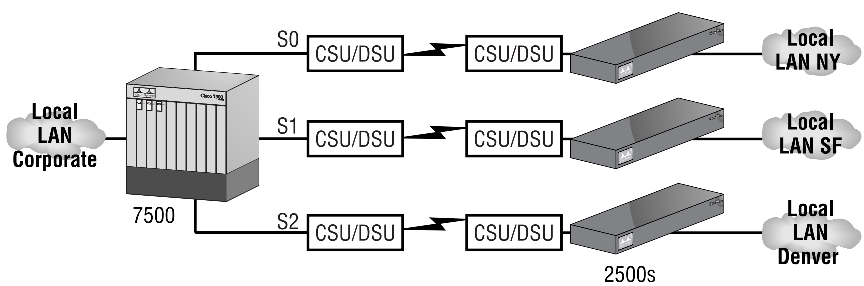
- Dedicated leased lines
- Dial-in modems
- Dial-up connections using Cisco routers (DDR)
- Packet switched services

Dedicated

Point-to-point serial links are dedicated links that provide full-time connectivity. Cisco router serial ports are used to gain access at a rate of up to 45Mbps. They connect into a channel service unit/data service unit (CSU/DSU), which then plugs into the demarc provided by the telephone company.

Figure 11.1 shows how point-to-point connections can be made between remote offices and the corporate office.

FIGURE 11.1 Point-to-point connections between branches and the corporate office



If the established business requirements dictate that constant connection and steady data flow must prevail, a dedicated point-to-point connection can be an optimal solution—but even so, this approach does have a disadvantage associated with it. Point-to-point connections require paying tariffs for them even when the connection is in an idle state with no data being transmitted.

Asynchronous Dial-In

Any user with an asynchronous modem can make connections to an internetwork using the public switched telephone network (PSTN), and there are many common situations requiring this type of access. Users who are traveling can dial in to gather e-mails or update a database, while others may want to dial in from home to finish projects, send and retrieve e-mails, and even print documents to be available for them when they arrive at work the next day.

Cisco answers this need by providing a variety of asynchronous dial-in products such as the AS5200 access server. This device provides up to 48 asynchronous modems for both dial-in and dial-out services, and it runs the Cisco IOS, so it can also perform routing, authentication, and security-related tasks. If demands don't dictate the need for that many ports, there are Cisco products that offer a lower port density.

Dial-on-Demand Routing

DDR (dial-on-demand routing) allows wide area links to be used selectively. With it, the administrator can define "interesting" traffic on the router, and initiate WAN links based upon that traffic. Access lists define interesting traffic, so there's a great deal of flexibility given to the administrator. For instance, an expensive ISDN connection to the Internet could be initiated to retrieve e-mail, but not for a WWW request. DDR is an effective tool in situations where WAN access is charged in some time interval, and it's best to use it in situations where WAN access is infrequent.

Dial-on-demand routing provides the missing software ingredient for creating a fully functional backup system. Versatile DDR can be used over several different types of connections, and is supported in Cisco IOS version 9 and later. It supports the following networking protocols: IP, IPX, AppleTalk, and others. DDR's flexibility reaches even further. It can be used over several different types of interfaces—synchronous and asynchronous serial interfaces, as well as ISDN.

Packet Switched Services

Packet switched services are usually run over a publicly maintained network, such as the public switched telephone network, but if necessary, a large organization can build a private packet switched network (PSN).

PSN data delivery can take place within frames, packets, or cells, and occurs transparently to end users.

Frame Relay, X.25, SMDS, and ATM are some of the topologies that employ packet switching technology—they'll be discussed next.

Packet Switched Networks

As we said, PSNs can be either private or public networks. Switching devices forward packets using an internal addressing scheme, which can be entirely different from what's used on the LAN. This is because a switch that's located at the WAN provider's office will typically check the address field of the packets only, and then carry out the forwarding based upon the static routes configured by an administrator.

An administrator must understand how switching protocols operate to customize the internetwork according to the specific characteristics of the switched network. For example, Frame Relay will perform a CRC only at the Data Link layer of the frame, so if the application you need to run on the WAN doesn't support upper-layer error checking, Frame Relay may not be the best solution for you. Because X.25 supports more extensive error checking, that would be a better choice.

The most popular switching protocols are as follows:

- Frame Relay
- X.25
- SMDS/ATM

Frame Relay

Recently, the high-performance WAN encapsulation method known as Frame Relay has become one of the most popular technologies in use. It operates at the Physical and Data Link layers of the OSI reference model, and was originally designed for use across Integrated Services Digital Network (ISDN) interfaces. But today, Frame Relay is used over a variety of other network interfaces.

Cisco Frame Relay supports the following protocols:

- IP
- DECnet

- AppleTalk
- Xerox Network Service (XNS)
- Novell IPX
- Connectionless Network Service (CLNS)
- International Organization for Standards (ISO)
- Banyan Vines
- Transparent bridging

Frame Relay provides a communications interface between DTE (data terminal equipment) and DCE (data circuit-terminating equipment—such as packet switches) devices. DTE consists of terminals, PCs, routers, and bridges—customer-owned end node and internetworking devices. DCE consists of carrier-owned internetworking devices.

Popular opinion maintains that Frame Relay is more efficient and faster than X.25 because it assumes error checking will be done through higher-layer protocols and application services.

Frame Relay provides connection-oriented, Data Link layer communication via virtual circuits just as X.25 does. These virtual circuits are logical connections created between two DTEs across a packet switched network, which is identified by a DLCI. (We'll get to DLCIs in a bit.) Also, like X.25, Frame Relay uses both PVCs and SVCs, although most Frame Relay networks use PVCs.

Frame Relay with Cisco Routers

When configuring Frame Relay on Cisco routers, you need to specify it as an encapsulation on serial interfaces. There are only two encapsulation types: Cisco and IETF (Internet engineering task force). The following router output shows the two different encapsulation methods when choosing Frame Relay on your Cisco router:

```
RouterA(config)#int s0
RouterA(config-if)#encapsulation frame-relay ?
  ietf  Use RFC1490 encapsulation
  <cr>
```

The default encapsulation is Cisco unless you manually type in IETF, and Cisco is the type used when connecting two Cisco devices. You'd opt for the IETF-type encapsulation if you needed to connect a Cisco device to a non-Cisco device with Frame Relay. So before choosing an encapsulation type, check with your ISP and find out which one they use. (If they don't know, hook up with a different ISP!)

Data Link Connection Identifiers

Frame Relay virtual circuits are identified by data link connection identifiers (DLCIs). A Frame Relay service provider, such as the telephone company, typically assigns DLCI values, which are used by Frame Relay to distinguish between different virtual circuits on the network. Since many virtual circuits can be terminated on one multipoint Frame Relay interface, many DLCIs are often affiliated with it.

For the IP devices at each end of a virtual circuit to communicate, their IP addresses need to be mapped to DLCIs. This mapping can function as a multipoint device—one that can identify to the Frame Relay network the appropriate destination virtual circuit for each packet that is sent over the single physical interface.

Frame Relay uses DLCIs the same way that X.25 uses X.121 addresses, and every DLCI number can be given either global or local meaning everywhere within the Frame Relay network. However, the customary implementation is to give each DLCI local meaning. What does this do? It makes two DTE devices connected via a virtual circuit use different DLCI values when referring to the same connection.

Configuring a DLCI number to be applied to an interface is shown below:

```
RouterA(config-if)#frame-relay interface-dlci ?
  <16-1007> Define a DLCI as part of the current
subinterface
RouterA(config-if)#frame-relay interface-dlci 16
```

Prioritizing DLCI Traffic To control which path traffic will take through a Frame Relay cloud, you can configure virtual circuits that match parameters within a priority queue list. These queues can then be matched to a specific DLCI, providing a traffic management tool to minimize congestion problems with slower links. This can be really helpful if your network commonly sustains traffic from sources with high-speed access that's queued at destination sites with lower-speed access, and can be achieved by applying priority levels to the DLCI.

The steps to configure DLCI priority levels are as follows:

1. Define a global priority list.
2. Enable Frame Relay on the serial interface.
3. Define either inverse ARP or static mappings.
4. Configure the LMI.

DLCI priority levels provide a way to define multiple DLCIs and associate each with different types of traffic. However, don't confuse DLCI priorities with router priority queues.

NOTE You can enable queuing and then use the same DLCIs for queuing by placing the higher-priority DLCIs into the high-priority queues.

To assign protocol traffic to match the specified parameters of a priority queue, you use the `priority-list protocol` command:

```
Router(config)#priority-list ?
  <1-16>  Priority list number

Router(config)#priority-list 1 ?
  default      Set priority queue for unspecified datagrams
  interface    Establish priorities for packets from a named
                 interface
  protocol     Priority queueing by protocol
  queue-limit  Set queue limits for priority queues

Router(config)#priority-list 1 protocol ?
  aarp              AppleTalk ARP
  appletalk         AppleTalk
  arp               IP ARP
  bridge            Bridging
  bstun             Block Serial Tunnel
  cdp               Cisco Discovery Protocol
  compressedtcp     Compressed TCP
  decnet            DECnet
  decnet_node       DECnet Node
  decnet_router-l1  DECnet Router L1
```

```
  decnet_router-l2  DECnet Router L2
  decnet_router-l2  DECnet Router L2
  ip                IP
  ipx               Novell IPX
  llc2              llc2
  pad               PAD links
  rsrb              Remote Source-Route Bridging
  snapshot          Snapshot routing support
  stun              Serial Tunnel

Router(config)#priority-list 1 protocol ip ?
  high
  medium
  normal
  low

Router(config)#priority-list 1 protocol ip high ?
  fragments  Prioritize fragmented IP packets
  gt         Prioritize packets greater than a specified
               size
  list       To specify an access list
  lt         Prioritize packets less than a specified size
  tcp        Prioritize TCP packets 'to' or 'from' the
               specified port
  udp        Prioritize UDP packets 'to' or 'from' the
               specified port
  <cr>
Router(config)#priority-list 1 protocol ip high gt ?
  <0-65535>  Packet size (include MAC encapsulation bytes)
```

The list below provides an explanation of the router output listed above.

- The priority list number represents the number of the priority list—a value between 1 and 16.
- The protocol name represents the name of the protocol being specified.
- The priority level represents the name of the queue—high, medium, normal, or low.

- The equality (`gt`) represents the conditional value.
- The byte count represents the number of bytes within the packet, including the frame header.

To establish the DLCIs for use by each of the four individual priority queues that apply the specified priority list to an interface, you use the `frame relay priority-dlci-group` command:

```
Router(config-if)#frame priority-dlci-group ?
  <1-16>  Assign priority group

Router(config-if)#frame priority-dlci-group 1 ?
  <16-1007>  DLCI for high priority

Router(config-if)#frame priority-dlci-group 1 16 ?
  <16-1007>  DLCI for medium priority
  <cr>

Router(config-if)#frame priority-dlci-group 1 16 17 ?
  <16-1007>  DLCI for normal priority
  <cr>

Router(config-if)#frame priority-dlci-group 1 16 17 18 ?
  <16-1007>  DLCI for low priority
  <cr>
```

The list below explains the meaning of the router output above.

- The priority group number represents the number of the priority that's applied to the interface, between 1 and 16.
- The high DLCI represents the DLCI number that's assigned to the high queue.
- The medium DLCI represents the DLCI number that's assigned to the medium queue.
- The normal DLCI represents the DLCI number that's assigned to the normal queue.
- The low DLCI represents the DLCI number that's assigned to the low queue.

If a DLCI value isn't configured for a queue, the last assigned DLCI value used will be propagated to complete the syntax by default.

Setting Access Lists with Priorities If you want to define an access list to use a high-priority queue, use the `list` parameter as shown in the following example:

```
Router(config)#priority-list 1 protocol ip high ?
  fragments  Prioritize fragmented IP packets
  gt         Prioritize packets greater than a specified
               size
  list       To specify an access list
  lt         Prioritize packets less than a specified size
  tcp        Prioritize TCP packets 'to' or 'from' the
               specified port
  udp        Prioritize UDP packets 'to' or 'from' the
               specified port
  <cr>

Router(config)#priority-list 1 protocol ip high list ?
  <1-199>  IP access list

Router(config)#priority-list 1 protocol ip high list 10 ?
  <cr>
```

You can choose any access list between 1 and 199, which covers IP standard and IP extended access lists.

Local Management Interface (LMI)

The LMI (Local Management Interface) was developed in 1990 by Cisco Systems, StrataCom, Northern Telecom, and Digital Equipment Corporation, and became known as the Gang-of-Four LMI or Cisco LMI. This gang took the basic Frame Relay protocol from the CCIT and added extensions onto the protocol features that allow internetworking devices to communicate easily with a Frame Relay network.

LMI messages provide information about the current DLCI values, whether their significance is global or local, and they report the status of virtual circuits.

NOTE Beginning with IOS version 11.2, the LMI type is autosensed. This enables the interface to determine the LMI type supported by the switch.

To configure the LMI type, you need to do as follows:

- Set the LMI type.
- Set the LMI keepalive interval.
- Set the LMI polling and timer intervals (not required).

If you're not going to use the autosense feature, you'll need to check with your Frame Relay provider to find out which type to use instead. The default type is Cisco, but you may need to change to ANSI or Q.933A. The three different LMI types are depicted in the router output below.

```
RouterA(config-if)#frame-relay lmi-type ?
  cisco
  ansi
  q933a
```

As seen in the output, all three standard LMI signaling formats are supported:

Cisco LMI defined by the gang of four (default)

ANSI Annex D defined by ANSI standard T1.617

ITU-T (q933a) Annex A defined by Q.933

To establish the interval at which your router will send keepalive messages, use the `frame-relay keepalive` command. The default period is every 10 seconds, but be aware that this value must be set to less than that of the corresponding interval on the switch.

```
Router(config-if)#keepalive ?
 <0-32767>  Keepalive period (default 10 seconds)
 <cr>
```

The 10-second default interval can also be seen by using the `sh int` command:

```
Router#sh int s0
Serial0 is administratively down, line protocol is down
  Hardware is HD64570
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec, rely
    255/255, load 1/255
  Encapsulation FRAME-RELAY, loopback not set, keepalive set
    (10 sec)
```

```
LMI enq sent  0, LMI stat recvd 0, LMI upd recvd 0, DTE
  LMI down
LMI enq recvd 0, LMI stat sent  0, LMI upd sent  0
LMI DLCI 1023  LMI type is CISCO  frame relay DTE
```

NOTE: The above output was edited for brevity.

You can set the LMI polling and timer intervals by using the `frame-relay lmi-n39x` command. This specifies the interval between full status requests made to the Frame Relay switch from your router.

```
Router(config-if)#frame-relay lmi?
lmi-n391dte  lmi-n392dce  lmi-n392dte  lmi-n393dce  lmi-n393dte
lmi-t392dce  lmi-type
```

The list below describes the different LMI polling and timer commands.

- The `lmi-n391dte` sets a full status polling interval on a DTE interface or NNI (Network-to-Network Interface).
- The `lmi-n392dce` sets the DCE and NNI error threshold.
- The `lmi-n392dte` sets the DTE and NNI error threshold.
- The `lmi-n393dce` sets the DCE and NNI monitored events count.
- The `lmi-n393dte` sets the DTE and NNI monitored events count.
- The `lmi-t392dce` sets the polling verification timer on a DCE interface or NNI.

Subinterfaces

You can have multiple virtual circuits on a single serial interface and yet treat each as a separate interface. These are known as *subinterfaces*. Think of a subinterface as a hardware interface defined by the IOS software.

An advantage gained through using subinterfaces is the ability to assign different network layer characteristics to each subinterface and virtual circuit, such as IP routing on one virtual circuit and IPX on another. Figure 11.2 shows how a single physical interface simulates multiple logical interfaces.

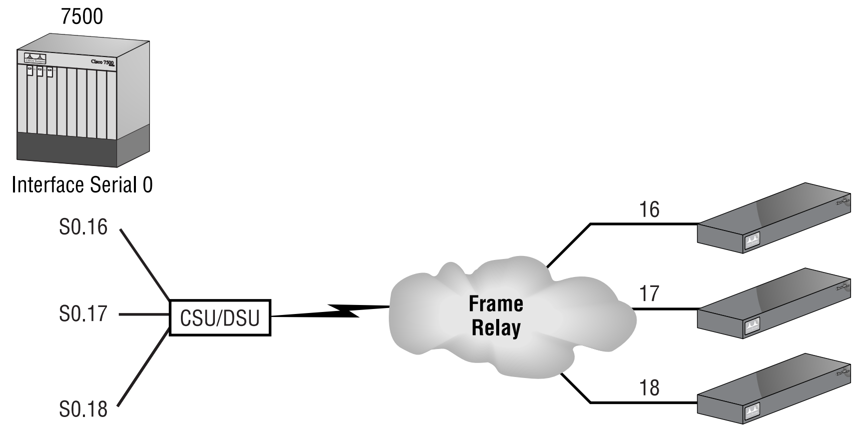


FIGURE 11.2 Subinterfaces representing several logical interfaces

You define subinterfaces with the `int s0.`*`subinterface number`* command as shown below.

```
RouterA(config)#int s0.?
  <0-4294967295>  Serial interface number
RouterA(config)#int s0.16 ?
  multipoint      Treat as a multipoint link
  point-to-point  Treat as a point-to-point link
```

You can define a limitless number of subinterfaces on a given physical interface (keeping router memory in mind). In the above example, we chose to use subinterface 16 because that represents the DLCI number assigned to that interface. However, you can choose any number between 0 and 4,292,967,295.

There are two types of subinterfaces:

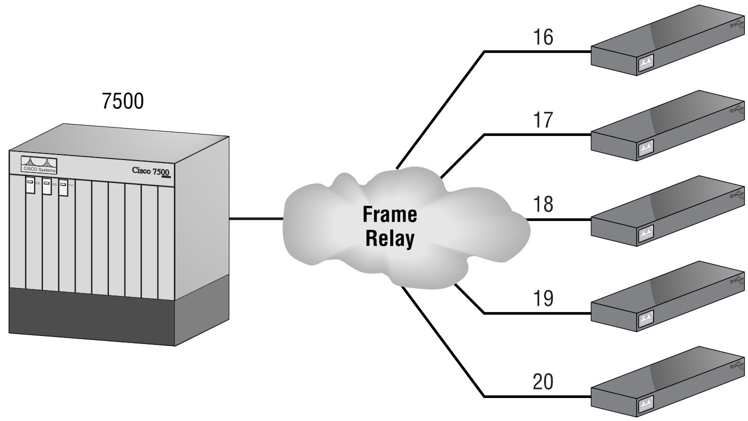
Point-to-point Used when a single virtual circuit connects one router to another

Multipoint Used when the router is the center of a star of virtual circuits

An example of a production router running multiple subinterfaces is shown below, and corresponds to Figure 11.3. Notice that the subinterface number matches the DLCI number. Also notice that there is no LMI type defined, which means they're running in autosense mode.

FIGURE 11.3

Subinterface example



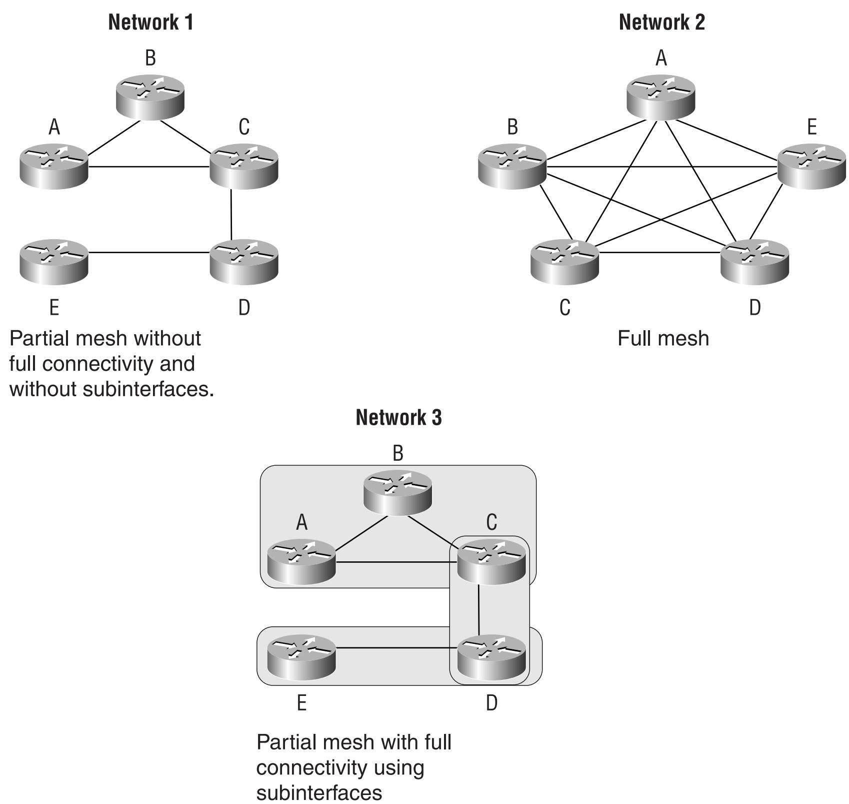

```
interface Serial0.16 point-to-point
ip address 192.168.2.22 255.255.255.252
 ipx network 101
 frame-relay interface-dlci 16
!
interface Serial0.17 point-to-point
ip address 192.168.2.101 255.255.255.252
 ipx network 102
 frame-relay interface-dlci 17
!
interface Serial0.18 point-to-point
ip address 192.168.2.113 255.255.255.252
 ipx network 103
 frame-relay interface-dlci 18
!
interface Serial0.19 point-to-point
ip address 192.168.2.109 255.255.255.252
 ipx network 104
 frame-relay interface-dlci 19
!
interface Serial0.20 point-to-point
ip address 192.168.2.105 255.255.255.252
 ipx network 105
 frame-relay interface-dlci 20
```

Partial Meshed Networks

You can use subinterfaces to mitigate partial meshed Frame Relay networks and split horizon protocols. For example, say you were running the IP protocol on a LAN network. If on the same physical network, Router A can talk to Router B, and Router B can talk to Router C—you can usually assume that Router A can talk to Router C. Though this is true with a LAN, it's not true with a Frame Relay network, unless Router A has a virtual circuit to Router C.

In Figure 11.4, Network 1 is configured with five locations. To be able to make this network function, you would have to create a meshed network as shown in Network 2. However, even though Network 2's example works, it's an expensive solution—configuring subinterfaces as shown in the Network 3 solution is much more cost effective.

FIGURE 11.4 Partial meshed network examples



In Network 3, configuring subinterfaces actually works to subdivide the Frame Relay network into smaller subnetworks—each with its own network number. So locations A, B, and C connect to a fully meshed network, while locations C and D, and D and E, are connected via point-to-point connections. Locations C and D connect to two subinterfaces and forward packets.

Mapping Frame Relay

As we mentioned earlier in the chapter, for IP devices on opposite ends of a virtual circuit to communicate, their addresses must be properly mapped to the DLCIs. There are two ways to ensure that the address-to-DLCI mapping takes place:

- Via the `frame-relay map` command
- Via the inverse ARP function

Inverse ARP (IARP) uses a dynamic address mapping process to request the next hop protocol address for a specific connection, given its known DLCI number. The responses to the IARP are entered in an address-to-DLCI mapping table, which is then used to supply the next hop protocol address of the DLCI for outgoing traffic.

IARP is enabled by default, but can be disabled on a by-protocol basis. This allows you to run dynamic mapping with some protocols and static mappings with others.

Static mappings link a specific next hop protocol address to a specific DLCI number. Since you don't need IARP functioning on an interface that's using static mapping, the IARP function is automatically disabled for a specified protocol on a specific DLCI.

Here's an example using the `frame-relay map` command:

```
RouterA(config)#int s0.16
RouterA(config-if)#encap frame-relay ietf
RouterA(config-if)#no inverse-arp
RouterA(config-if)#ip address 172.16.30.1 255.255.255.0
RouterA(config-if)#frame-relay map ip 172.16.30.17 30 cisco
  broadcast
```

```
RouterA(config-if)#frame-relay map ip 172.16.30.18 50
  broadcast
RouterA(config-if)#frame-relay map ip 172.16.30.19 40
```

Here's what we did: First, we chose our subinterface, then added the encapsulation command using IETF. We then turned off IARP, and mapped three virtual circuits to their corresponding DLCI numbers. Notice the `cisco` encapsulation on the first virtual circuit. The other two use the encapsulation method specified in the interface command (IETF). The `frame-relay map` command is the only way to mix both Cisco and IETF encapsulation types.

The broadcast at the end of the `map` command directs the router to forward the broadcasts for this interface to the specified virtual circuit (50). This means Router A will forward broadcasts when multicasting isn't enabled. It also means that you're allowed to send broadcasts of routing protocols such as OSPF down a Frame Relay link without having to specify the OSPF neighbor command.

NOTE

The `no inverse-arp` command wasn't really necessary because it is automatically disabled for the protocol specified in the static map (IP). However, by typing **no inverse-arp**, you turn it off for all protocols. If you want to turn off inverse ARP for a specific protocol only, use the `protocol` argument instead.

When using the `inverse-arp` function, you don't have to use the `map` command. This approach makes the configuration look as follows instead:

```
RouterA(config)#int s0.16
RouterA(config-if)#encap frame-relay ietf
RouterA(config-if)#ip address 172.16.30.1 255.255.255.0
```

Yes, you're right—that *is* a whole lot easier! However, it's not as stable as using the `map` command. Why? Sometimes, when using the `inverse-arp` function, configuration errors can occur because virtual circuits can be insidiously and dynamically mapped to unknown devices.

Monitoring Frame Relay

The Cisco IOS provides many different Exec tasks with which to monitor Frame Relay connections. Table 11.1 shows the commands and tasks you can perform on your Frame Relay networks.

TABLE 11.1 Monitoring Frame Relay

Exec Command	Function
`Clear frame-relay-inarp`	Clears dynamically created Frame Relay maps created by inverse ARP
`Sh int type [number]`	Displays the information about Frame Relay DLCIs and the LMI
`Sh frame-relay lmi [type number]`	Displays LMI statistics
`Sh frame-relay map`	Displays the current Frame Relay map entries
`Sh frame-relay pvc [type number [dlci]]`	Displays the PVC statistics
`Sh frame-relay traffic`	Displays the Frame Relay traffic statistics
`Sh frame-relay route`	Displays the configured static routes
`Sh frame-relay svc maplist`	Displays all the SVCs under a specified map list

Broadcasting on Frame Relay

Frame Relay is a nonbroadcast network. This means it definitely will not propagate normal routing and routed protocol broadcasts across the Frame cloud without special configurations in place. However, there is a way to make this happen anyway. Frame Relay can replicate broadcast traffic and retransmit broadcast packets to multiple DLCIs with Frame Relay encapsulation.

Frame Relay has its very own queue that includes its own buffers and configurable service rate, which is independent of the other, normal interface queues.

To create a queue so that Frame Relay has a place to hold broadcast traffic, use the `frame-relay broadcast-queue` command. The example below specifies a broadcast queue holding 180 packets (the default is 64), a maximum byte transmission rate of 128,000 bytes per second (default is 256,000), and a maximum packet transmission rate of 160 packets per second (default is 36).

```
Router(config-if)#fram broadcast-queue ?
  <1-65535>  Queue size for broadcasts

Router(config-if)#fram broadcast-queue 180 ?
  <1000-1000000>  Byte rate per sec. for broadcasts
    transmission

Router(config-if)#fram broadcast-queue 180 128000 ?
  <1-999>  Max. packets/S broadcasts transmission

Router(config-if)#fram broadcast-queue 180 128000 160
```

Novell Broadcasts If you're running Novell IPX over Frame Relay, you must configure SAP traffic to advertise NetWare services. The only problem is that both SAP and RIP transmitting from a Novell device by default every 60 seconds can cause some very real bandwidth problems. The answer lies in controlling all the SAP traffic—you can do that with:

- SAP filters created with special access lists
- SAP timers used to change the SAP and RIP timers
- Broadcast queues that impose a limit on the amount of bandwidth made available to a broadcast

OSPF

And then there's OSPF—no stranger to the cherished routing protocol pastime of broadcasting to say hello to a neighbor. Even though this isn't necessarily a bad thing, if it's not configured correctly, it can cause some serious problems on your Frame Relay network.

To configure OSPF to broadcast to neighboring routers through the Frame Relay cloud, you can either use the neighbor commands or just tell the whole Frame network that things have changed and now it supports routing and routed protocol broadcasts. Of course, telling your router that it's on a broadcast network is easier, but doing that comes with a price that's paid out of your throughput.

When running OSPF in its native environment (a nonbroadcast network), you can use the `neighbor` command to encapsulate the broadcasts in a Frame Relay packet.

You can assign a priority number to set the priority of the neighbor (the default is zero). If a neighbor doesn't respond, the poll interval sets the interval at which polls are sent until the neighbor comes online—the default is 120 seconds.

To set your routers to redefine the Frame Relay network as a broadcast network, use the `ip ospf` network command:

```
Router(config-if)#ip ospf ?
  authentication-key   Authentication password (key)
  cost                 Interface cost
  dead-interval        Interval after which a neighbor is
                         declared dead
  demand-circuit       OSPF demand circuit
  hello-interval       Time between HELLO packets
  message-digest-key   Message digest authentication
                         password (key)
  network              Network type
  priority             Router priority
  retransmit-interval  Time between retransmitting lost link
                         state
                       advertisements
  transmit-delay       Link state transmit delay
Router(config-if)#ip ospf network ?
  broadcast            Specify OSPF Type of Network
  non-broadcast        Specify OSPF Type of Network
  point-to-multipoint  Specify OSPF Type of Network
```

If you use the `broadcast` argument, it will establish the network as a broadcast network. The `non-broadcast` option will set the network back to the default, and the `point-to-multipoint` option configures a router interface to work in a multipoint network environment.

Frame Relay Switching

If you use the PVC switching feature, you can build an entire Frame Relay network using Cisco routers.

There are two parts to Frame Relay switching:

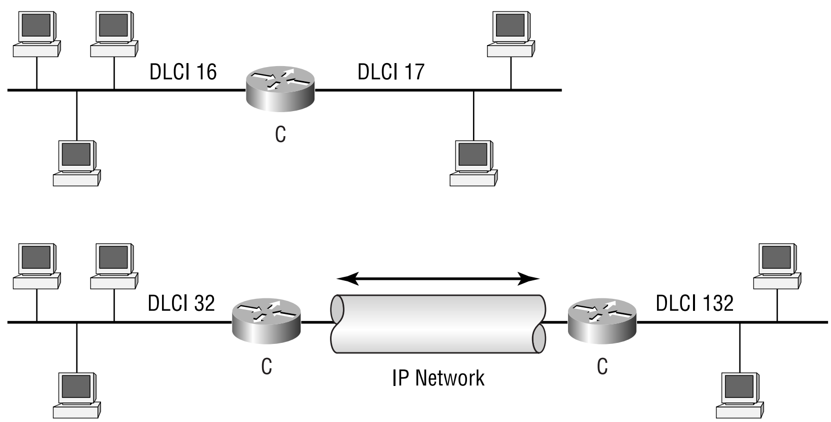
- Frame Relay DTE (router)
- Frame Relay DCE (switch)

Cisco allows for two types of frame switching:

- Local Frame Relay switching configures your router to forward Frame Relay frames based on the DLCI number in the frame's header.
- Remote Frame Relay switching enables the router to encapsulate frames in an IP packet, which is then tunneled across an IP backbone.

Figure 11.5 shows the two different types of Frame Relay switching configurable on a Cisco router.

FIGURE 11.5 Frame Relay switching



To configure a Cisco router for Frame Relay switching, you must follow the three steps below:

1. Enable Frame Relay switching.
2. Configure the DTE device, DCE switch, or Network-to-Network Interface (NNI) support.
3. Specify the static routes.

The following router configuration demonstrates how to configure Frame Relay switching.

```
Router(config)#frame-relay switching
Router(config)#int s0
Router(config-if)#frame-relay intf-type ?
  dce  Configure a FR DCE
  dte  Configure a FR DTE
  nni  Configure a FR NNI
Router(config-if)#frame-relay intf-type dce
Router(config-if)#frame-relay route ?
  <16-1007>  input dlci to be switched
Router(config-if)#frame-relay route 16 ?
  interface  outgoing interface for pvc switching
Router(config-if)#frame-relay route 16 int s1 ?
  <16-1007>  output dlci to use when switching
Router(config-if)#frame-relay route 16 int s1 39
```

X.25 Networks

X.25 was born in a different world from that of today's digital networks. Originally designed in the 1970s when circuits were both analog and noisy, X.25 is way over-built for today's needs.

It uses addressing defined by X.121, where addresses are between 1 and 14 decimal digits long. The first four bits are the DNIC (Data Network Identifier Code), and the remaining ones are free to be assigned by the administrator.

X.25 defines point-to-point communications between DTEs and DCEs. As mentioned earlier, DTE stands for data terminating equipment, and is usually a router of some sort; DCE stands for data circuit-terminating equipment, and is usually a modem or CSU/DSU. The DCE connects to the X.25 service provider's network with the ultimate goal of establishing a virtual circuit between two DTE devices. X.25 supports both switched and permanent virtual circuits.

Regardless of the type of system connected to the network, versatile X.25 works well. It's heavily used in the packet switched networks (PSNs) of telephone companies that charge their customers based on how much they use the network. So it makes sense that the development of the X.25 standard was begun by common carriers. In the 1970s, there was a need for WAN protocols that could provide connectivity across public data networks (PDNs), and X.25 is now administered as an international standard by the ITU-T.

X.25 network devices can typically be placed in one of three categories:

Data terminating equipment (DTE) End systems that communicate over an X.25 network, such as host systems, terminals, and PCs that belong to the individual subscriber, and are present at the same site.

Data circuit-terminating equipment (DCE) Specific communications equipment, such as modems and packet switches, that interface between a packet switching exchange (PSE) and DTE devices. They're typically found in carrier facilities.

Packet switching exchange (PSE) These switches constitute the majority of a carrier's network and handle the transfer of data between DTE devices via the X.25 packet switched network.

X.25 Sessions

X.25 sessions are established using the following process:

1. One DTE device contacts another requesting a communication session.
2. The receiving DTE device either accepts or refuses the connection.
3. If the request is accepted, the two systems begin full-duplex information transfer.
4. Either DTE device can terminate the connection.

After the session has been terminated, any further communication requires establishing a new session.

Virtual Circuits

Virtual circuits are logical, not physical, connections that are formed so that reliable communication between network devices can take place. A virtual circuit represents a logical, bi-directional path from one DTE device to another over an X.25 network. The connection can physically pass through *x* amount of transitional nodes like PSEs and DCE devices. Plus, a whole bunch of virtual circuits can be multiplexed onto one physical circuit, then demultiplexed at the remote end—the data are then sent to the proper destinations.

X.25 uses two types of virtual circuits.

SVC SVC stands for switched virtual circuit. An *SVC* is a temporary connection used for intermittent data transfers, and requires two DTE devices to establish, maintain, and then terminate a session every time they need to talk.

PVC PVCs (permanent virtual circuits) are established and used for recurrent, steady data transfer. Since they don't need sessions to be established and terminated, a DTE can transmit data whenever necessary—the session is already set up and active, and remains that way.

X.25 Protocol Suite

The X.25 protocol suite maps to the lower three layers—Physical through Network layers—of the OSI reference model. The following protocols are typically used in X.25 implementations:

- Packet Layer Protocol (PLP)
- Link Access Procedure, Balanced (LAPB)
- X.21bis and other Physical layer serial interfaces (such as EIA/TIA-232, EIA/TIA-449, EIA-530, G.703, and so forth)

Packet Layer Protocol The packet layer protocol (PLP) is X.25's Network layer protocol. It manages packet exchanges between DTE devices across virtual circuits, but PLP can also run over Logical Link Control 2 (LLC2) implementations on LANs, and Integrated Services Digital Network (ISDN) interfaces running Link Access Procedure on the D channel (LAPD).

Here are PLP's five modes of operation:

Call Setup mode Used to establish SVCs between DTE devices. To initially set up a virtual circuit, PLP uses X.121's addressing scheme. Different virtual circuits can be in different modes at the same time because Call Setup mode is deployed as individual virtual circuits require it. This mode is used only with SVCs, not with PVCs.

Data Transfer mode Used for data transfer between two DTE devices via a virtual circuit. Tasks such as segmentation, reassembly, bit padding, and error and flow control occur in this mode. Just like Call Setup mode, Data Transfer mode is also deployed on a per–virtual circuit basis, but unlike Call Setup, it's used with both SVCs and PVCs.

Idle mode Used when a virtual circuit is established, but no transfer of data occurs. It's deployed on a per–virtual circuit basis, and only with SVCs.

Call Clearing mode Used to terminate communication sessions between DTE devices as well as SVCs. It's also deployed on a per–virtual circuit basis, and only with SVCs.

Restarting mode Used to synchronize the transmission between a DCE device that's locally connected and a DTE device—tasks such as communication and packet framing between DTE and DCE devices happen here. Since it affects all the established virtual circuits of the DTE device, it isn't deployed on a per–virtual circuit basis.

LAPB LAPB's job is to make sure that frames are error free and properly sequenced, and it's a bit-oriented protocol. Below, we've listed the three different frame types of LAPB.

Information frames (I-frames) Transport upper-layer information and a bit (no pun intended) of control information. I-frames schlep both send and receive sequence numbers, and relate to jobs such as sequencing, flow control, error detection, and recovery.

Supervisory frames (S-frames) Bearing control information, S-frames handle both requesting and suspending transmissions, plus they report on status and acknowledge that I-frames have been received. S-frames only receive sequence numbers.

Unnumbered frames (U-frames) Also bearing control information, they handle things such as link setup and disconnection, and error reporting. U-frames don't schlep any sequence numbers at all.

X.21bis Used in X.25 at the physical layer, the X.21bis protocol specifies the electrical and mechanical processes for the use of the physical media. It oversees both activation and deactivation of whatever physical media connects the DTE and DCE devices. At a speed of up to 19.2Kbps, X21bis supports point-to-point connections and synchronous, full-duplex transmission over four-wire media.

X.25 on Cisco Routers

Cisco routers support X.25 encapsulation via the `encap x25` command, which you can apply while in Interface Configuration mode. There are many tuneable features with X.25, as shown below.

```
RouterA#config t
Enter configuration commands, one per line.  End with CNTL/Z.
RouterA(config)#int s0
RouterA(config-if)#encap x25
RouterA(config-if)#x25 ?
  accept-reverse             Accept all reverse charged calls
  address                    Set interface X.121 address
  alias                      Define an alias address pattern
  default                    Set protocol for calls with
                               unknown Call User Data
  facility                   Set explicit facilities for
                               originated calls
  hic                        Set highest incoming channel
  hoc                        Set highest outgoing channel
  hold-queue                 Set limit on packets queued per
                               circuit
  hold-vc-timer              Set time to prevent calls to a
                               failed destination
  htc                        Set highest two-way channel
  idle                       Set inactivity time before
                               clearing SVC
  ip-precedence              Open one virtual circuit for
                               each IP TOS
  ips                        Set default maximum input
                               packet size
  lic                        Set lowest incoming channel
  linkrestart                Restart when LAPB resets
  loc                        Set lowest outgoing channel
  ltc                        Set lowest two-way channel
  map                        Map protocol addresses to
                               X.121 address
  modulo                     Set operating standard
  nvc                        Set maximum VCs simultaneously
                               open to one host per protocol
```

```
  ops                        Set default maximum output
                               packet size
  pad-access                 Accept only PAD connections from
                               statically mapped X25 hosts
  pvc                        Configure a Permanent Virtual
                               Circuit
  suppress-called-address    Omit destination address in
                               outgoing calls
  suppress-calling-address   Omit source address in outgoing
                               calls
  t20                        Set DTE Restart Request
                               retransmission timer
  t21                        Set DTE Call Request
                               retransmission timer
  t22                        Set DTE Reset Request
                               retransmission timer
  t23                        Set DTE Clear Request
                               retransmission timer
  threshold                  Set packet count acknowledgement
                               threshold
  use-source-address         Use local source address for
                               forwarded calls
  win                        Set default input window
                               (maximum unacknowledged
                               packets)
  wout                       Set default output window
                               (maximum unacknowledged
                               packets)

RouterA(config-if)#
```

X.121 addresses aren't burned into ROM like LAN addresses, so you need to tell your Cisco router about the local X.121 address on an X.25 serial interface. However, if your router does not start or terminate X.25 calls, this is optional. You set the X.121 address with the `x25 address` command, as shown below.

```
RouterA(config)#int s0
RouterA(config-if)#x25 address ?
  X.121 Addr  X.121 address
RouterA(config-if)#x25 address 12345678
```

The default packet size of 128 bytes doesn't work with every vendor's implementation of X.25. But have no worries, you can configure your Cisco routers with the correct input packet size (IPS) and output packet size (OPS) with the commands `x25 ips` and `x25 ops`, as shown below.

```
RouterA(config-if)#x25 ips ?
  <16-4096>  Bytes (power of two)
RouterA(config-if)#x25 ips 256
RouterA(config-if)#x25 ops 256
```

Also, you might need to adjust your window size for packets that are used by flow control mechanisms. The default window size is two, but you can change this with `x25 win` (window input size) and `x25 wout` (window output size), as shown below.

```
RouterA(config-if)#x25 win ?
  <1-127>  Packets
RouterA(config-if)#x25 win 7
RouterA(config-if)#x25 wout 7
```

Cisco also supports the modulo, which sets the interface's data packet sequencing. Eight is the default. Use the `x25 modulo` command to set the number:

```
Router(config-if)#x25 modulo ?
  128  Packet numbering modulus
Packet numbering modulus
```

You can use the `x25 map` command to establish a static map between a Network layer protocol and the X.121 address used within the X.25 network. It will permit you to put in nine different addresses when configuring a single `x25 map` command:

```
Router(config-if)#x25 map ip ?
  A.B.C.D  Protocol specific address

Router(config-if)#x25 map ip 172.16.10.5 ?
  X.121 Addr     Destination host address
  appletalk      AppleTalk
  compressedtcp  Compressed TCP
  decnet         DECnet
  ip             IP
  ipx            Novell IPX
```

```
  qllc           qllc protocol

Router(config-if)#x25 map ip 172.16.10.5 ipx ?
  N.H.H.H  Protocol specific address

Router(config-if)#x25 map ip 172.16.10.5 ipx
  100.1234.1234.1234 ?
  X.121 Addr     Destination host address
  appletalk      AppleTalk
  compressedtcp  Compressed TCP
  decnet         DECnet
  ip             IP
  ipx            Novell IPX

Router(config-if)#x25 map ip 172.16.10.5 ipx
  100.1234.1234.1234 12345678 ?
  accept-reverse  Accepting incoming reverse-charged calls
  broadcast       Send broadcasts to this host
  compress        Specify Packet By Packet Compression
  cug             Specify a Closed User Group number
  idle            Specify VC idle timer
  method          Specify encapsulation method
  no-incoming     Do not use map for incoming Calls
  no-outgoing     Do not use map for outgoing Calls
  nudata          Specify user formatted network user ID
  nuid            Specify Cisco formatted network user ID
  nvc             Set number of virtual circuits for this
                    map
  packetsize      Request maximum packet sizes for
                    originated calls
  passive         Compress outgoing TCP packets only if
                    incoming TCP packets
                  are compressed
  reverse         Use reverse charging on originated calls
  rpoa            Specify RPOA
  throughput      Request bandwidth in X.25 network
  transit-delay   Specify transit delay (msec)
  windowsize      Request window sizes for originated calls
```

```
  <cr>

Router(config-if)#$172.16.10.5 ipx 100.1234.1234.1234
12345678 nvc 8
```

The `x25 nvc` command is used to set the maximum number (up to eight) of SVCs that a host or router can open.

The `x25 facilities` command forces optional fields on a per-call basis for calls initiated by the router interface:

```
Router(config-if)#x25 facility ?
  cug            Specify a Closed User Group number
  packetsize     Specify maximum packet sizes
  reverse        Use reverse charging on originated calls
  rpoa           Specify transit RPOA list in Call Requests
  throughput     Request bandwidth in X.25 network
  transit-delay  Specify maximum acceptable transit delay
  windowsize     Specify window sizes
```

OSPF

As with Frame Relay, you need to specifically configure X.25 for it to propagate OSPF broadcasts. Also as with Frame Relay, you can either configure X.25 to send encapsulated broadcasts to specified locations or configure the entire network as a broadcast network.

To configure X.25 to encapsulate the broadcasts and send them to a specific destination, use the `x25 map` command:

```
Router(config-if)#x25 map ?
  appletalk      AppleTalk
  bridge         Bridging
  cdp            Cisco Discovery Protocol
  compressedtcp  Compressed TCP
  decnet         DECnet
  ip             IP
  ipx            Novell IPX
  pad            PAD links
  qllc           qllc protocol
  qllc           qllc protocol
Router(config-if)#x25 map ip 172.16.10.1 ?
  X.121 Addr     Destination host address
```

```
  appletalk      AppleTalk
  compressedtcp  Compressed TCP
  decnet         DECnet
  ip             IP
  ipx            Novell IPX
  qllc           qllc protocol
Router(config-if)#x25 map ip 172.16.10.1 12345678 ?
  accept-reverse  Accepting incoming reverse-charged calls
  broadcast       Send broadcasts to this host
  compress        Specify Packet By Packet Compression
  cug             Specify a Closed User Group number
  idle            Specify VC idle timer
  method          Specify encapsulation method
  no-incoming     Do not use map for incoming Calls
  no-outgoing     Do not use map for outgoing Calls
  nudata          Specify user formatted network user ID
  nuid            Specify Cisco formatted network user ID
  nvc             Set number of virtual circuits for this
                    map
  packetsize      Request maximum packet sizes for
                    originated calls
  passive         Compress outgoing TCP packets only if
                    incoming TCP packets
                  are compressed
  reverse         Use reverse charging on originated calls
  rpoa            Specify RPOA
  throughput      Request bandwidth in X.25 network
  transit-delay   Specify transit delay (msec)
  windowsize      Request window sizes for originated calls
  <cr>
Router(config-if)#x25 map ip 172.16.10.1 12345678 broadcast
```

To make OSPF regard the network as a broadcast network, use the `ip ospf network` broadcast command. Doing this will save you a lot of work because you won't have to define all the neighbors. However, it will cost you in terms of throughput.

Here's the `ip ospf network` broadcast command in action:

```
Router(config-if)#ip ospf network ?
  broadcast            Specify OSPF Type of Network
  non-broadcast        Specify OSPF Type of Network
  point-to-multipoint  Specify OSPF Type of Network
```

The same split horizon–oriented problems that were mentioned in the Frame Relay section can also be the bane of the X.25 network. But have no worries—you can also use the subinterface strategy to solve this problem if you're using a partial mesh network.

Switching

You can locally route X.25 virtual circuits between serial ports on Cisco routers. You can create an X.25 switching environment by using static routing statements to map X.121 addresses to serial interfaces, and by using X.25-over-TCP (XOT) commands. This will enable X.25 interfaces to make SVC connections.

However, first you have to enable X.25 routing on the routers that you want to connect before adding your routes. Here is how to enable `x25 routing` and an `x25 route`:

```
Router(config)#x25 routing
Router(config)#x25 route ?
  #<number>  Optional positional parameter
  WORD       X.121 address pattern to match
```

Using the `x25 routing` command transforms the router into an X.25 router. The position value (if used) tells the router where to put this entry in the table. By default, it will be placed on the bottom, and read sequentially from top to bottom:

```
Router(config)#x25 route 20 ?
  alias              Treat the X.121 address as local
  cud                Called User Data pattern to match
  interface          Route to a local interface
  ip                 Route to a remote Cisco router
  substitute-dest    Specify destination rewrite pattern
  substitute-source  Specify source rewrite pattern

Router(config)#x25 route 20 cud ?
  WORD  CUD pattern to match
```

```
Router(config)#x25 route 20 cud ^pad$ int s0
Router(config)#x25 route 20 int s1
Router(config)#x25 route .* ip 172.16.10.10
```

Thus configured, the routing table will now forward all calls for X.121 address 20 out Interface s0. However, if the call doesn't match the call user data (CUD) string pad, it will be forwarded out Interface s1. The `x25 route .*` command tells the router to forward all calls that don't match the X.121 address 20 to IP address `172.16.10.10`.

SMDS Networks

Switched Multimegabit Data Service (SMDS) is a digital WAN service provided by Regional Bell Operating Companies (RBOCs) and MCI. SMDS is a connectionless cell-relay WAN topology that runs on top of a full-meshed fiber technology.

You need some special equipment to run SMDS:

- CSC-MCI or CSC-SCI serial interface controller cards, and an HSSI interface—or you can use the serial port on any Cisco router
- EIA/TIA-449 or V.25 applique on chassis-based systems, or EIA/TIA-449 transition cable on any Cisco router
- A special SMDS DSU (which costs a whole lot more than a normal DSU)
- Packet switched IOS software

SDSU

An SMDS Data Service Unit (SDSU) is used to encapsulate packets as they enter the cell network. Like ATM, SMDS uses fixed-size packets, which are 53 octets in size.

SMDS Addressing

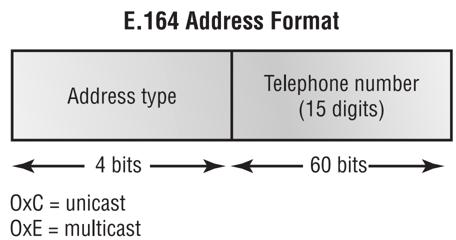
The service provider assigns SMDS addresses. Two different types of addresses can be used within your Cisco configuration:

E Multicast addresses used to broadcast a packet to multiple end points

C Unicast address for identifying individual network devices

These addresses are 64 bits (15 digits) long, with the first 4 bits representing the address type (E or C), and the other 60 representing the device address. Addresses in this format are known as E.164 addresses, and are depicted in Figure 11.6.

FIGURE 11.6
SMDS address format



Here's an example of an E.164 15-digit SMDS address:

```
C25266672424FFFF
```

The 60-bit device portion of the address is represented in binary-coded decimal (BCD) format. Each section of 4 bits represents a single telephone number digit and can be a value of up to 15 digits. Sometimes you may be assigned only 11 digits, in which case the last 4 will be occupied with ones as in the above example.

It's also possible to enter the address in Ethernet-style notation, as in the following example:

```
C252.6666.2323.FFFF
```

And a multicast address would look as follows:

```
E291.1000.9999.FFFF
```

Configuring SMDS

Your first step is to obtain your SMDS addresses from your service provider. Next, enable SMDS on your router interface(s).

You set the encapsulation method just as you do for Frame Relay, X.25, etc. Use the `encap smds` command, then add the SMDS address that will apply to the interface using the `smds address` command:

```
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
Router(config)#int s0
Router(config)#ip address 172.16.10.2 255.255.255.0
Router(config-if)#encap smds
Router(config-if)#smds ?
  address      Set an interface SMDS address
  dxi-mode     SMDS DXI3.2 mode
  enable-arp   Enable ARP processing
  glean-mode   SMDS GLEAN mode
  multicast    Set an SMDS multicast (or broadcast) address
  nec-mode     SMDS NEC mode
  static-map   Map high level protocol address to SMDS address
Router(config-if)#smds address C252.6666.2323.FFFF
```

SMDS routing tables are typically dynamic, but you can configure static tables by using the `smds static-map` command. This is important because you need to define static mappings if your routing protocols don't support dynamic routing.

Here's the `smds static-map` command in action:

```
Router(config-if)#smds static-map ?
  A.B.C.D    Protocol specific address
  appletalk  AppleTalk
  decnet     DECnet
  ip         IP
  ipx        Novell IPX
  pad        PAD links
Router(config-if)#smds static-map ip 172.16.10.1
C252.5678.3434.FFFF
```

Notice all the different protocols available for use. You also can add a broadcast argument at the end of the line to indicate whether broadcast traffic will be carried.

To map an SMDS group address to a multicast address used by higher-layer protocols (such as IP), use the `smds multicast` command:

```
Router(config-if)#smds multicast ?
  aarp                  AppleTalk ARP
  appletalk             AppleTalk
  arp                   IP ARP
  bridge                Bridging
```

```
  cdp                    Cisco Discovery Protocol
  decnet                 DECnet
  decnet_node            DECnet Node
  decnet_prime_router    DECnet Prime Router
  decnet_router-l1       DECnet Router L1
  decnet_router-l2       DECnet Router L2
  ip                     IP
  ipx                    Novell IPX
Router(config-if)#smds multicast ip E291.1000.1234.1243
  172.16.10.4 ?
  A.B.C.D  IP address mask
Router(config-if)#$ast ip E291.1000.1234.1243 172.16.10.4
  255.255.255.0
```

An additional approach is to enable dynamic Address Resolution Protocol (ARP) or use static ARP entries. To create a static entry, use the `arp` command. To enable dynamic ARP, use the `smds enable-arp` command:

```
Router(config-if)#smds enable-arp
```

You can enable dynamic address mapping when using IPX by using the `smds glean-mode ipx` command:

```
Router(config-if)#smds glean-mode ?
  ipx  Novell IPX
Router(config-if)#smds glean-mode ipx ?
  <1-65535>  TIMEOUT value (minutes)
  broadcast  Make SMDS address in dynamic maps a broadcast
    address
  <cr>
Router(config-if)#smds glean-mode ipx 10 broadcast
```

ATM Networks

Asynchronous Transmission Mode (ATM) is another cell-switching multiplexing technology that uses circuit-switching for constant transmission delay with guaranteed capacity, combined with packet-switching for flexibility and efficiency.

ATM is connection oriented, and employs virtual path identifiers (VPIs) and a virtual channel identifier (VCI) to create a single virtual circuit. This virtual circuit is a private connection between two devices on the network, meaning that each ATM device must make a separate connection between every device with which it needs to communicate.

Cisco supports the following hardware for ATM transmission (depending on router type):

- ATM interface processor (AIP)
- ATM port adapter (PA)
- ATM network processor module (NPM)

If you have a router that doesn't support any of the interfaces listed above, you can use a serial interface configured for multiprotocol encapsulation over the Asynchronous Transfer Mode Data Exchange Interface (ATM-DXI) instead.

The RFC supports two different methods for transporting multiprotocol connectionless network interconnect traffic over an ATM network:

- A single PVC
- Different VCs for each protocol used (e.g., IP, IPX, etc.)

Like SMDS, ATM uses a pricey and special DSU called an ADSU. This provides the ATM interface to the network, and converts outgoing packets into cells and incoming packets into packets. It is also responsible for deducing the DXI frame address (DFA) from the VPI and VCI running on each PVC.

Configuring ATM

To configure ATM, you must first assign the protocols you're going to run on it. If you're using a serial interface, assign ATM-DXI encapsulation by using the `encap atm-dxi` command:

```
Router(config)#int s0
Router(config-if)#ip address 172.16.10.1 255.255.255.0
Router(config-if)#ipx network 172abc
Router(config-if)#apple address 10.172
Router(config-if)#encap atm-dxi
```

If you're running multiple protocols, you'll need to set up a PVC for each one. You can do this via the `dxi pvc` command:

```
Router(config-if)#dxi pvc ?
  <0-15>  VPI
Router(config-if)#dxi pvc 1 ?
  <0-63>  VCI
Router(config-if)#dxi pvc 1 1 ?
  mux    MUX Encapsulation
  nlpid  NLPID Encapsulation
  snap   LLC/SNAP Encapsulation
  <cr>
Router(config-if)#dxi pvc 1 1 snap
Router(config-if)#dxi pvc 2 2 snap
Router(config-if)#dxi pvc 3 3 snap
```

The MUX option is used to specify that only one protocol will be carried on the PVC (remember—only one protocol is configured per PVC). The Subnetwork Access Protocol allows the LLC to read the protocols within each PVC.

NOTE

Network Layer Protocol Identification (NLPID) was used before LLC. SNAP is the default encapsulation starting in IOS 10.3. The default encapsulation was NLPID prior to 10.3.

To map ATM protocol addresses to VCIs and VPIs, use the `dxi map` command:

```
Router(config-if)#dxi map ?
  appletalk  AppleTalk
  bridge     Bridging
  decnet     DECnet
  ip         IP
  ipx        Novell IPX
  qllc       qllc protocol
  snapshot   Snapshot routing support
Router(config-if)#dxi map ip 172.16.10.5 ?
  <0-15>  VPI
```

```
Router(config-if)#dxi map ip 172.16.10.5 1 ?
  <0-63>  VCI
Router(config-if)#dxi map ip 172.16.10.5 1 1 ?
  broadcast  Broadcasts should be forwarded to this address
  <cr>
Router(config-if)#dxi map ip 172.16.10.5 1 1 broadcast
Router(config-if)#dxi map ipx 10.2345.2345.2345 2 2 broadcast
Router(config-if)#dxi map appletalk 10.172 3 3 broadcast
```

You must use the `map` command for each protocol.

Monitoring ATM on the ATM-DXI Interface

You can display the status of your serial interface, the PVC, and maps with the commands shown in Table 11.2.

TABLE 11.2 ATM Monitoring Commands

Command	Function
`sh int atm [slot/port]`	Displays the serial ATM interface status
`sh dxi pvc`	Displays the ATM-DXI PVC information
`sh dxi map`	Displays the ATM-DXI map information

Summary

In this chapter, the following points were covered:

- The common issues to be considered when evaluating a WAN service.

  Availability How the internetwork must stay working 24 hours a day.

  Bandwidth Accurately determining the actual and eventual bandwidth requirements with information gathered from both users and management.

  Cost Cisco offers an abundance of switches and routers tailored to many wallet sizes.

Ease of management The ramifications, such as the degree of difficulty associated with creating any network connections, must be understood and regarded carefully.

Type of application traffic This can be typically comprised of small to very large packets.

Routing protocols The characteristics of these protocols must be understood and then configured properly.

- The differences between WAN connection types: dedicated, asynchronous dial-in, dial-on-demand, and packet switched services. Dedicated point-to-point serial links are dedicated links that provide full-time connectivity. Cisco answers the asynchronous need by providing a variety of asynchronous dial-in products, such as the AS5200 access server. DDR (dial-on-demand routing) allows wide area links to be used selectively. We also found out how PSN data delivery can take place within frames, packets, or cells, and how that occurs transparently to end users.
- Cisco's main packet switching network types: Frame Relay, X.25, SMDS, and ATM.

Review Questions

1. What encapsulation method would you use to configure ATM on a serial port?

    A. ATM-Serial

    B. HDLC

    C. ATM-DXI

    D. ATM

2. When would it be necessary to prioritize DLCI traffic?

    A. When bandwidth is at a premium

    B. When you have traffic from sites with high-speed access being queued at destination sites with lower-speed access

    C. When running X.25 at remote locations

    D. When you need to prioritize queues

3. Which command would you use to assign protocol traffic that would match the specified parameters to a priority queue?

    A. `queue`

    B. `protocol queue`

    C. `priority-queue`

    D. `priority-list`

4. For which of the following is X.21bis used?
   A. Frame Relay 56Kbps lines
   B. Frame types used in X.25
   C. X.25 Physical layer specifications
   D. PLP Call Setup mode

5. How many Frame Relay encapsulation methods are used with Cisco routers?
   A. Two
   B. Three
   C. Four
   D. Five

6. How many LMI types are supported?
   A. Two
   B. Three
   C. Four
   D. Five

7. Which of the following is true about LMI?
   A. LMIs map DLCI numbers to virtual circuits
   B. LMIs map X.121 addresses to virtual circuits
   C. LMIs report the status of virtual circuits
   D. LMI messages provide information about the current DLCI values

8. What are X.121 addresses used for?

   A. Mapping DLCI addresses to logical interfaces

   B. Mapping X.25 addresses to logical hardware addresses

   C. Receiving LMI messages

   D. Providing information about the current DLCI values

9. Which of the following commands will define access list 10 to use a high-priority queue?

   A. `frame priority-dlci-group 10`

   B. `access-list 10 permit eq high`

   C. `priority-list 10 protocol ip high list 5`

   D. `priority-list 5 protocol ip high list 10`

10. What is a disadvantage to having point-to-point connections?

   A. A point-to-point connection requires that tariffs be paid even when the connection is in an idle state and no data are being transmitted

   B. A point-to-point connection requires users to dial the connection manually when data need to be transmitted

   C. A point-to-point connection requires interesting traffic to be defined on the router with access lists when data need to be transmitted

   D. A point-to-point connection requires a lease through an ISP using a point-to-point routing protocol

11. What command do you use to set the LMI polling and timer intervals?

A. `frame-relay n39x-lmi`

B. `frame-relay lmi-xn39`

C. `frame-relay lmi-n39x`

D. `frame-relay lmi-x39n`

12. How do you configure OSPF to broadcast to other routers through the Frame Relay cloud?

A. By creating subinterfaces

B. IARP

C. By mapping X.121 addresses

D. With the `neighbor` command

13. What command would you use to create a queue so that Frame Relay has a place to hold broadcast traffic?

A. `frame-relay queue 16 eq broadcast`

B. `frame-relay broadcast-queue`

C. `frame-relay broadcast 16 eq queue 16`

D. `frame-relay queue 1 low 16 broadcast 16`

14. What command should you use to set your routers to redefine the Frame Relay network as an OSPF broadcast network?

A. `ip ospf network`

B. `ip ospf broadcast`

C. `network ospf broadcast all`

D. `network ospf broadcast` *`network number`*

15. What are the two parts of Frame Relay switching?

A. Frame Relay DTE (switch)

B. Frame Relay DTE (router)

C. Frame Relay DCE (router)

D. Frame Relay DCE (switch)

16. What are the two types of frame switching?

A. Local

B. Remote

C. Standby

D. Cut-through

17. What is the solution for using partial meshed Frame Relay networks with split-horizon protocols?

A. DLCI addressing

B. X.121 addresses

C. Secondary Ethernet interfaces

D. Subinterfaces

18. What are the three types of LMI methods used by Cisco routers?

A. Cisco

B. ANSI

C. IETF

D. q933a

19. What is IARP used for?

- **A.** Mapping X.121 addresses to X.25 addresses
- **B.** Mapping DLCIs to network protocol addresses
- **C.** SMDS addressing
- **D.** Mapping ATM addresses to virtual addresses

20. Which two of the following are true regarding SMDS addressing?

- **A.** E: multicast addresses
- **B.** E: unicast addresses
- **C.** C: unicast addresses
- **D.** C: multicast addresses