



# 17

## ISDN

### CERTIFICATION OBJECTIVES

- |       |                               |       |                         |
|-------|-------------------------------|-------|-------------------------|
| 17.01 | ISDN Introduction             | 17.04 | Dialer Profiles and DDR |
| 17.02 | ISDN Interface Configuration  | ✓     | Two-Minute Drill        |
| 17.03 | Legacy Dial-on-Demand Routing | Q&A   | Self Test               |

Chapter 15 introduced you to wide area networks and the first type of WAN connection: leased lines using HDLC and PPP. Chapter 16 introduced you to the second type of WAN connection: packet-switched connections using Frame Relay. This chapter introduces you to the third type of WAN connection: circuit-switched connections. Circuit-switched connections include analog and digital dialup connections. Analog connections use modems, while digital connections use ISDN and ISDN hardware for dialup connections. This chapter solely focuses on using ISDN for dialup. The hardware configurations for analog connections are different than for ISDN; however, the actual dialup commands are the same. Analog dialup is not covered in this book but is covered on Cisco's CCNP Remote Access exam.

## CERTIFICATION OBJECTIVE 17.01

### ISDN Introduction

The Integrated Services Digital Network (ISDN) is a group of standards that define how voice and data connections can be dynamically set up across digital circuits. Because ISDN uses digital circuits, it has the following advantages over analog connections:

- *ISDN sets up calls faster* Analog takes 30–60 seconds to complete a call, while ISDN takes only second or two.
- *ISDN has a guaranteed data rate* Analog provides no guarantee for bandwidth on a connection, whereas ISDN guarantees 64 Kbps for each connection.
- *ISDN is more suitable to handle different types of services* Analog is not good at handling a mixture of voice, video, and data connections, whereas ISDN is.

#### exam

##### Watch

***ISDN is a better technology than analog modem dialup connections because of a faster setup time, guaranteed data rates, and multiple services are handled better.***

This section discusses the types of connection used for ISDN as well as the standards ISDN uses to initiate phone connections. Out of all of the chapters in this book, as you will see, this chapter has the most acronyms, making it harder to learn.

## ISDN Connections

Before I begin discussing ISDN itself, I first want to discuss the properties of the connection that ISDN uses. ISDN is a channelized service. *Channelized* services use a process called *time division multiplexing (TDM)* to create many logical channels on a single piece of wire. A channel is often referred to as a *time slot*.

Each channel, or time slot, is given its own amount of bandwidth and time on the wire, as is depicted in Figure 17-1. As you can see from the physical view of this figure, each channel is not simultaneously transmitting its information along with other channels. Instead, each channel must take its own turn in sending a small bit of information. All channels are given the same amount of bandwidth and time, and once all of the channels are given their chance to send information, the first channel

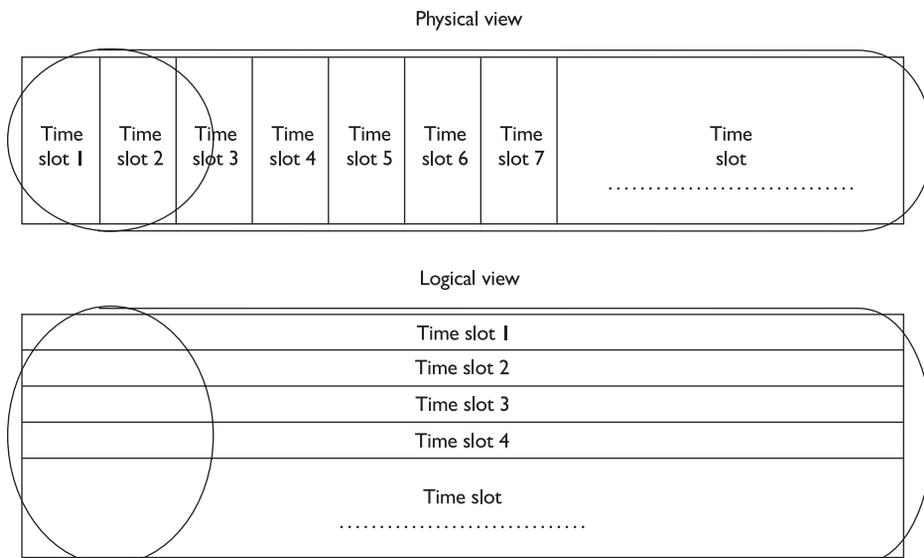
begins again. Even if a channel doesn't have anything to send, a string of zeros are sent. The bottom part of Figure 17-1 shows a logical view of a TDM connection. From a user's perspective, it looks as if all channels are transmitting simultaneously.

**exam**  
**Watch** Know the terms defined in Table 17-1.

Table 17-1 has some common terms used when referring to channelized connections.

**FIGURE 17-1**

Physical and logical views of a TDM connection



## 4 Chapter 17: ISDN

**TABLE 17-1** Channelized Connection Terms

Term	Definition
DS0	Is the smallest type of channelized connection, representing 64 Kbps. Each channel in Figure 17-1 is a DS0.
DS1	Is a group of channelized connections. There are two basic types of DS1s: T1 and E1.
T1	Is a group of 24 DS0s that is common in North America. With its overhead, it has a clock rate of 1.544 Mbps.
E1	Is a group of 32 DS0s that is common in Europe. It has a clock rate of 2.048 Mbps.

ISDN supports two types of connections: Basic Rate Interface (BRI) and Primary Rate Interface (PRI). A BRI connection is somewhat of a fractional T1/E1 connection.

PRIs are supported across both T1 and E1 connections. Table 17-2 compares the three different types of connections.

An ISDN BRI contains a total of 3 DS0s for 192 Kbps of bandwidth. Two DS0s, called bearer channels, are used to make phone calls for voice, video, and data connections. The signaling channel contains one DS0 and is broken into two components: 16 Kbps is used for signaling

information (setting up and tearing down circuit-switched connections), and 48 Kbps is used for frame synchronization, clocking, and physical layer framing.

There are two types of ISDN PRI connections: one for T1s and one for E1s. The PRI T1 uses 23 DS0s as bearer channels and 1 DS0 for signaling. The framing, clocking, and synchronization are built into the T1 frame structure and do not require a separate DS0 for these functions. A PRI E1 has a total of 32 channels, of which 30 DS0s are bearer channels; 1 DS0 is used for signaling; and 1 DS0 is used for framing, synchronization, and clocking.

**exam**

**Watch**

**Definitely remember the information in Table 17-2. Each bearer channel, which is used for phone connections, only has 64 Kbps of bandwidth.**

**TABLE 17-2**

ISDN Connection Types

Connection	Bearer Channel	Signaling Channel	Total Bandwidth
BRI	2 DS0s	1 DS0	192 Kbps
PRI T1	23 DS0s	1 DS0	1.544 Mbps
PRI E1	30 DS0s	2 DS0s	2.048 Mbps

## ISDN Standards

It is difficult to learn how ISDN operates, in part because it is not a single standard, but a group of many different standards that work together to provide digital circuit-switched connections. Work on these standards began in the 1960s and was formally standardized in the early 1980s. ITU-T is responsible for developing and maintaining these standards, shown in Table 17-3.

**exam**

**Watch**

**Q.921 is the signaling protocol used at layer-2 for the ISDN switch and the router (or other device) to communicate with each other. LAPD is the framing protocol used,**

**which is based on ISO's HDLC frame format. Q.931 is the layer-3 protocol used to set up and tear down phone connections between ISDN end-point devices, such as routers.**

One of the problems, sometimes, with ITU-T standards is that the standard is not exact in its description. For example, the Q series of standards that define how your device interoperates with the ISDN switch are not specific in how the interaction should occur. Therefore, many different types of ISDN switches exist with different flavors of the Q series of standards. To accommodate these different implementations, Cisco routers allow you to configure the switch type that you are connected to. This

**TABLE 17-3** ISDN Standards

Type	Standard	Definition
Telephone standards	E.163	Defines the International telephone numbering plan
	E.164	Defines the International ISDN addressing
Terms, concepts, and interfaces	I.100	Defines the ISDN terms and concepts
	I.400	Defines the User-Network Interface (UNI) and its components
Signaling	Q.921	Defines Link Access Procedure on the D channel (LAPD), which is responsible for the data link layer (layer-2) connection between the router and the ISDN switch
	Q.931	Defines the network layer signaling (layer-3) used to set up and tear down phone connections

allows you to use the signaling protocol that your switch supports. As you will see later on in this chapter, this is one of the ISDN components that you must configure on your router.

## Functional Groups and Reference Points

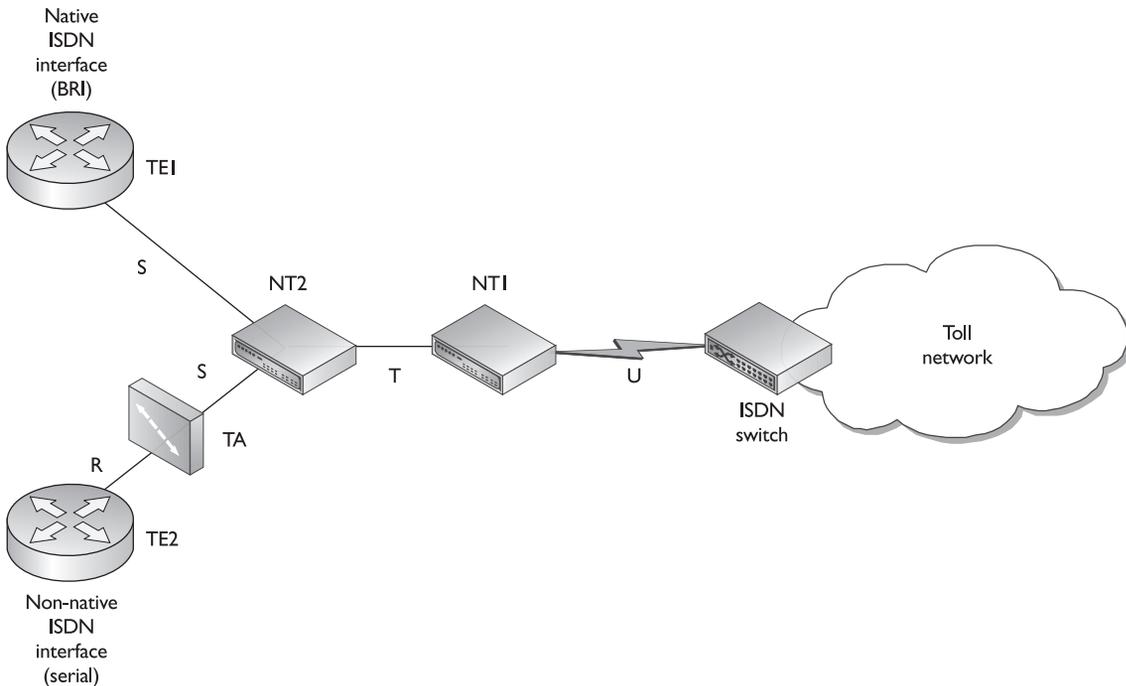
To help simplify the process for implementing ISDN, ITU-T's I standards define the ISDN components and relationships between the components. The components are called *function groups*. *Reference points* define the relationships between the components. The function groups and reference points can be seen in Figure 17-2. Table 17-4 defines the function groups found in Figure 17-2. Table 17-5 defines the reference points.

Figure 17-2 and Tables 17-4 and 17-5 give a nice logical description of the components and

**exam**

**Watch** Remember the function groups and reference points information in Tables 17-4 and 17-5 when preparing for the exam.

**FIGURE 17-2** ISDN function groups and reference points



**TABLE 17-4** ISDN Function Groups

Function Group	Definition
TE1 (Terminal Equipment 1)	Is an ISDN device with a native ISDN interface (such as a router with a BRI interface) that connects to an NT1 or NT2.
TE2 (Terminal Equipment 2)	Is an ISDN device with a non-native ISDN interface (such as a router with a serial interface) used for ISDN connectivity
TA (Terminal Adapter)	Connects a TE2 (non-native ISDN) to an NT2 or NT1
NT2 (Network Termination 2)	Connects multiple ISDN devices together, similar to a hub in Ethernet (the NT1 and NT2 are typically in the <i>same</i> physical chassis)
NT1 (Network Termination 1)	Connects your ISDN devices to the carrier network (converts ISDN four-wire connection to the carrier's two-wire connection)
LE (Local Exchange)	Provides a boundary between an NT1 located at the customer's site and the phone company's circuit-switched network. Note that this is not a physical device, but the phone company's network.

their interaction. In real life, however, ISDN isn't laid out so nice and neat. Let's look at a few examples to illustrate the physical connections that Cisco routers use for ISDN.

Cisco supports three types of BRI connections for their routers:

- Native ISDN interfaces with a built-in NT1
- Native ISDN interfaces without a built-in NT1
- Serial interfaces with an external terminal adapter and NT1

Cisco also supports two types of PRI connections for their routers:

- Native ISDN interfaces with an integrated CSU/DSU
- Native ISDN interfaces without an integrated CSU/DSU

**TABLE 17-5**

ISDN Reference Points

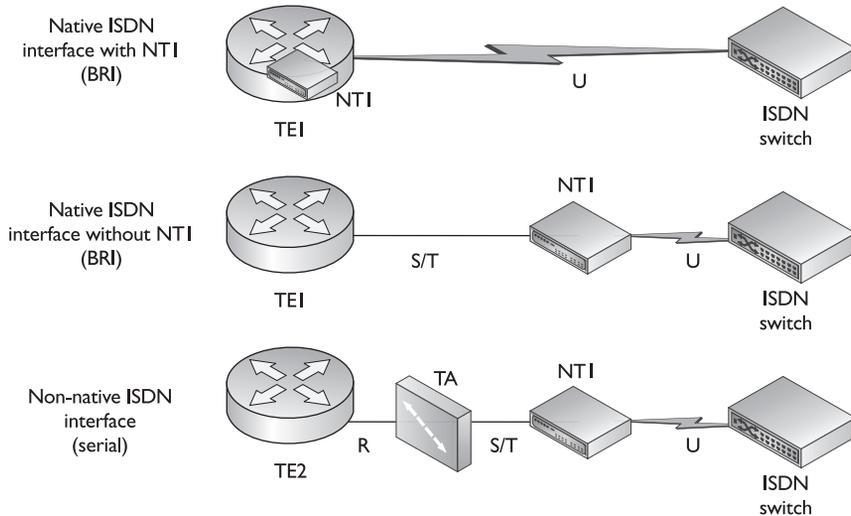
Reference Point	Definition
U	Defines the connection between an NT1 and an LE
T	Defines the connection between an NT2 and an NT1
S	Defines the connection between a TA/TE1 and an NT2
R	Defines the connection between a TE2 and a TA

The top part of Figure 17-3 shows an example of a router with a BRI interface and a built-in NT1. The S and T reference points are in the chassis of the router, and the R reference point is not included, since this is a native ISDN interface. The U reference point connects the router to the carrier. If you had a Cisco router with this type of interface, it would be labeled U. For a PRI U interface, the CSU/DSU is built into the PRI controller card.

The middle part of Figure 17-3 shows an example of a router with a BRI interface, but an external NT1. On a Cisco router, the BRI interface would be labeled S/T. In this situation, you would need to purchase an external NT1 device. The cable you would use would be UTP, with RJ-45 connectors. Here are the pinouts of this eight-pin cable: 1–2 unused, 3 TX+, 4 RX+, 5 RX–, 6 TX–, 7–8 unused. If you have a PRI S/T interface, CSU/DSU is not built into the physical interface: you will need to purchase this.

The bottom part of Figure 17-3 shows an example of a router with a serial interface that is used for an ISDN connection. By default, a serial interface doesn't understand an ISDN connection. A TA adapts the connection from an NT1 so that the serial interface can deal with ISDN. Typically, you would use a serial cable, such as an EIA/TIA-232, EIA/TIA-449, V.35, or X.21 cable, to connect the serial interface of the TA. Since this is a non-native interface, the R reference point defines the function between the router and the TA.

**FIGURE 17-3**  
BRI router connections



## CERTIFICATION OBJECTIVE 17.02

# ISDN Interface Configuration

Now that you have a basic understanding of the reference points and function groups of ISDN, let's talk about some of the basic ISDN configuration tasks you'll need to perform in order to interface your router with the ISDN switch. To initialize the connection between your router and the ISDN switch, you'll need to perform the following three steps:

1. Set up the ISDN switch type that the ISDN switch is using.
2. Optionally, specify the SPID or SPIDs (Service Profile Identifier) your carrier assigns to your BRI bearer (B) channels.
3. Verify your ISDN connection.

## Switch Types

One of the first things you need to do is configure the ISDN switch type that your router is connected to. This can be configured at the *Global Configuration* or *Interface Subconfiguration* mode. If you define it globally, all of your ISDN interfaces will use the same switch type. You can override this on an interface-by-interface basis by configuring the switch type on a specific interface. Here is the configuration:

```
Router(config)# isdn switch-type ISDN_switch_type
-or-
Router(config-if)# isdn switch-type ISDN_switch_type
```

Prior to IOS 12.0, you could configure the switch type only globally. Starting in IOS 12.0, you can configure it at either location. Table 17-6 lists the ISDN switch

types you can configure. Note that you must configure the correct switch type in order for your ISDN connection to function. In some cases, your provider might use one type of switch hardware but emulate a different switch type in software—you'll need to know what switch type the switch is emulating.

### exam

#### Watch

*The `isdn switch-type` command can be used at Global or Interface Configuration mode. A switch type configured at Interface Subconfiguration mode overrides the global setting.*

**TABLE 17-6**  
ISDN Switch  
Type Parameters

Parameter	Connection	Description
<b>basic-5ess</b>	BRI	AT&T switch (used in North America)
<b>basic-dms100</b>	BRI	Nortel DMS-100 switch (used in North America)
<b>basic-ni1</b>	BRI	National ISDN 1 (used in North America)
<b>basic-ni2</b>	BRI	National ISDN 2 (used in North America)
<b>basic-1tr6</b>	BRI	(Germany)
<b>basic-net3</b>	BRI	(UK and parts of Europe)
<b>basic-nwnet3</b>	BRI	(Norway)
<b>basic-nznet3</b>	BRI	(New Zealand)
<b>basic-ts013</b>	BRI	TS013 and TS014 switches (Australia)
<b>ntt</b>	BRI	(Japan)
<b>vn2</b>	BRI	(France)
<b>vn3</b>	BRI	(France)
<b>vn4</b>	BRI	(France)
<b>vn5</b>	BRI	(France)
<b>pri-4ess</b>	PRI	AT&T switch (U.S.)
<b>pri-5ess</b>	PRI	AT&T switch (U.S.)
<b>pri-dms100</b>	PRI	NT switch (North America)
<b>pri-nt</b>	PRI	(Japan)
<b>pri-net5</b>	PRI	(Europe)

## ISDN SPIDs

Service Profile IDs (SPIDs) are sometimes used by carriers on BRI connections that have a National ISDN-1 or Nortel DMS-100 switch. Because these two switches are typically used in North America, you will probably not have to worry about SPIDs from carriers elsewhere. SPIDs are used by the carrier to authenticate call requests and are used only on the local connection between your router and the ISDN switch. In this sense, they're like DLCIs—locally significant.

Based on the carrier's setup, you might be required to configure one or two SPIDs for your bearer channels before any type of phone call can be made by your router. Use the following configuration to define your SPIDs:

```
Router(config)# interface bri [slot_#/]port#
Router(config-if)# isdn spid1 spid_#_for_1st_BRI local_dial_#
Router(config-if)# isdn spid2 spid_#_for_2nd_BRI local_dial_#
```

SPID1 is for the first B-channel (B is short for bearer), and SPID2 is for the second B-channel. This number is normally your ten-digit telephone number plus some extra identifying digits. The local dial number is normally your seven-digit phone number (the three-digit local exchange number plus the four digits of your phone number). Your carrier will tell you whether you have to configure SPIDs or not and what you need to configure.

## exam

### Watch

*Use the `isdn spid1/spid2` commands to assign SPIDs for National ISDN-I and Nortel DMS-100 switches.*



**17.01.** The CD contains a multimedia demonstration of configuring the ISDN switch type and SPIDs on a router.

## PRI Commands

If you have a PRI interface, you'll need to configure some additional parameters before you can start making phone calls. After you have defined the ISDN switch type, you'll next need to configure the T1/E1 controller card and the serial interface associated with the controller card. The following two sections will show you the necessary configuration for your PRI connection.

### Controller Card Configuration

Use the following configuration to set up your T1 or E1 PRI controller card:

```
Router(config)# controller t1|e1 [slot_#/]port_#
Router(config-controller)# framing esf|sf|crc4|nocrc4
Router(config-controller)# linecode ami|b8zs|hdb3
Router(config-controller)# clock source line
                        primary|secondary|internal
Router(config-controller)# pri-group timeslots [1-24|1-31]
Router(config-controller)# [no] shutdown
```

The physical framing used on the T1 or E1 is configured with the **framing** command. If you are configuring a T1 in North America, you'll typically use **esf** (Extended Super Frame); an E1 typically uses **crc4**. Following this is the line coding, which defines how 1's and 0's are physically represented on the wire. T1s typically use **b8zs**, and E1s use **hdb3**.

The **clock source** command defines how the router will acquire its clocking for synchronous digital connections. **primary** tells the router that the router will acquire clocking information from this line. **secondary** tells the router to use this interface as a backup source for acquiring the clocking. **internal** tells the router that it will provide clocking on the wire to the carrier—normally you don't use this third parameter in a production environment.

The **pri-group timeslots** command tells your router which time slot or time slots are going to be used for ISDN connections. You can purchase a fraction of the time slots if you don't need the full number of channels on a T1 or E1. This command tells the router which ones you are, and are not, using. Use the **shutdown** command to disable or enable the controller.

Here's a simple example of a router's configuration for a T1 PRI:

```
Router(config)# controller t1 0/0
Router(config-controller)# framing esf
Router(config-controller)# linecode b8zs
Router(config-controller)# clock source line primary
Router(config-controller)# pri-group timeslots 1-24
Router(config-controller)# no shutdown
```

Use the following command to verify the configuration of your controller card:

```
Router# show controllers t1|e1 [slot_#/port_#]
```

Here's an example:

```
Router# show controller t1 0
T1 0 is up.
  No alarms detected.
  Framing is ESF, Line Code is B8ZS, Clock Source is Line Primary.

  Version Info of slot 2:  HW: 2, Firmware: 14, NEAT PLD: 13,
  NR Bus PLD: 19
  Data in current interval (476 seconds elapsed):
    0 Line Code Violations, 0 Path Code Violations
<--output omitted-->
```

Notice the first few lines of the display. In the first line, the physical layer is up. In the second line, no alarms are detected (the bottom part of the display shows the error statistics). The third line shows the configuration: the framing is ESF, line coding is B8ZS, and this line is the primary clock source.

### Serial Interface Configuration

Once you have set up your T1 or E1 controller card, you can now proceed with the configuration of your serial interface. Actually, the configuration is not done on a *physical* serial interface, but a logical one that corresponds to the PRI-grouped time slots you created with the **pri-group timeslots** command. The main function of this interface is to tell the router which DS0 is being used as the D-channel (signaling). Use one of these two commands to set up the logical serial interface:

```
Router(config)# interface serial [slot_#/]port_#:23
Router(config)# interface serial [slot_#/]port_#:15
```

Use the same slot and port numbers that you used for the controller card configuration. Use the **23** parameter for a T1—this indicates that the last time slot is used for signaling. Use the **15** parameter for an E1—this indicates that the fourteenth time slot is used for signaling. Once you have created your logical serial interface, any dialup, encapsulation, or addressing commands, such as **encapsulation ppp** or **ip address**, are configured on the *logical* serial interface.



**17.02. The CD contains a multimedia demonstration of configuring an ISDN PRI controller card and creating a logical ISDN PRI serial interface on a router.**

## exam

### Watch

Use the *controller* command to access your T1 or E1 controller for a PRI. The *pri-group* command specifies which DS0s the carrier has activated. To specify the

*signaling channel*, use the *interface serial* command followed by the slot and port of the controller card, and then a colon and either 23 for a T1 or 15 for an E1.

## Verifying Connections

Now that you have set up ISDN connectivity from your router to the ISDN switch, you will want to verify whether or not your router is communicating with the switch at both the physical and data link layers. Remember that the ITU-T Q.921 standard is used for communications at the data link layer. Here are the three commands that you'll use to verify that these two layers are functioning: **show interfaces**, **show isdn status**, and **debug isdn q921**. The following sections cover the use of these three commands.

### The **show interfaces** Command

You have used the **show interfaces** command throughout this book to verify the status of the physical and data link layers. You can also use this command to verify the status of your ISDN connection:

```
Router# show interface bri [slot_#/]port_#[[:1|2]
```

The **1** or **2** at the end of the command allows you to specify which B-channel you want to see. To view both B-channels, use this syntax:

```
Router# show interface bri [slot_#/]port_# 1 2
```

Here is an example of viewing the status of the first B-channel:

```
Router# show interface bri 0:1  
BRI0:1 is up, line protocol is up  
Hardware is BRI with U interface and external S bus interface  
MTU 1500 bytes, BW 64 Kbit, DLY 20000 usec, rely 255/255,  
    load 3/255  
Encapsulation PPP, loopback not set, keepalive set (10 sec)  
LCP Open, multilink Open  
<--output omitted-->
```



***17.03. The CD contains a multimedia demonstration of using the **show interfaces bri** command on a router.***

### The **show isdn status** Command

The **show isdn status** command gives you more detailed information about the status of the physical and data link layers than the **show interfaces** command:

```

Router# show isdn status
The current ISDN Switchtype = basic-ni1
ISDN BRI0 interface
  Layer 1 Status:
    ACTIVE
  Layer 2 Status:
    TEI = 64, State = MULTIPLE_FRAME_ESTABLISHED
    TEI = 65, State = MULTIPLE_FRAME_ESTABLISHED
  Spid status
TEI 64, ces = 1, state = 8 (established)
  Spid1 configured, spid1 sent, spid1 valid
Endpoint ID Info: epsf = 0, usid = 70, tid = 1
TEI 65, ces = 2, state = 8 (established)
  Spid1 configured, spid1 sent, spid1 valid
Endpoint ID Info: epsf = 0, usid = 70, tid = 2
  Layer 3 Status:
    No Active Layer 3 Call(s)
    Activated dsl 0 CCBs = 0
    Total Allocated ISDN CCBs = 0

```

In this example, layer 1 is ACTIVE. If there were a problem with the physical layer, it would say DEACTIVATED. To troubleshoot layer-1 problems, check the following:

- Check your cable and make sure the interface was activated with **no shutdown**.
- Call the carrier and verify that they have enabled their interface.

For layer-2 problems, you will see NOT Activated instead of actual TEI numbers if there is a problem. For an operational data link layer connection, you should see MULTIPLE\_FRAME\_ESTABLISHED as the state. If there is a problem with the data link layer, check the following:

## exam

### Watch

**Use the `show isdn status` command to verify your data link connection to the carrier's switch. Look for a `MULTIPLE_FRAME_ESTABLISHED` state.**

- Verify that you have configured the correct ISDN switch type.
- If you are using SPIDs, verify their configuration.

The layer 3 status refers to whether or not there are any phone connections that are active. In this example, there are none.



**17.04.** The CD contains a multimedia demonstration of using the `show isdn status` command on a router.

### The `debug isdn q921` Command

Use the `debug isdn q921` command for more detailed troubleshooting of the data link layer:

```
Router# debug isdn q921
May 23 11:19:12.106: ISDN BR0: TX -> RRp sapi = 0   tei = 64 nr = 0
May 23 11:19:12.122: ISDN BR0: RX <- RRF sapi = 0   tei = 64 nr = 2
```

In this example, you should see your router sending (TX) Q.921 frames to the switch and the switch's (RX). If you are seeing your router sending these frames but not receiving any responses back, check the switch type that you configured as well as your SPID values.



**17.05.** The CD contains a multimedia demonstration of using the `debug isdn q921` command on a router.

## EXERCISE 17-1



### Configuring ISDN Switch Connectivity

The last section dealt with setting up the ISDN connection between a Cisco router and a carrier's ISDN switch. This exercise will help you reinforce this material by configuring ISDN connectivity. You'll perform this lab using Boson's NetSim™ simulator. This exercise has you first set static routes two routers (2600 and 2500) and verify network connectivity. Following this, you'll configure your ACL. You can find a picture of the network diagram for Boson's NetSim™ simulator in the Introduction of this book. After starting up the simulator, click on the *LabNavigator* button. Next, double-click on *Exercise 17-1* and click on the *Load Lab* button. This will load the lab configuration based on Chapter 5's and 7's exercises. The switch type used is Nortel DMS-100, and the two SPIDs are 4075551212 and 4075551213.

1. On the 2600 router, disable both the `serial0` and `serial1` interfaces. Verify your configuration.

At the top of the simulator in the menu bar, click on the *eRouters* icon and choose 2600. Disable the interfaces: **configure terminal, interface serial0, shutdown, exit, interface serial1, shutdown**, and

**end.** Verify the status of the serial interfaces: **show interface s0** and **show interface s1**. Make sure that they have been administratively disabled.

2. On 2600 router, set the ISDN switch type. Set up the two SPIDs. Verify your configuration.

On the 2600, set the ISDN switch type: **configure terminal** and **isdn switch-type basic-dms100**. Enter the BRI interface: **interface bri 0**. Assign your first SPID: **isdn spid1 4075551212**. Assign your second SPID: **isdn spid2 4075551213**. Enable the interface: **no shutdown**. Exit Configuration mode: **end**. View the status of the interface: **show interface bri 0**. The physical *and* data link layer should be up. Use the **show isdn status** command and check the Layer 2 Status, which should be `MULTIPLE_FRAME_ESTABLISHED`.

You should now be more comfortable with establishing ISDN connectivity to a carrier's ISDN switch.

## CERTIFICATION OBJECTIVE 17.03

### Legacy Dial-on-Demand Routing

The last section dealt with just the connection between the router and the ISDN switch (Q.921). The next two sections deal with how to have your router use its ISDN interface

#### exam

##### Watch

**DDR is best suited for the following areas: backing up a primary WAN connection; traffic that is low volume and periodic; or phone calls that are short and temporary.**

to establish a phone connection that can be used to transport data. Cisco uses the Dial-on-Demand Routing (DDR) feature to trigger phone calls, analog or digital, when it has *interesting* traffic to send to a remote destination. Interesting traffic is traffic that you define as important enough for the router to make a phone call. For example, you might not want ICMP to trigger a phone call, but telnet or FTP. Or perhaps traffic from particular

subnet should trigger a phone call. As you will see, you have a lot of flexibility in defining what is interesting and what is not.

Because the phone call the router is making might incur a toll charge, or a per-minute charge, you don't want your router to make unnecessary phone calls, or to keep these connections up indefinitely.

DDR is an excellent backup solution to other WAN connections, such as leased lines or Frame Relay. However, one thing to point out is that BRI and, especially, analog connections should be used to back up low-bandwidth primary connections.

Another thing to consider is that if you are using DDR, remember that analog connections take 30–60 seconds to establish, which might cause application timeout problems for you in any type of DDR scenario. Also consider that analog connections don't provide a guaranteed connection rate. The first time you connect, you might get a 48 Kbps connection, and the second time, a 33.6Kbps connection—it all depends on the quality of the line and the modem that you are connecting to.

## DDR Process

DDR goes through a four-step process when setting up a phone connection, which will then allow you to transfer data across it:

1. Your router receives a packet, and by checking its routing table, the router has determined that it needs to switch the packet out of the DDR interface.
2. Your router then determines whether or not the packet is *interesting*.
3. If the traffic is interesting and the phone connection hasn't been established yet, the router makes a phone call to establish the circuit-switched connection.

If the packet isn't interesting and the DDR interface is not up, the router drops the packet; however, if the DDR connection has already been established, the router will allow both interesting and noninteresting traffic across the DDR circuit.

4. Once the circuit is up, the router will switch traffic out the DDR interface.

**e x a m**

**W a t c h**

**Remember these four steps for when a DDR call gets set up.**

## Legacy DDR Configuration

There are actually two ways of configuring DDR: legacy and profiles. This section covers the legacy, or old, method, and the last section in this book briefly covers profiles (the new method). In order for your router to perform the four steps covered in the earlier section "DDR Process," you will need to configure the commands in the following four corresponding steps:

1. Configure static routes for your traffic: for IP traffic, use the **ip route** command.
2. Define which traffic is interesting with the **dialer-list** commands.
3. Activate the **dialer-list** commands on the dialup interface with the **dialer-group** command.
4. Define the layer-3 address and phone number of the remote destination with the **dialer map** command.

There are other commands you can configure, but they are optional. First, you must define a static route to reach the destination. If you want the connection up

## exam

### Watch

**Remember these four steps for configuring DDR; especially the commands associated with each step. The *ip route* and *dialer-list* commands**

**are Global Configuration mode commands and the *dialer-group* and *dialer map* are Interface Subconfiguration mode commands.**

only temporarily, then using a routing protocol like IP RIP or IGRP is out of the question—these send out periodic broadcasts that would keep a dialup link up indefinitely. The simplest solution is to use a static route. There are other options, such as snapshot routing, but these options are beyond the scope of this book. They are, however, covered on Cisco's CCNP Remote Access exam. Second, you'll use **dialer-list** commands to define what traffic is interesting (what traffic will trigger phone calls). Like ACL commands, these commands are dormant until you activate them. To activate them, as when activating ACLs, you'll apply them to your dialup interface with the **dialer-group** command. And last, you need to tell your router how to reach the destination specified in the static route—which phone number it should dial to make the circuit-switched connection. This is configured in the **dialer map** command.

## Configuring Static Routes

As mentioned in the last section, you want only specific traffic to trigger phone calls. What you don't want is unnecessary traffic triggering phone calls. For example, you probably don't want your routing protocol, IP RIPv1, for example, triggering phone calls every time it needs to send a routing update (which is every 30 seconds). This is

especially true if there is a toll charge to make the phone call. One way of preventing this is to define a static route to define the remote destination(s), like this:

```
Router(config)# ip route IP_network_# subnet_mask
remote_router's_IP_address|router_interface
[administrative_distance]
```

If you have only one destination to reach off of the dialup interface, then you can specify your router's interface as the exit point. However, if the dialup interface is used to connect to multiple destinations, then specify the remote router's IP address instead.

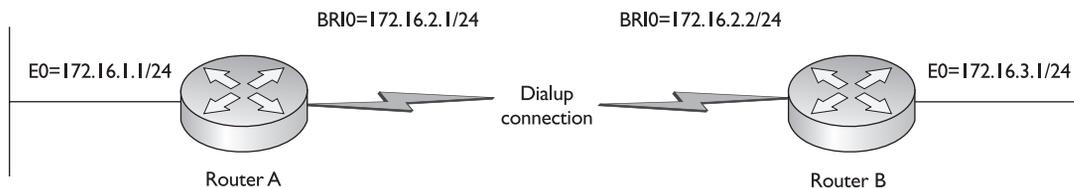
If you are using DDR to back up a primary WAN connection, make sure that you set the administrative distance (AD) of the static route to a number *higher* than the routing protocol used across the primary connection. For example, let's assume that you are using RIP across the primary connection. Remember that the AD of a static route defaults to 0 or 1, depending on how you specify the destination. If you don't specify the administrative distance, then your router would use the dialup connection *instead* of the primary connection because the static route has an AD of 0 or 1, while RIP has an AD of 120. To fix this problem, make sure the static route for the backup connection has an AD higher than routing protocol, such as 121 in RIP's case. Let's take a look at an example, shown in Figure 17-4, to illustrate routing issues.

Assume the two routers in this example are running RIPv1. Here's RouterA's config:

```
RouterA(config)# ip route 172.16.3.0 255.255.255.0 172.16.2.2
RouterA(config)# router rip
RouterA(config-router)# network 172.16.0.0
RouterA(config-router)# exit
RouterA(config)# interface ethernet 0
RouterA(config-if)# ip address 172.16.1.1 255.255.255.0
RouterA(config-if)# exit
RouterA(config)# interface bri 0
RouterA(config-if)# ip address 172.16.2.1 255.255.255.0
```

In this example, a static route has been defined to reach 172.16.3.0/24. However, look at RIP's configuration closely. Remember that RIP is *classful*—this means that

**FIGURE 17-4** Routing Issues with DDR



you specify the Class A, B, or C network number with the **network** statement and any interface associated with this network number will participate in the routing process. In this example, every interface associated with network 172.16.0.0/16 will participate in RIPv1. And since the BRI is being used for DDR to RouterB, the last thing you want is to have these routers dialing each other up every 30 seconds to share routing information.

Here are four solutions that you can use to prevent this problem from occurring:

- Make sure the network number of the DDR interface is not included in the **network** statement of your routing protocol. In this example, you could change the address on the BRI interface to a different network number.
- In your **dialer-list** configuration, exclude routing updates as interesting traffic (this is discussed in the next section).
- In your routing protocol's configuration, specify the DDR interface as passive. A passive interface will process received updates on the interface, but will not generate updates on it. To define the interface as passive, enter the *Routing Subconfiguration* mode for the routing protocol and configure this command: **passive interface\_name**. The name of the interface is the name you use to access it, such as `br10`.

There are other methods that you can use, but they are beyond the scope of this book.



**17.06. The CD contains a multimedia demonstration of configuring a static route for DDR on a router.**

## Configuring Dialer Lists

Once you have taken care of your routing setup, you'll then need to use the **dialer-list** command to define what traffic is interesting:

```
Router(config)# dialer-list list_# protocol protocol_name
                  permit|deny [access-list ACL_#]
```

First, you must give the list a unique list number—this needs to be different from all of the other dialer lists on your router. Also, like an ACL number, this groups related dialer list entries together. Next, specify the protocol name, like **ip** or **ipx**, that is considered to be interesting traffic. Follow this with the action: **permit** means the traffic is interesting and **deny** means the traffic isn't interesting. If you don't specify an ACL number, which is optional, then all of the traffic for a particular protocol

is included. If you specify an optional ACL number, only traffic specified in the ACL is included—this allows you to refine the criteria for traffic that is or isn't interesting. Any traffic specified with a **permit** parameter in the ACL is interesting. Note that there is an implicit deny at the bottom of the dialer list entries—any traffic that doesn't match the dialer list is deemed not interesting. Remember that noninteresting traffic will not trigger phone calls.

Here's a simple example of creating a dialer list:

```
Router(config)# dialer-list 1 protocol ipx permit
Router(config)# dialer-list 1 protocol ip permit
                  access-list 1
Router(config)# access-list 1 permit 172.16.1.0 0.0.0.255
```

In this example, there are two entries in the dialer list. The first entry specifies that all IPX traffic is interesting and will trigger phone calls. The second entry specifies that only traffic in ACL 1 is to be considered interesting. In this example, this is only traffic from devices with an address of 172.16.1.0/24. If you wanted to be more specific, you could have used an extended ACL instead of a standard one, like this:

```
Router(config)# dialer-list 1 protocol ip permit
                  access-list 100
Router(config)# access-list 100 permit tcp
                  172.16.1.0 0.0.0.255
                  172.16.3.0 0.0.0.255 eq smtp
Router(config)# access-list 100 permit tcp
                  172.16.1.0 0.0.0.255
                  172.16.3.0 0.0.0.255 eq telnet
```

In this example, anyone from 172.16.1.0/24 that sends e-mail to or telnets to 172.16.3.0/24 can trigger a phone call. Also, with dialer lists, you can mix and match the methods that you use to specify interesting traffic. In other words, a dialer list can include a standard ACL, an extended ACL, and all traffic for a protocol. Just remember to be as *specific* as you can about which traffic is considered interesting.



**17.07. The CD contains a multimedia demonstration of creating a dialer list on a router.**

## Activating Dialer Lists

Once you have created your dialer list, it will not do anything until you activate it on your DDR interface with the **dialer-group** command:

```
Router(config)# interface type [slot_#/]port_#
Router(config-if)# dialer-group dialer_list_#
```

Here's a simple example:

```
Router(config)# dialer-list 1 protocol ip permit
Router(config)# interface bri0
Router(config-if)# dialer-group 1
```



Note that in this example, any type of IP traffic will trigger a phone call.

**When initially setting up your DDR connection, you might want to allow any IP traffic to trigger a phone call. Then a simple ping should suffice to trigger a phone call. However, once you have the connection functioning, I highly recommend that you change this configuration to include extended and/or standard ACLs to define only necessary traffic as interesting.**

There is one very important point to make about dialer lists and interesting traffic. First, only interesting traffic can trigger a phone call. However, once the phone

connection has been established, *any* traffic can traverse the phone connection. In other words, a dialer list is *not* an ACL. A dialer list specifies only what traffic triggers phone calls. If you want to restrict traffic from traversing the DDR connection, configure an ACL and apply it to the DDR interface in the: 17.08. outbound direction.

## exam

### Watch

Use the *dialer-list* command to specify which traffic should trigger phone calls. Activate your dialer list on an interface with the *dialer-group* command.



**17.08.** The CD contains a multimedia demonstration of activating a dialer list on a router.

## Configuring Dialer Maps

Now that you have defined what traffic is interesting with your **dialer-list** commands and activated your dialer list on your router's interface with the **dialer-group** command, you are now ready to tell your router how to call the remote destination. To tell your router to make a phone call using legacy DDR, use the **dialer map** command:

```
Router(config)# interface type [slot_#/]port_#
Router(config-if)# dialer map protocol_name
                        address_of_destination_router
                        [name remote_router_name]
                        [speed 56|64] [broadcast]
                        destination_phone_number
```

The first thing you need to specify is the name of the layer-3 protocol and the remote router's layer-3 address. Optionally, you can specify the name of the router. This is used with PPP authentication and maps to a **username** command you have configured on your router. Typically, you'll use PPP as the encapsulation type for the interface, since this is almost a de facto standard for dialup connections.

Following the remote name is the speed of the connection. By default, ISDN BRI connections default to 64 Kbps. However, some carriers, when they sell you a single-channel BRI, will clock you only 56 Kbps worth of bandwidth. If this is the case, make sure that you change the speed to 56.

Also, by default, local broadcasts and multicasts will not traverse this connection. If you are running a routing protocol across this connection and want its broadcasts or multicasts to be sent across the connection, specify the **broadcast** parameter. Last, and most important, you need to specify the telephone number the router should use when dialing the destination.

## exam

### Watch

**Be familiar with the syntax of the *dialer map* command and its parameters: the layer-3 protocol,**

**the remote router's address, the remote's name, and the remote router's telephone number.**

Here's an example of setting up PPP authentication and the destination's phone number:

```
RouterA(config)# username RouterB password richard
RouterA(config)# interface bri0
RouterA(config-if)# no shutdown
RouterA(config-if)# encapsulation ppp
RouterA(config-if)# ppp authentication chap
RouterA(config-if)# dialer map ip 172.16.2.2 name RouterB 14075551212
```

Notice the encapsulation was set to PPP and the authentication is CHAP. The **dialer map** command specifies the address of the remote router (172.16.2.2), its name (RouterB), and the phone number to dial in order to reach the destination. Since CHAP is being used, the name in the **dialer map** command tells the router which **username** command to use for PPP CHAP authentication. Before the phone call will be brought up by this router, the two routers will have to perform CHAP authentication—if this fails, the phone connection is terminated.



**17.09. The CD contains a multimedia demonstration of configuring a dialer map on a router.**

### Configuring Optional Parameters

The DDR commands discussed so far are required to configure legacy DDR. The commands discussed in this section are optional. Once your router makes a phone call to the destination, any traffic (interesting and noninteresting) is allowed to traverse the connection. Of course, you don't want this connection to remain up indefinitely, especially if it is a toll call.

DDR connections have a default timeout of 120 seconds. As long as interesting traffic is crossing the connection, the timeout value is reset. Note that noninteresting traffic does *not* reset the timer. Once the timer reaches 0, the DDR connection is terminated—this is true even if noninteresting traffic is traversing the link. To change the idle timeout period, use this configuration:

```
Router(config)# interface type [slot_#/]port_#
Router(config-if)# dialer idle-timeout #_of_seconds
```

Specify the number of seconds a connection can remain idle (while no interest traffic is traversing it) before the connection is torn down. The connection idle timeout, however, can pose a problem if you have a single DDR connection, which is currently idle, and you have traffic that needs to trigger a phone call to a different destination. You can overcome this problem by defining a fast idle timer with the following command:

```
Router(config)# interface type [slot_#/]port_#
Router(config-if)# dialer fast-idle #_of_seconds
```

This timer specifies that after this number of idle seconds, if a new connection is required, the current connection is terminated and the new one is established (assuming no interesting traffic is traversing the currently active connection).



**17.10. The CD contains a multimedia demonstration of configuring DDR idle timeouts on a router.**

Another optional command is **dialer load-threshold**. This command allows you to perform load balancing across the two B-channels on your BRI. This feature is also referred to as *bandwidth on demand (BOD)*. For example, you might have a situation where your router makes a phone call on the first B-channel of your

**exam****Watch**

**DDR connections have a default idle timeout of 120 seconds (two minutes) if no interesting traffic is seen. Interesting traffic is defined with the *dialer-list* commands.**

BRI and after a period of time, you exceed the 64 Kbps bandwidth available on this channel. By default, your traffic would experience congestion and, in the worse case, would be dropped. To deal with this temporary burst of traffic, you can have your router bring up the second B-channel to handle the burst, and once the traffic falls back down to 64 Kbps or lower, drop the connection on the second B-channel.

To configure this option, use the following configuration:

```
Router(config)# interface type [slot_#/]port_#
Router(config-if)# dialer load-threshold load
either | inbound | outbound
```

**exam****Watch**

**When specifying the load threshold value with the *dialer load-threshold* command, a value of 1 represents 1 percent, 128, 50 percent and 255, 100 percent for a load value.**

The load threshold is specified as a number from 1 to 255. 1 represents 1 percent, 128, 50 percent, and 255, 100 percent load. In other words, this value is *not* a percentage. Once the load on the interface reaches this value, your router will bring up the second B-channel. You can measure the load in both directions (**either**), as traffic comes into the interface (**inbound**), or as traffic leaves the interface (**outbound**).



**17.11. The CD contains a multimedia demonstration of configuring the DDR load threshold on a router.**

### Example Legacy DDR Configuration

To help you with understanding how all of the DDR components work together, let's take a look at a configuration example. I'll use the network shown in Figure 17-5. In this example, RouterA dials RouterB. I'll assume that CHAP is used for authentication and that only telnet traffic will trigger phone calls. Here's RouterA's configuration:

```
Router(config)# hostname RouterA
RouterA(config)# isdn switch-type basic-5ess
RouterA(config)# username RouterB password richard
```

```

RouterA(config)# ip route 192.168.3.0 255.255.255.0 192.168.1.2
RouterA(config)# dialer-list 1 protocol ip permit access-list 100
RouterA(config)# access-list 1 permit tcp any any eq telnet
RouterA(config)# interface bri0
RouterA(config-if)# no shutdown
RouterA(config-if)# encapsulation ppp
RouterA(config-if)# ppp authentication chap
RouterA(config-if)# ip address 192.168.1.1 255.255.255.0
RouterA(config-if)# dialer-group 1
RouterA(config-if)# dialer map ip 192.168.1.2 name RouterB 7247584321

```

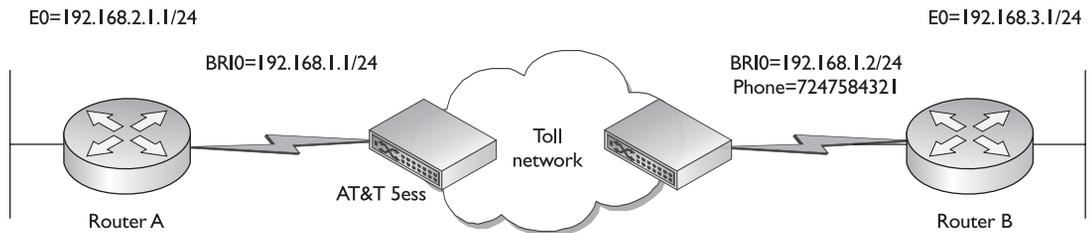
This example shows that RouterA is connected to an AT&T 5ESS switch (**basic-5ess**). There is a static route pointing to RouterB's network (192.168.3.0/24). The dialer list specifies that any **permit** statements in ACL 100 will trigger traffic, which is only telnets. The dialer list is activated on the BRI interface with the **dialer-group** command. Also note that PPP and CHAP are enabled on the BRI interface.

The **dialer map** command specifies the phone number (724-758-4321) for RouterB (192.168.1.2, which ties back to the static route). The **name** parameter references the **username** command to use for CHAP authentication (the password is *richard*).



**Please note that for ISDN, if one router is making a call and the other router is receiving it, you do not have to configure DDR on the second router—just your normal configuration. If you want two-way calling, you'll need to configure DDR on both routers. One problem with this approach, however, is that if both routers try to call each other simultaneously, you might get a busy signal or both B-channels might come up instead of one.**

**FIGURE 17-5** Legacy DDR example



## Legacy DDR Verification

As you can see from the preceding example, the configuration is not too difficult. However, you have quite a few commands to configure; and if you forget a command, or misconfigure a command, tracking down the problem is not a simple process.

To see which DDR interface has made phone calls, as well as the status of the phone calls, use the **show dialer** command:

```
Router# show dialer
BRI0 - dialer type = ISDN
Dial String      Successes  Failures  Last called  Last status
7782002          1          0         00:02:26    successful
0 incoming call(s) have been screened.
0 incoming call(s) rejected for callback.

BRI0:1 - dialer type = ISDN
Idle timer (120 secs), Fast idle timer (20 secs)
Wait for carrier (30 secs), Re-enable (15 secs)
Dialer state is data link layer up
Dial reason: ip (s=172.16.110.1, d=172.16.110.2)
Time until disconnect 52 secs
Connected to 7782002 (Router2)

BRI0:2 - dialer type = ISDN
Idle timer (120 secs), Fast idle timer (20 secs)
Wait for carrier (30 secs), Re-enable (15 secs)
Dialer state is idle
```

### exam

#### Watch

*The `show dialer` command displays all active phone calls, while the `show isdn active` command displays only active ISDN calls.*

From this output, you can see which phone numbers have been dialed, whether or not the phone calls were successful, the last time a remote router was called, and other statistics. For example, the phone number 778-2002 was dialed successfully one time a little bit over two minutes ago. Only the first B-channel was used with this connection (BRI0:1), which is currently up and will be

disconnected in 52 seconds because no interesting traffic has gone across it in the last 68 seconds—the default idle timer is 120 seconds.



**17.12. The CD contains a multimedia demonstration of using the `show dialer` command on a router.**

To view only the active ISDN calls, use the **show isdn active** command:

```
Router# show isdn active
-----
                        ISDN ACTIVE CALLS
-----
History Table MaxLength = 320 entries
History Retain Timer = 15 Minutes
-----
Call Calling Called Duration Remote Time until Record Charge
Type Number Number Seconds Name Disconnect Unit/Currency
-----
Out          7782002 Active(12) RouterB          117          u(D)
-----
```

In this output, there is only one active ISDN call. As shown by the Call Type (Out), this router initiated the connection. This connection has been up for 12 seconds, but for the last 3 seconds (120 – 117), no interesting traffic has traversed the dialup connection.



**17.13. The CD contains a multimedia demonstration of using the *show isdn active* command on a router.**

The **show isdn active** command shows only the active calls. To see calls the router either made or accepted previously, use the **show isdn history** command, shown here:

```
Router# show isdn history
-----
                        ISDN CALL HISTORY
-----
History Table MaxLength = 320 entries
History Retain Timer = 15 Minutes
-----
Call Calling Called Duration Remote Time until Record Charge
Type Number Number Seconds Name Disconnect Unit/Currency
-----
Out          3590000          240 RouterB
In   3591111          98 RouterC
-----
```

In this example, this router made a phone call to 359-0000, which lasted 240 seconds. The second line shows that RouterC made a call to this router, and this call lasted 98 seconds.



**17.14. The CD contains a multimedia demonstration of using the `show isdn history` command on a router.**

## Using debug for Troubleshooting

For detailed troubleshooting of DDR connections, you can use **debug** commands. The **debug dialer** command shows the DDR process of setting up or tearing down a connection:

```
Router# debug dialer
Dialing cause: BRI0: ip (s=192.168.1.1 d=192.168.11.25)
```

In this example, traffic from 192.168.1.1 triggered a phone call on BRI0. Therefore, this traffic from 192.168.1.1 must have been defined as interesting. If you are seeing a phone call triggered, then you have done everything correctly. If you are not seeing a phone connection being made, then examine the following:

1. Examine your routing table to make sure your router knows how to reach the destination (**show ip route**).
2. Verify that your DDR interface has been activated with the **no shutdown** command (**show interfaces**).
3. Check if you forgot to create or misconfigured your **dialer-list** commands.
4. Check if you forgot to activate the dialer list on your router's interface with the **dialer-group** command.



**17.15. The CD contains a multimedia demonstration of using the `debug dialer` command on a router.**

If you are having problems with ISDN making phone calls, you can use the **debug isdn q931** command to troubleshoot layer-3 ISDN DDR connections. This command will show the details of the setup and teardown of ISDN phone connections. Here is an example of the output of this command:

```
Router# debug isdn q931
RX <- SETUP pd = 8 callref = 0x06
Bearer Capability i = 0x8890
Channel ID i = 0x89
```

```

Calling Party Number i = 0x0083, '4075551212'
TX -> CONNECT pd = 8 callref = 0x86
RX <- CONNECT_ACK pd = 8 callref = 0x06

```

In this example, a phone call was being made to 407-555-1212 and was successfully set up (TX -> CONNECT and RX <- CONNECT\_ACK).



**17.16. The CD contains a multimedia demonstration of using the `debug isdn q931` command on a router.**

## exam

### watch

The `debug dialer` command displays when the router initiates and terminates any type of phone call. The `debug isdn q931` command displays the mechanics of setting up and tearing down ISDN phone calls.

## Troubleshooting Steps

As you could see from the configuration section, there are many things that can go wrong with setting up a DDR connection. And with DDR, unfortunately, there isn't a single command on a router that will tell you the exact problem. Instead, you'll have to go through a handful of troubleshooting steps to determine what the problem is.

If your router is not making a phone call, then answer the following items:

- Is your router interacting with the ISDN switch?
  - Check the connection with the **show isdn status** command.
  - See if the router is sending and receiving Q.921 information with the **debug isdn q921** command.
  - Verify that your SPIDs are configured correctly with the **show running-config** command.
- Does your router have a static route pointing to the remote destination?
  - Use the **show ip route** command to examine your routing table.
- Is your dialer list configured correctly and activated?
  - Use the **show running-config** command to examine your **dialer-list** commands and if the DDR list has been activated on the dialup interface (**dialer-group**).

- Is your router attempting to dial the destination phone number?
  - Use the **debug dialer** command to see if the router is attempting to dial out.
  - Verify the phone number your router is dialing in the **dialer map** command.

If your router is actually dialing phone numbers, but the phone call is not completing, you should answer the following questions:

- For ISDN phone calls, is the phone connection being set up?
  - Check the ISDN connection setup with the **debug isdn q931** command.
- Is the encapsulation type the same on both ends?
  - Use the **show interfaces** command to check the encapsulation type (PPP or HDLC).
- If you are using PPP, is there a negotiation problem with the PPP parameters?
  - Use the **debug ppp negotiation** command to see if it is an LCP problem.
  - If you are using PAP or CHAP authentication, use the **debug ppp authentication** command to pinpoint authentication problems.

If the phone call is successfully set up, but the connection terminates prematurely, then answer the following questions:

- Have you defined your interesting traffic correctly with the **dialer-list** commands?
  - Use the **show dialer** command to check the status of the DDR connection.
  - If the DDR connection uses ISDN, use the **show isdn active** and **show isdn history** commands.
  - Check your dialer list configuration with the **show running-config** command.

## exam

### Watch

**Know how to use the correct command to troubleshoot specific DDR problems.**

As you can see from these items, troubleshooting DDR is not a simple process.

## CERTIFICATION OBJECTIVE 17.04

### Dialer Profiles and DDR

With legacy DDR, the dialup interface must use the same configuration no matter what destinations it is connecting to. This can create issues when you have multiple destinations that you are connecting to. Plus, if your primary DDR interface fails, there is no simple alternative to using a backup DDR interface for dial-out connections. Dialer profiles solve this problem and provide the following enhancements:

#### exam

##### Watch

**Remember the three enhancements that dialer profiles have over legacy DDR.**

- Allows a physical interface to be shared by many logical DDR interfaces, which provides flexibility in how you set up and use your DDR connections.
- Allows you to share multiple dialup interfaces to back up multiple primary WAN circuits.
- Do not need a separate dialer map command for each protocol/destination combination, which reduces the complexity of your DDR configuration.

### Dialer Profile Components

Dialer profiles contain two types of interfaces: logical DDR interfaces and physical interfaces. The *logical* DDR interfaces have the DDR configuration placed on them, while the *physical* interfaces have the physical properties and ISDN components (in the case of a BRI or PRI interface) configured on them. With dialer profiles, the logical interface performs the DDR function and chooses a physical interface to use to make the phone call. This enables you to group together a bunch of physical interfaces and allow a logical interface to use a free physical interface in the group to make a call. This provides you with a lot of flexibility and control over the use of your physical dialup interfaces.

Dialer profiles contain the following components:

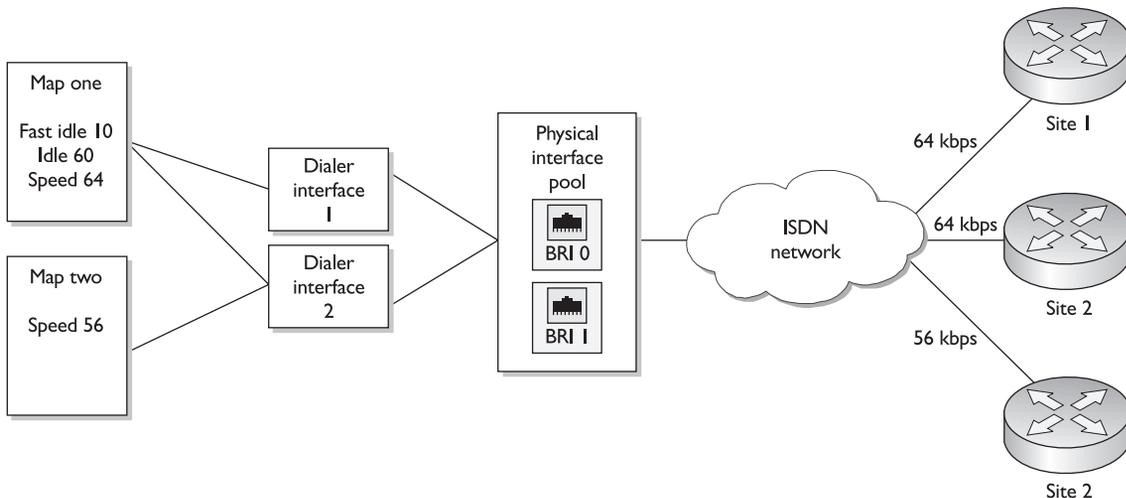
- **Dialer interface** Contains the DDR configuration components, including the phone number to dial and the PPP authentication information to use. Multiple destinations can be called from the same dialer interface, but most administrators create a separate dialer interface for each destination.

- **Physical interface or interfaces** Contains the physical connection properties, such as the ISDN switch type, as well as which dialer interfaces are allowed to use it.
- **Dialer pool** Defines which dialer interfaces can use which physical interfaces.
- **Dialer map class (optional)** Defines call characteristics for a specific calling destination, which allows a single dialer interface to be configured correctly for multiple calling destinations.

Let's use Figure 17-6 to illustrate the use of these three components. There are three sites the router calls: Site1, Site2, and Site3. Each of these sites has different configuration characteristics: Site1 and Site2 have 64 Kbps BRI connection while Site3 has only a 56 Kbps BRI connection. Site1 and Site2 also have a 60-second idle timer, with a 10-second fast-idle timer, while Site3 has the default idle timer. One dialer pool has been configured with two BRI interfaces. The router will use this pool when connecting to any of three sites. Two dialer interfaces are set up that can use this pool of physical interfaces.

The first dialer interface, *Dialer interface 1*, has a configuration to dial to Site1. Notice that the map class called *Map one* specifies the configuration for the connection to Site1. *Dialer interface 2* is used to dial to two different sites: Site2 and Site3. When dialing to Site2, the *Map one* map class is used; when dialing to Site3, *Map two* is used.

**FIGURE 17-6** Dialer profile components



Notice that in this example that by separating the DDR components, you have a lot more flexibility when setting up connections using multiple physical interfaces and multiple destinations.

## Configuring Dialer Profiles

Configuring dialer profiles is similar to configuring legacy DDR. With legacy DDR, the first two things you have to configure are your static routes and your dialer lists. This is also true with dialer profiles. You use the *same* commands for these two tasks. Once you have configured these two items, you are ready to proceed to configuring your dialer profile. Also, if you are using PPP authentication, you'll need to create your local database of usernames and passwords.

From this point onward, the configuration is different from a legacy configuration. With a legacy configuration, all of your DDR information is configured on the router's physical interface. With dialer profiles, the configuration is broken into at least two components: dialer interfaces, physical interfaces, and, optionally, map classes.

### Dialer Interface Configuration

Dialer interfaces are logical interfaces on the router. They are like loopback interfaces, which were discussed in Chapter 11. To create a dialer interface's configuration, use the following:

```
Router(config)# interface dialer port_#
Router(config-if)# encapsulation ppp
Router(config-if)# ppp authentication
                    pap|chap|chap pap|pap chap
Router(config-if)# ip address IP_address subnet_mask
Router(config-if)# dialer remote-name name
Router(config-if)# dialer string phone_# [class map_name]
Router(config-if)# dialer pool pool_#
Router(config-if)# dialer-group dialer_list_#
```

The first thing you must do is to create your logical dialer interface with the **interface dialer** command. You must assign a port number to the interface, which is an arbitrary number. This number must be unique among all dialer interfaces. When you enter this command, you are taken into *Interface Subconfiguration* mode.

Once you are in *Interface Subconfiguration* mode, you need to specify the encapsulation type (**encapsulation ppp**) and, optionally, the authentication method to use

(**ppp authentication**). You can also specify your layer-3 addressing, such as the IP address of the interface (**ip address**). Please note that the router treats the dialer interface like any other interface. When you create it, the dialer interface is automatically enabled.

You must specify the name of the remote router, even if you are not using PPP authentication. Use the **dialer remote-name** command to specify the name. If you don't enter this command, you will not be able to enter any other **dialer** commands on the interface.

Following this is the **dialer string** command. This command defines the phone number to call to reach the destination. With this command, you can point to an optional map class with the **class** parameter. If you don't specify a map class, the configuration parameters configured on the dialer interface are used. These parameters can include the idle timer (**dialer idle-timer**), the fast-idle timer (**dialer fast-idle**), and the speed of the ISDN connection (**dialer isdn speed**). You need to specify a map class only if the dialer interface is used to dial multiple locations, where these locations have different DDR configuration parameters.

The **dialer pool** command specifies which group of physical interfaces the dialer interface can use. The number you specify here must match the number used by the **dialer pool-member** command on the physical interface or interfaces you want the dialer interface to use. The pool number can range from 1 to 255.

Following this is the **dialer-group** command. Recall from the section "Legacy DDR Configuration" that this command activates a dialer list on the router's interface, which tells the router which traffic should trigger phone calls on this interface.

## exam

### Watch

**Dialer profiles perform the DDR configuration under a logical dialer interface (*interface dialer*). All your DDR configuration is performed here. The *dialer remote-name* specifies**

**the name of the remote router. The *dialer string* denotes the phone number to call. The *dialer pool*, specifies which physical interfaces the dialer interface can use.**

## Map Classes

If you specified a map class name in the **dialer string** command in the dialer interface configuration, you will need to create a corresponding map class. The function of a map class is to separate the configurations from the interface and centralize them under one set. You can then take this set and apply it to multiple interfaces. This reduces

the amount of configuration that you have to perform and makes it easier to set up a consistent configuration. To create a map class, use these commands:

```
Router(config)# map-class dialer map_name
Router(config-map)# dialer isdn speed 56
Router(config-map)# dialer idle-timeout #_of_seconds
Router(config-map)# dialer fast-idle #_of_seconds
```

The name you specify with the **map-class** command must match the name specified in the **dialer string** command. When you execute this command, you are taken into *Map Subconfiguration* mode. The **dialer isdn speed** command allows you to specify the speed of the B-channel in an ISDN connection, which defaults to 64 Kbps. You can set it to 56 Kbps if your provider provides only 56 Kbps B-channels or the remote side only supports 56Kbps connections. The **dialer idle-timeout** and **dialer fast-idle** commands were discussed in the section “Legacy DDR Configuration.” Note that if these commands are configured in the map and also on the dialer interface, the map class name specified in the **dialer string** command supercedes the commands configured on the dialer interface.

## Physical Interface Configuration

The last thing you must configure are your physical dialup interfaces. This book focuses on ISDN interfaces, so only these configurations are shown. There are basically four things you’ll do on the physical interface: enable it, specify the encapsulation type (and the optional PPP authentication), and specify the DDR pool that the interface belongs to. Here are the commands you should use:

```
Router(config)# interface type [slot_#/]port_#
Router(config-if)# no shutdown
Router(config-if)# encapsulation ppp
Router(config-if)# ppp authentication
                    chap|pap|chap pap|pap chap
Router(config-if)# dialer pool-member pool_#
                    [priority priority_#]
                    [min-link #_of_B_channels]
                    [max-link #_of_B_channels]
```

The first thing you should do is to enable the physical interface with the **no shutdown** command. The second thing you must do is to configure the encapsulation type and authentication, if you’re using PPP. Both PPP and HDLC are supported; however, almost everyone uses PPP. Since you probably don’t know which authentication

a dialer interface will use (one that is configured with PPP authentication), you probably want to specify both PAP and CHAP unless you've standardized on one authentication method.

The last thing you must do on the physical interface is to configure the **dialer pool-member** command. This command specifies which dialer interfaces (**dialer pool** command) can use this physical interface. If you want multiple physical interfaces to be in the same pool, then specify the pool number on the other physical interfaces with this command. The pool number can range from 1 to 255.

There are three optional parameters with this command. The **priority** parameter can have values from 1 to 255. This parameter prioritizes the interfaces in the same pool number: the higher the number, the higher the priority. If there is more than one physical interface in a pool, you can assign a priority to each interface. Then, when a dialer interface makes a phone connection using this pool, it will use the physical interface that has the highest priority that is currently available. If the physical interfaces have the same priority (the default), the dialer interface will use the physically lowest-numbered interface. An important item to point out about physical interfaces is that you can associated multiple pools to the same physical interface. This parameter can be used to avoid contention for physical interfaces, especially if there is more than one pool associated with a physical interface.

The **min-link** and **max-link** parameters specify how many B-channels are reserved on the physical interface for this pool. These parameters are typically used on a PRI connection. The **min-link** parameter specifies the minimum reserved channels, while the **max-link** command reserves the maximum number of B-channels for this pool. Here's a simple example to help explain the usage of these parameters:

```
Router(config)# interface serial0:23
Router(config-if)# no shutdown
Router(config-if)# encapsulation ppp
Router(config-if)# dialer pool-member 1 min-link 1 max-link 4
```

This example shows the configuration of a T1 PRI. In this example, pool 1 is associated with this interface. Pool 1 is allowed to use from one to four B-channels on this PRI: it is guaranteed at least one B-channel but can use up to four, if there are free channels. Another use of this command is to restrict the number of B-channels a dialer interface or interfaces can use—this is important if you have a limited number of B-channels and need to ensure that certain connections have access to your B-channels. If you don't specify minimum and maximum values, the interface can use any and all B-channels on the physical interface.

**exam****Watch**

**When configuring dialer profiles, don't configure any layer-3 addressing on your physical interfaces—this is done on the logical dialer interface. Also, use the `dialer pool-member`**

**command to specify which dialer interfaces can use this physical interface—the pool numbers must match that configured with the `dialer pool` command under the logical dialer interface.**

### Verifying Your Dialer Profile Configuration

Once you have configured dialer profiles on your router, you can use the same exact commands to troubleshoot your dialup connections that you used in legacy DDR. The one exception to this is that since you are using a dialer interface to make the phone calls, specify the dialer interface, and not the physical interface, when troubleshooting and examining interface configurations. If no phone calls are being made, above all, make sure that the physical interface is enabled and is associated with the same pool number as the dialer interface.

Also, there is one additional command you can use to troubleshoot dialer profiles:

```
Router# show dialer interface bri {serial:23|15} [slot_#/]port_#
```

This command shows DDR statistics for incoming and outgoing calls for the physical interfaces associated with the dialer interface. Here's an example:

```
Router# show dialer interface bri 0
BRI0 - dialer type = ISDN
DIAL String      Successes      Failures      Last called   Last
status
0 incoming call(s) have been screened.
```

```
BRI0: B-Channel 1
Idle timer (120 secs), Fast idle timer (20 secs)
Wait for carrier (30 secs), Re-enable (15 secs)
Dialer state is data link layer up
Dial reason: ip (s=192.168.2.2, d=192.168.3.2)
```

```
Interface bound to profile Dialer1
```

```
Time until disconnect 102 secs
Current call connected 00:00:19
Connected to 7247584321 (RouterB)
```

```

BRI1: B-Channel 2
Idle timer (120 secs), Fast idle timer (20 secs)
Wait for carrier (30 secs), Re-enable (15 secs)
Dialer state is idle

```

In this example, interface `dialer 1` is using the first B-channel of `bri0`. The first B-channel is currently connected to RouterB, while the second B-channel is idle. The `Dialer state is data link layer up` message indicates that both the physical and data link layers are operational. If you see `Physical layer up`, this means that for PPP, LCP is operational, but NCP is not.

## Dialer Profile Example

To help you understand the configuration using dialer profiles, let's take the legacy DDR example I showed earlier and convert this to use dialer profiles. The network this example uses was shown previously in Figure 17-5. The code configuration follows.

Here's RouterA's configuration:

```

Router(config)# hostname RouterA
RouterA(config)# isdn switch-type basic-5ess
RouterA(config)# username RouterB password richard
RouterA(config)# ip route 192.168.3.0 255.255.255.0 192.168.1.2
RouterA(config)# dialer-list 1 protocol ip permit access-list 100
RouterA(config)# access-list 1 permit tcp any any eq telnet
RouterA(config)# interface dialer 1
RouterA(config-if)# encapsulation ppp
RouterA(config-if)# ppp authentication chap
RouterA(config-if)# ip address 192.168.1.1 255.255.255.0
RouterA(config-if)# dialer remote-name RouterB
RouterA(config-if)# dialer string 7247584321
RouterA(config-if)# dialer pool 1
RouterA(config-if)# dialer-group 1
RouterA(config-if)# exit
RouterA(config)# interface bri0
RouterA(config-if)# no shutdown
RouterA(config-if)# encapsulation ppp
RouterA(config-if)# ppp authentication chap
RouterA(config-if)# dialer pool-member 1

```

This example shows that RouterA is connected to an AT&T 5ESS switch (**basic-5ess**). There is a static route pointing to RouterB's network (192.168.3.0/24). The dialer list specifies that any **permit** statements in ACL 100 will trigger traffic, which is only telnets. The dialer list is activated on the *dialer* interface with the **dialer-**

**group** command. Also note that PPP and CHAP are enabled on the dialer *and* BRI interfaces.

Notice that the configuration is a little more complex than the legacy DDR configuration when you examine the configuration of the dialer and physical interfaces. The physical interface is assigned to pool 1, and the dialer interface references this pool. Also notice that all of the DDR commands are configured on the dialer interface. Typically, you use dialer profiles only when you have many destinations you need to call, and a limited number of physical interfaces. Legacy DDR is preferred when you have only one site you need to connect to off of the dialup interface.



**17.17. The CD contains a multimedia demonstration of configuring dialer profiles on a router.**

## CERTIFICATION SUMMARY

ISDN provides digital circuit-switched connections. It has the following advantages over analog modems: fast call setup (one–two seconds), guaranteed data rate, and suitability for multiple services, such as data, voice, and video. A BRI has 2 bearer channels (64 Kbps each) and a signaling channel (16 Kbps). A T1 PRI has 23 bearer channels (64 Kbps each), and an E1 has 30 bearer channels (a T1 has 1 signaling channel and an E1 2 signaling channels).

The Q.921 (layer-2) standard defines the interaction between the router and the ISDN switch, while the Q.931 (layer-3) standard defines the call setup and teardown process for ISDN phone calls. LAPD defines the framing used for layer-2.

A TE1 is an ISDN native interface, whereas a TE2 has a nonnative interface and requires a TA. An NT1 connects your TE1/TE1 to the carrier's network—it converts an ISDN four-wire connection to the carrier's two-wire connection). The U reference point defines the connection between the NT1 and LE. The T reference point defines the connection between the NT1 and NT2. The S reference point defines the connection between the TA or TE1 to the NT2, and the R reference point defines the connection between the TE2 and the TA.

The **isdn switch-type** command specifies your ISDN switch type: this can be done from *Global Configuration* mode or *Interface Subconfiguration* mode. The National ISDN 1 and Nortel DMS-100 switches typically require you to configure SPIDs on your router. If you have a PRI T1 or E1, you must first configure your controller by going into *Controller Subconfiguration* mode (**controller**). Here you specify the line coding, framing, and which DS0s are used by the PRI. To specify which channel

is the signaling channel, use the **interface serial** command. Use **15** for an E1 and **23** for a T1. The **show isdn status** command displays layer-2 ISDN information.

There are two methods for establishing a dialup connection: legacy DDR and dialer profiles. With legacy DDR, all dialup commands are configured on the physical dialup interface. With dialer profiles, the dialup commands are placed on a logical interface and you specify which physical interfaces the logical interface can use (**dialer pool** and **dialer pool-member** commands). For DDR, you need to specify a route (**ip route**) to the destination, what traffic will trigger a call (**dialer-list** and **dialer-group**), and how to reach the destination (**dialer map** with legacy and **dialer string** with profiles). Idle DDR connections will time out after not see any interesting traffic for a period of 120 seconds.

Use the **show dialer** and **show isdn active** to list your current ISDN phone connections. The **debug dialer** and **debug isdn q931** are helpful commands in troubleshooting the setup of ISDN phone calls.

 **TWO-MINUTE DRILL****ISDN Introduction**

- ❑ A BRI has 2 B-channels (64 Kbps each) and 1 D-channel (16 Kbps), a PRI T1 has 23 B-channels and 1 D-channel, and a PRI E1 has 30 B-channels and 1 D-channel. Q.921 defines the connection between the router and the switch, and Q.931 defines how a phone connection is set up. LAPD is used as the ISDN frame type.
- ❑ A TE1 has a native ISDN interface. A TE2 has a serial interface and requires a TA. An NT2 connects multiple ISDN devices together, and an NT1 connects to the carrier, converting four-wire to two-wire. R is the connection between the TE2 and the TA. S is the connection between the TA/TE1 and the NT2. T is the connection between the NT2 and NT1, and U is the connection between the NT1 and LE.

**ISDN Interface Configuration**

- ❑ Use the **isdn switch-type** command to configure your ISDN switch type globally or on an interface. Use the **show isdn status** command to verify layer-1 and layer-2 connectivity.
- ❑ SPIDs are used by some switches to authenticate call requests; they are configured with the **isdn spid1|spid2** command.
- ❑ For PRI controllers, you must configure the following on the controller: **controller t1|e1, framing, linecode, clock source**, and **pri-group timeslots**. Then create the logical interface: **interface serial port\_#:23|15**.

**Legacy Dial-on-Demand Routing**

- ❑ DDR is best suited for backup of primary WAN connections, when the traffic is low volume and periodic, and phone calls are short and temporary.
- ❑ You need to set up a static route and define interesting traffic (**dialer-list**). Activate the dialer list on the interface (**dialer-group**) and specify the dialing parameters (**dialer map**). The default idle timeout for interesting traffic is 120 seconds.

- ❑ The **show dialer** and **show isdn active** show current ISDN calls. Use the **debug dialer** command to see if your router is attempting to make phone calls.

### Dialer Profiles and DDR

- ❑ Dialer profiles contain the following components: dialer interface, physical interface, dialer pool, and map classes (optional).
- ❑ Only the PPP encapsulation, authentication, and pool membership are configured on the physical interface (**dialer pool-member**).
- ❑ All DDR commands are configured on the logical dialer interface **dialer remote-name, dialer string, dialer pool, dialer group**. You must also assign the PPP encapsulation (and authentication) and the IP address to the dialer interface. Map classes can be used to group together common configuration parameters that are applied to dialer interfaces. To see which logical interfaces are associated with a physical interface, use the **show dialer interface bri0** command.

## SELF TEST

The following Self Test questions will help you measure your understanding of the material presented in this chapter. Read all the choices carefully, as there may be more than one correct answer. Choose all correct answers for each question.

### ISDN Introduction

1. What uses 64 Kbps of bandwidth?
  - A. PRI
  - B. BRI
  - C. DS1
  - D. DS0
2. \_\_\_\_\_ defines LAPD, which is responsible for the data-link layer connection between the router and the ISDN switch.
  - A. Q.931
  - B. Q.921
  - C. I.921
  - D. I.931
3. The \_\_\_\_\_ reference point defines the connection between the NT2 and the NT1.
4. The \_\_\_\_\_ converts an ISDN four-wire connection to a two-wire connection.

### ISDN Interface Configuration

5. Which router command specifies the ISDN switch the router is connected to?
  - A. **isdn switch-type**
  - B. **isdn connection-type**
  - C. **isdn spid1**
  - D. **interface serial0:15**
6. Which controller command specifies how ones and zeros are represented on a digital circuit?
  - A. **framing**
  - B. **linecode**
  - C. **clock source**
  - D. **interface**

7. Enter the PRI command that specifies time slots 1–24 are used on a T1 controller: \_\_\_\_\_.
8. Enter the router command that shows the status of the ISDN Q.921 connection between the router and the switch: \_\_\_\_\_

### Legacy Dial-on-Demand Routing

9. Which of the following situations are best for DDR connections?
  - A. Primary WAN connection
  - B. A lot of constant traffic
  - C. Long phone calls
  - D. Backup connection
10. Which command defines interesting traffic?
  - A. **dialer-group**
  - B. **dialer-list**
  - C. **dialer map**
  - D. **dialer remote-name**
11. Enter the command to trigger phone calls on an interface for dialer list 1: \_\_\_\_\_.
12. An idle DDR connection will be torn down after \_\_\_\_\_ seconds of not seeing interesting traffic.
13. The **dialer map** command contains all of the following parameters except \_\_\_\_\_.
  - A. Protocol name
  - B. Remote router name
  - C. Address of local router
  - D. Speed of the connection

### Dialer Profiles and DDR

14. Enter the router command to create a logical DDR interface with a port number of 0:  
\_\_\_\_\_.
15. Which of the following commands belongs on the physical interface when using dialer profiles?
  - A. **dialer pool-member**
  - B. **dialer-group**
  - C. **ip address**
  - D. **dialer string**

# SELF TEST ANSWERS

## ISDN Introduction

- D.** A DS0 uses 64 Kbps of bandwidth.  
 **A** and **C** use either 24 or 32 DS0s. **B** uses 3 DS0s.
- B.** Q.921 defines LAPD, which is responsible for the data-link layer connection between the router and the ISDN switch.  
 **A** defines how layer-3 ISDN phone calls are set up. **C** and **D** are nonexistent standards.
- The T reference point defines the connection between the NT2 and NT1.
- The NT1 converts an ISDN four-wire connection to a two-wire connection.

## ISDN Interface Configuration

- A.** The **isdn switch-type** command defines the switch type the router is connected to.  
 **B** is an invalid command. **C** specifies the SPID for the first B-channel. **D** specifies the logical interface for an E1 PRI controller in port 0.
- B.** The **linecode** controller command specifies how ones and zeros are represented on a digital circuit.  
 **A** specifies the controller's physical layer framing. **C** specifies how clocking is determined on the controller. **D** is not a controller command, but a global one.
- pri-group timeslots 1-24.**
- show isdn status.**

## Legacy Dial-on-Demand Routing

- D.** DDR connections are best used as backup, or short, temporary connections.  
 **A, B,** and **C** are suited for WAN services such as leased lines or packet-switched services.
- B.** The **dialer-list** command defines interesting traffic for DDR.  
 **A** associates the interesting traffic with a DDR interface. **C** specifies how to reach the destination. **D** is a dialer profile command used to configure the remote device's name.
- dialer-group 1.**
- An idle DDR connection will be torn down after 120 seconds of not seeing interesting traffic.

13.  C. The **dialer map** command does not contain the local router's address, but the remote's.  
 A, B, and D are part of the dialer map command.

### Dialer Profiles and DDR

14.  **interface dialer 0.**
15.  A. The **dialer pool-member** command, along with the PPP configuration, is done on the physical interface.  
 B, C, and D are done on the logical dialer interface.