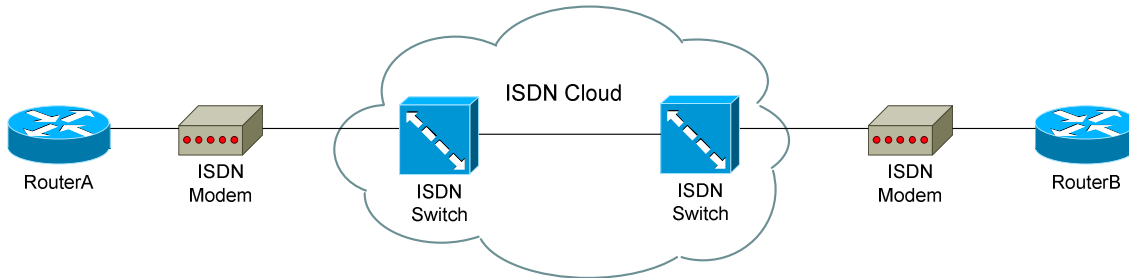


## - Integrated Services Digital Network -

### ISDN (Integrated Services Digital Network)



ISDN is a circuit-switched digital service that can transmit voice and data over existing phone lines. It has faster call setup and bandwidth rates than dial-up connections, and is often utilized as a backup line to a more expensive dedicated leased line.

Like Frame-Relay, ISDN has layer-2 “switches” that control traffic inside the ISDN cloud. There are multiple ISDN switch-types.

The cost of ISDN is based on the number of calls made, and the duration of those calls. Thus, it is not advantageous to have the ISDN connection always active, nor do you want ISDN calls made every few seconds.

There are two types of ISDN:

- **Basic Rate Interface (BRI)** - contains two “B” channels, and one “D” channel. The two **B channels** carry 64K of bandwidth each, and are dedicated for data or voice traffic. The single **D channel** carries 16K of bandwidth, and is dedicated for signaling and call-setup. The total bandwidth for ISDN BRI is 144K (64K+64K+16K).
- **Primary Rate Interface (PRI)** - contains twenty-three “B” channels, and one “D” channel. The twenty-three **B channels** carry 64K of bandwidth each, and are dedicated for data or voice traffic. The single **D channel** carries 64K of bandwidth, and is dedicated for signaling and call-setup. The total bandwidth for ISDN PRI is 1.544Mbs (23x64K+64K).

\* \* \*

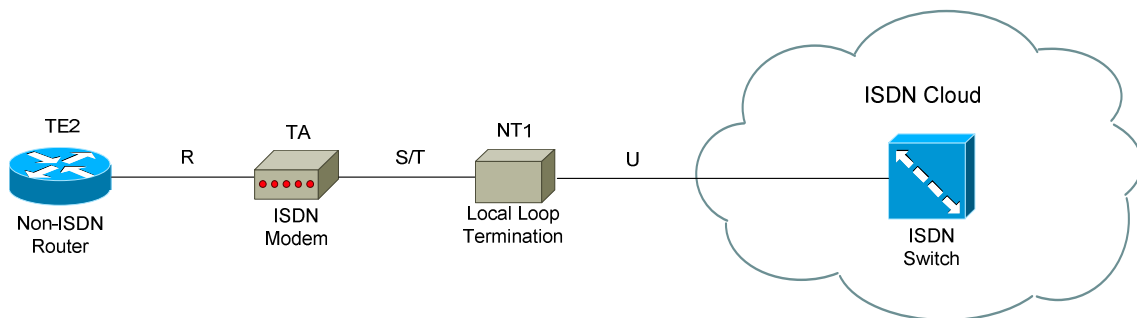
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## ISDN BRI Fundamentals

BRI is (by far) the most common installation of ISDN. As mentioned previously, ISDN BRI contains two **B channels** and one **D channel**. Each B channel carries 64K of bandwidth, and can be utilized for either voice or data. The D channel carries 16K of bandwidth is used for signaling and call-setup.

The equipment necessary for ISDN is identified with several terms, as is the “connection” between each device:

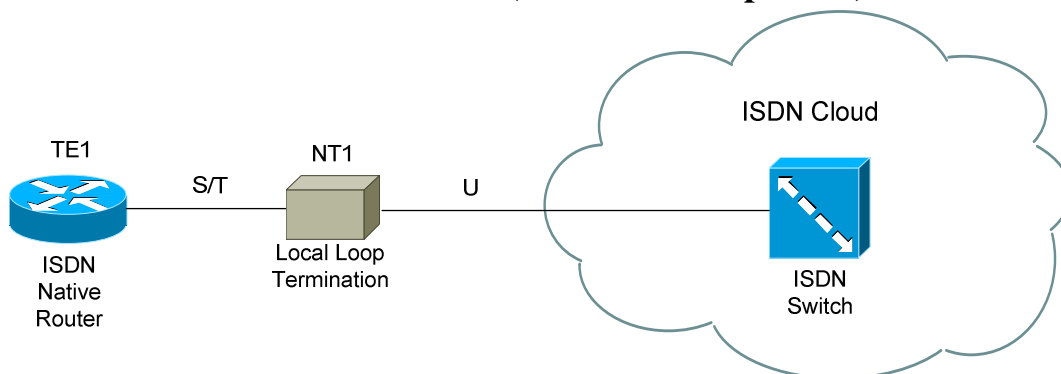


A **TE2 (Terminal Endpoint 2)** identifies a non-ISDN native device (essentially, a device without an ISDN BRI port). This could be a router or workstation that does not support ISDN natively.

To connect a TE2 device to an ISDN network, we need a **TA (Terminal Adapter)**. This is often referred to as the ISDN modem, though it does not technically modulate or demodulate a signal. The purpose of a TA is to provide the BRI interface for a non-ISDN device.

The **NT1 (Network Termination 1)** terminates the local loop from the ISDN Central Office (CO).

ISDN-native devices have the TA integrated (built-in BRI port). An ISDN native device is identified as a **TE1 (Terminal Endpoint 1)**:

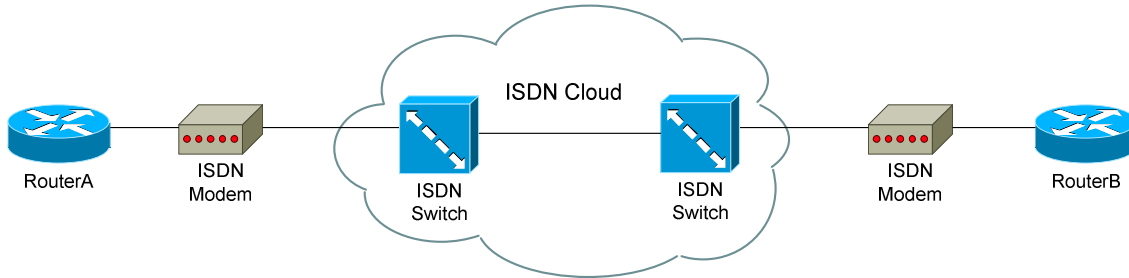


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## ISDN BRI Layers



ISDN employs three layers to its communication process.

**Layer 1** is concerned with the physical ISDN connection. The ISDN BRI connection eventually connects to an **ISDN Switch** at the CO. There are several types of ISDN switches used in the United States, including:

- Basic-5ess
- Basic-dms100
- Basic-ni1

Various alternate switch types exist in other countries. Your ISDN provider will identify which switch type is being used.

**Layer 2** utilizes two protocols on the D Channel, **Q.920** and **Q.921**, to provide the physical layer addressing for ISDN. TE1's (or TE2's + TA's) are physically identified using a **TEI (Terminal Endpoint Identifier)**:

- Static TEI's are numbered 0 – 63
- Dynamically assigned TEI's are numbered 64-126

The connection is then logically identified using **SAPI's (Service Access Point Identifiers)**.

**SPIDs (Service Profile Identifiers)** are also a component of Layer 2 (only BRI uses SPIDs, PRI does not). SPIDs identify two things:

- The phone number of each B channel
- The ISDN services you are entitled to.

Not all ISDN switch types require the use of SPIDs.

On the B channels, one of several Layer 2 encapsulations can be used, including HDLC, PPP, and Frame-Relay.

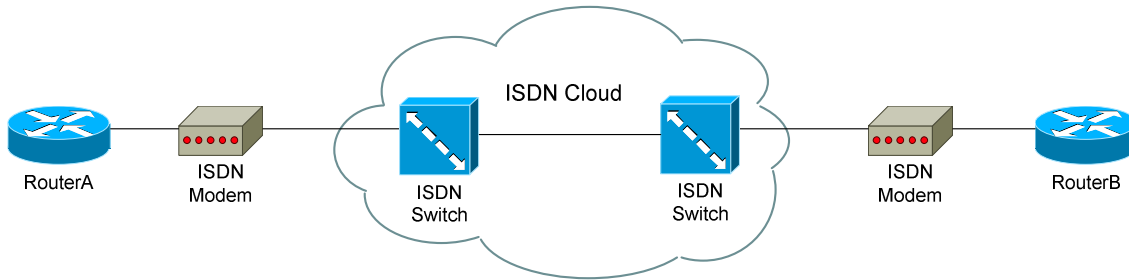
**Layer 3** utilizes just one protocol on the D Channel, **Q.931**, which controls call setup and teardown.

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## Configuring Basic ISDN BRI



Cisco routers that support ISDN will have BRI interfaces, or utilize serial interfaces for PRI connections. This guide will cover only the configuration of ISDN BRI.

The first thing that must be configured for ISDN is the *switch-type*, which can be configured either on the interface or in Global Configuration mode. The ISDN provider will indicate which ISDN switch-type is used:

```
Router(config)# isdn switch-type basic-ni
```

Other basic configuration is completed on the BRI interface:

```
Router(config)# int bri0/0
Router(config-if)# encapsulation ppp
Router(config-if)# ip address 172.16.1.1 255.255.0.0
Router(config-if)# isdn spid1 055512120100 5551212
Router(config-if)# isdn spid2 055512130100 5551213
Router(config-if)# dialer string 5552222
Router(config-if)# no shut
```

PPP is the most common encapsulation for ISDN.

The *isdn spid1* and *isdn spid2* commands identify the two B channels to the ISDN switch, and are assigned by the ISDN provider. SPIDs identify the phone number and expected services for each B Channel. Not all ISDN switch-types require SPID numbers.

The *dialer string* command contains the phone number of the remote router. This is the number that is “dialed” when the router is activating the ISDN connection.

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## ISDN Dial-on-Demand Routing (DDR)

DDR allows routers to only dial the ISDN connection when it is needed. This is accomplished by specifying “interesting” traffic, which is the only traffic that can activate the ISDN link.

To specify interesting traffic, a *dialer-list* must be create, and then applied to the BRI interface. A dialer-list is similar to an access list:

```
Router(config)# dialer-list 1 protocol ip permit
Router(config)# int bri0/0
Router(config-if)# dialer-group 1
```

The *dialer-list* command is specifying that all IP traffic is interesting, and thus can bring up the ISDN link. The *dialer-group* command applies the dialer-list to the BRI interface. Only one dialer-group command is allowed on a BRI interface.

A *dialer-list* can also point to an access-list:

```
Router(config)# dialer-list 1 protocol ip list 150
Router(config)# access-list 150 permit ip 172.16.0.0 0.0.255.255 any
Router(config)# access-list 150 permit tcp any host 172.17.1.10 eq 80
Router(config)# int bri0/0
Router(config-if)# dialer-group 1
```

Notice that the *dialer-list* points to extended access-list “150.” The first line of the access-list specifies that any traffic originating from the 172.16.x.x network is interesting. The second line of the access-list specifies that any traffic destined to the HTTP port on host 172.17.1.10 is interesting. Any traffic matching this criteria will be allowed to activate the ISDN link.

Always remember to apply the *dialer-list* with the *dialer-group* command.

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## ISDN Authentication

For additional dialing security, the *dialer map* command can be used, instead of the *dialer-string* command:

```
Router(config)# int bri0/0
Router(config-if)# dialer map ip 172.16.1.2 name RouterB 5552222
```

When the router dials *RouterB* (SPID# 5552222), the remote router's IP address and hostname must match with the *dialer map* statements, otherwise the call will not be successful.

If PPP is used for the ISDN encapsulation, additional authentication can be configured. Two forms of authentication exist for PPP:

- **PAP** (Password Authentication Protocol)
- **CHAP** (Challenge Handshake Authentication Protocol).

PAP sends username and password information in clear-text. CHAP hashes the information using MD5, and thus is the far more secure authentication method.

To configure PAP:

```
RouterA(config)# username RouterB password PASSWORD
RouterA(config)# int bri0/0
RouterA(config-if)# encapsulation ppp
RouterA(config-if)# ppp authentication pap
RouterA(config-if)# ppp pap sent-username RouterA password PASSWORD
```

The *username* command specifies the **remote** routers hostname. The *ppp papsent-username* allows us to specify the hostname the remote router should authenticate to. This is a **required** command with PAP.

To configure CHAP:

```
RouterA(config)# username RouterB password PASSWORD
RouterA(config)# int bri0/0
RouterA(config-if)# encapsulation ppp
RouterA(config-if)# ppp authentication chap
RouterA(config-if)# ppp chap hostname RouterA
```

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### Misc. ISDN Commands

```

Router(config)# int bri0/0
Router(config-if)# dialer load-threshold 128 either
Router(config-if)# dialer idle-timeout 60
Router(config-if)# ppp multilink

```

The *dialer load-threshold* command tells the router when to bring up the second “B” channel. This “load threshold” is a percentage based out of 255. The above example tells the router to bring up the second B channel when the first B channel is at 50% utilization.

The *either* argument specifies that the traffic can be either inbound or outbound. Otherwise, *inbound* or *outbound* can be specified.

The *dialer idle-timeout* command tells the router how long to wait (in seconds) after the last interesting traffic has been sent before disconnecting the ISDN link.

The *ppp multilink* command binds both B channels into one logical channel. This command can be coupled with the *dialer load-threshold* command, and the logical channel will only become active when the threshold is reached.

To always force both channels to be active when using *ppp multilink*:

```

Router(config)# int bri0/0
Router(config-if)# ppp multilink
Router(config-if)# ppp multilink links minimum 2

```

To dictate a delay period before activating or deactivating the second B channel, once the *load-threshold* has been reached:

```

Router(config)# int bri0/0
Router(config-if)# ppp timeout multilink link add 30
Router(config-if)# ppp timeout multilink link remove 45

```

To enable PPP compression on an ISDN BRI interface:

```

Router(config)# int bri0/0
Router(config-if)# compress stac
Router(config-if)# compress predictor

```

Stac (or Stacker) compression usually yields the best ratio, though it places a greater tax on the router’s CPU.

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## **PPP Callback**

PPP Callback is a security feature for ISDN, preventing unauthorized routers or devices from initiating the ISDN connection.

Callback is implemented as a client/server model. The client *requests* a callback, and the server will only *accept* this request if the client's authentication information is correct.

To configure the Callback *server*:

```
RouterA(config)# int bri0/0
RouterA(config-if)# ppp callback accept
RouterA(config-if)# dialer map ip 10.1.1.1 name RouterB class MYCLASS 2221112

RouterA(config)# map-class dialer MYCLASS
RouterA(config-map-class)# dialer callback-server username
```

To configure the Callback *client*:

```
RouterB(config)# int bri0/0
RouterB(config-if)# ppp callback request
RouterB(config-if)# dialer map ip 10.1.121 name RouterA 2221111
```

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### ISDN Backup Methods (Backup Interface)

The ISDN BRI interface can be used purely as a backup link. The interface will remain in **standby** mode, and only activate when a **monitored** interface goes into a down state.

```
Router(config)# interface serial0/0
Router(config-if)# backup interface bri0/0
Router(config-if)# backup delay 100 300
```

The *bri0/0* interface is a *backup* to the *serial0/0* interface. Once the *serial0/0* interface enters a down state, the *bri0/0* interface will activate after a delay of *100* seconds. Once the *serial0/0* interface comes back up, the *bri0/0* interface will enter a standby state after *300* seconds.

Manually shutting down the *serial0/0* interface will **not** bring the *bri0/0* interface out of standby mode. The *serial0/0* interface must be in a **down** state, not an **administratively shutdown** state.

Also, the *bri0/0* interface will never make a connection while in standby. Once taken out of standby, it will not connect until interesting traffic is sent across the link.

### ISDN Backup Methods (Dialer Watch)

Instead of monitoring an *interface*, a **watch-list** can be configured to monitor a *route*. If the monitored route is removed from the routing table, the ISDN link will be automatically activated.

```
Router(config)# dialer watch-list 1 ip 10.1.0.0 255.255.0.0
Router(config)# dialer watch-list 1 delay connect 10
Router(config)# dialer watch-list 1 delay disconnect 30
Router(config)# dialer watch-list 1 delay route-check initial 25

Router(config)# interface bri0/0
Router(config-if)# dialer idle-timeout 180
Router(config-if)# dialer watch-group 1
```

If the *10.1.0.0/16* network is removed from the routing table, the router will *connect* the ISDN link after *10* seconds. *Dialer watch* will continue checking the routing table at intervals equal to the *dialer idle-timeout*. Once the route is back in the table, the router will *disconnect* the link after *30* seconds.

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## ISDN and Routing Protocols

ISDN is a pay-per-usage technology, and thus should only be active when necessary. Routing protocols, however, are prone to activate the link unnecessarily. For example, OSPF periodically sends Hello packets to maintain neighbor adjacencies. Various mechanisms exist to allow ISDN and routing protocols to coexist.

OSPF and ISDN can coexist by configuring a *demand-circuit*:

```
Router(config)# int bri0/0
Router(config-if)# ip ospf demand-circuit
```

This prevents OSPF from sending out periodic Hellos across the ISDN link, while still maintaining neighbor relationships. This also eliminates the periodic OSPF link-state table refresh (default every 30 minutes).

The *ospf demand-circuit* only needs to be configured on one side of the link. After applying this command, only changes to the OSPF topology database will trigger the link.

**Snapshot routing** is used with Distance Vector routing protocols. Snapshot routing essentially “freezes” the routing table, preventing updates. Periodically, the routing table is “unfrozen” to allow updates to occur, and then frozen again.

When using snapshot routing, one router takes on the role of a “client,” the other takes on the role of a “server.” The client will initiate a connection with the server after a specific period of time, to allow routing updates to occur:

```
RouterA(config)# int bri0/0
RouterA(config-if)# snapshot server 3 dialer
RouterA(config-if)# dialer map snapshot 1 name RouterB 5552222

RouterB(config)# int bri0/0
RouterB(config-if)# snapshot client 3 300 dialer
RouterB(config-if)# dialer map snapshot 1 name RouterA 5551111
```

RouterB will dial RouterA after 300 minutes have passed. There will be a 3 minute period for both routers to exchange updates before the link is brought back down.

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## Configuring Dialer Interfaces

Instead of applying ISDN configuration directly to the BRI interface, a virtual interface can be created called a **dialer** interface.

This is useful when multiple BRI interfaces exist on the same router. These physical interfaces can be combined into a single logical interface using **dialer pools** or **rotary-groups**.

Example of a dialer pool configuration:

```

Router(config)# int bri0/0
Router(config-if)# encapsulation ppp
Router(config-if)# isdn spid1 333121201 3331212
Router(config-if)# dialer pool-member 1

Router(config)# int bri0/1
Router(config-if)# encapsulation ppp
Router(config-if)# isdn spid1 555111101 5551111
Router(config-if)# dialer pool-member 1

Router(config)# dialer-list 1 permit icmp any any
Router(config)# int dialer0
Router(config-if)# encapsulation ppp
Router(config-if)# dialer pool 1
Router(config-if)# ip address 10.1.1.1 255.255.0.0
Router(config-if)# dialer string 7770101
Router(config-if)# ppp authentication chap
Router(config-if)# dialer-group 1

```

Example of a rotary-group configuration:

```

Router(config)# int bri0/0
Router(config-if)# encapsulation ppp
Router(config-if)# isdn spid1 333121201 3331212
Router(config-if)# dialer rotary-group 3

Router(config)# int bri0/1
Router(config-if)# encapsulation ppp
Router(config-if)# isdn spid1 555111101 5551111
Router(config-if)# dialer rotary-group 3

Router(config)# dialer-list 1 permit icmp any any
Router(config)# int dialer3
Router(config-if)# encapsulation ppp
Router(config-if)# ip address 10.1.1.1 255.255.0.0
Router(config-if)# dialer string 7770101
Router(config-if)# ppp authentication chap
Router(config-if)# dialer-group 1

```

Notice that that the *interface dialer* number matched the *rotary-group* number.

There is one key difference between dialer pools and rotary groups. Dialer pools support **map-classes**, which can apply specific parameters to each destination called. Rotary groups do not support map-classes.

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## **Testing ISDN**

To initiate a test call on an ISDN BRI interface:

```
Router# isdn test call interface bri0/0 5552222
```

To disconnect this test call:

```
Router# isdn test disconnect interface bri0/0 all
```

## **Troubleshooting ISDN**

The *show isdn active* command displays whether a call is connected, and the number dialed.

The *show isdn status* command will display information on the status between the router and ISDN switch, including whether the SPIDs are configured correctly. This is the most useful command for troubleshooting Layer 1, 2, or 3 ISDN connectivity problems.

The *show dialer interface bri* command will also display if a call is connected, and will display previous dialing attempts and whether they were successful or not.

The *debug isdn q921* command troubleshoots communication between the router and ISDN switch.

The *debug isdn q931* command troubleshoots ISDN call setup.

The *debug dialer events* and *debug dialer packets* commands are used to troubleshoot dial setup, and whether the proper interesting traffic is activating the ISDN link.

The *isdn disconnect interface bri* command allows a currently active call to be disconnected.

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