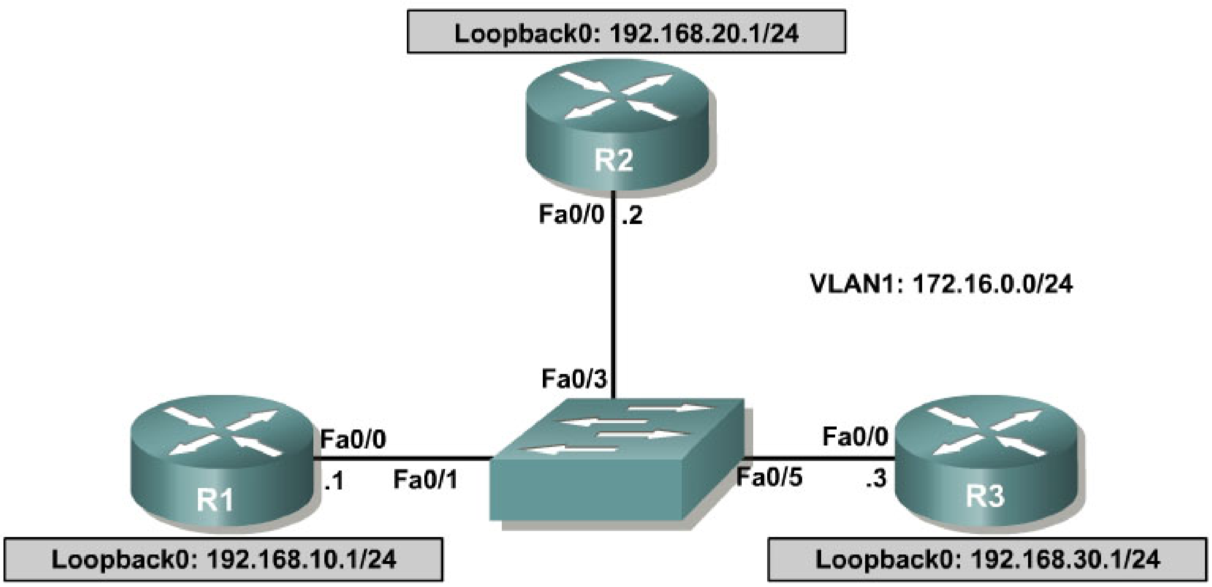
Lab 4-1 Configuring Basic Integrated IS-IS

Learning Objectives

- Configure and verify the operation of Integrated IS-IS on a router
- Configure a NET identifying a domain, area, and intermediate system
- Configure and verify Level 1 and Level 2 IS-IS adjacencies
- Verify and understand the IS-IS topology table
- Manipulate IS-IS adjacency timers
- Implement IS-IS domain and link authentication

Topology Diagram



Scenario

The IS-IS routing protocol has become increasingly popular with widespread usage among service providers. The International Travel Agency (ITA) is considering implementing IS-IS because it is a link state protocol that enables very fast convergence with large scalability and flexibility. But before making a final decision, management wants a non-production network set up to test the IS-IS routing protocol.

The backbone of the production ITA WAN consists of three routers connected by an Ethernet core. Because the routers are also connected to the Internet, authentication is needed to prevent unauthorized routers from participating in the IS-IS process.

Step 1: Addressing and Basic Connectivity

Build and configure the network according to the diagram, but do not configure IS-IS yet. Configure loopback interfaces and addresses as well.

Use **ping** to test connectivity between the directly connected Fast Ethernet interfaces. You could alternatively use the following TCL script to ping across the Fast Ethernet link:

```
foreach address {
172.16.0.1
172.16.0.2
172.16.0.3 } { ping $address }
```

Step 2: Configuring Basic IS-IS

IS-IS (ISO/IEC 10589) is implemented with network service access point (NSAP) addresses consisting of three fields: area address, system ID, and NSEL (also known as N-selector, the service identifier or the process ID). The area address field can be from one to thirteen octets, the system ID field is usually six octets (must be six for Cisco IOS), and the NSEL identifies a process on the device. It is a loose equivalent to a port or socket in IP. The NSEL is not used in routing decisions.

When the NSEL is set to 00, the NSAP is referred to as the network entity title (NET). NETs and NSAPs are represented in hexadecimal, and must start and end on a byte boundary, such as 49.0001.1111.1111.1111.00

Level 1, or L1, IS-IS routing is based on system ID. Therefore, each router must have a unique system ID within the area. L1 IS-IS routing equates to intra-area routing. It is customary to use either a MAC address from the router or, for Integrated IS-IS, to code the IP address of a loopback address, for example, into the system ID.

Area addresses starting with 48, 49, 50, or 51 are private addresses. This group of addresses should not be advertised to other connectionless network service (CLNS) networks. The area address must be the same for all routers in an area.

On a LAN, one of the routers is elected the designated intermediate system (DIS) based on interface priority. The default is 64. If all interface priorities are the same, the router with the highest subnetwork point of attachment (SNPA) address is selected. The (Ethernet) MAC address serves as the SNPA address for Ethernet LANs. The DIS serves the same purpose for IS-IS as the designated router does for OSPF. The ITA network engineer decides that R1 is the DIS, so its priority must be set higher than R2 and R3.

Now, configure Integrated IS-IS on each router and set a priority of 100 on the FastEthernet 0/0 interface of R1 as follows:

```
R1(config)# router isis
R1(config-router)# net 49.0001.1111.1111.1111.00
R1(config-router)# interface fastethernet 0/0
R1(config-if)# ip router isis
R1(config-if)# isis priority 100
R1(config-if)# interface loopback 0
R1(config-if)# ip router isis

R2(config)# router isis
R2(config-router)# net 49.0001.2222.2222.2222.00
R2(config-router)# interface fastethernet 0/0
R2(config-if)# ip router isis
R2(config-if)# interface loopback 0
R2(config-if)# ip router isis

R3(config)# router isis
R3(config-router)# net 49.0001.3333.3333.3333.00
R3(config-router)# interface fastethernet 0/0
R3(config-if)# ip router isis
R3(config-if)# interface loopback 0
R3(config-if)# ip router isis
```

1. Identify parts of the NSAP/NET addresses.

   a. Area Address:

   ____

   b. R1 System ID:

   ____

   c. R2 System ID:

   ____

   d. R3 System ID:

   ____

   e. NSEL:

   ____

Step 3: Verifying IS-IS Adjacencies and Operation

Verify IS-IS operation using **show** commands on any of the three routers. The following is output for R1:

```
R1# show ip protocols
Routing Protocol is "isis"
  Invalid after 0 seconds, hold down 0, flushed after 0
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: isis
  Address Summarization:
    None
  Maximum path: 4
```



```
  Routing for Networks:
    FastEthernet0/0
    Loopback0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.30.1         115      00:00:36
    192.168.20.1         115      00:00:36
  Distance: (default is 115)
```

Because you are also working with the OSI connectionless protocol suite, use the **show clns protocols** command to see the IS-IS protocol output:

```
R1# show clns protocols

IS-IS Router: <Null Tag>
  System Id: 1111.1111.1111.00  IS-Type: level-1-2
  Manual area address(es):
        49.0001
  Routing for area address(es):
        49.0001
  Interfaces supported by IS-IS:
        FastEthernet0/0 - IP
        Loopback0 - IP
  Redistribute:
    static (on by default)
  Distance for L2 CLNS routes: 110
  RRR level: none
  Generate narrow metrics: level-1-2
  Accept narrow metrics:   level-1-2
  Generate wide metrics:   none
  Accept wide metrics:     none
R1#
```

Notice that the update timers are set to zero (0). Updates are not sent at regular intervals because they are event driven. The Last Update field indicates how long it has been since the last update in hours:minutes:seconds.

Issue the **show clns neighbors** command to view adjacencies:

```
R1# show clns neighbors

System Id     Interface    SNPA                State  Holdtime   Type Protocol
R2            Fa0/0        0004.9ad2.d0c0      Up     9          L1L2 IS-IS
R3            Fa0/0        0002.16f4.1ba0      Up     29         L1L2 IS-IS
```

Neighbor ISs (Intermediate Systems) and neighbor ESs (End Systems) are shown, if applicable. You can use the keyword **detail** to display comprehensive neighbor information:

```
R1# show clns neighbors detail

System Id     Interface    SNPA                State  Holdtime   Type Protocol
R2            Fa0/0        0004.9ad2.d0c0      Up     24         L1L2 IS-IS
  Area Address(es): 49.0001
  IP Address(es):  172.16.0.2*
  Uptime: 00:07:30
  NSF capable
R3            Fa0/0        0002.16f4.1ba0      Up     27         L1L2 IS-IS
  Area Address(es): 49.0001
```



```
  IP Address(es):  172.16.0.3*
  Uptime: 00:07:00
  NSF capable
```

The system IDs of the IS neighbors are the hostnames of the respective neighbor routers. Starting with Cisco IOS Release 12.0(5), Cisco routers support dynamic hostname mapping. The feature is enabled by default. As seen in the sample output, the configured system ID of 2222.2222.2222 has been replaced by the hostname R2. Similarly, R3 replaces 3333.3333.3333.

The adjacency Type for both neighbors is L1L2. By default, Cisco IOS enables both L1 and L2 adjacency negotiation on IS-IS routers. You can use the router configuration mode command **is-type** or the interface configuration command **isis circuit-type** to specify how the router operates for L1 and L2 routing.

You can use the **show isis database** and **show clns interface fa0/0** commands to obtain DIS and related information. First, issue the **clear isis *** command on all routers to force IS-IS to refresh its link-state databases and recalculate all routes. A minute or two may be needed for all routers to update their respective IS-IS databases.

```
All_Router# clear isis *
```

Issue the **show isis database** command to view the content of the IS-IS database:

```
R1# show isis database

IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00            * 0x00000008   0x088F        1191              0/0/0
R1.01-00            * 0x00000002   0x9B60        1192              0/0/0
R2.00-00              0x00000001   0x8736        1190              0/0/0
R3.00-00              0x00000002   0x39A1        1195              0/0/0
IS-IS Level-2 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00            * 0x00000017   0x4E1B        1195              0/0/0
R1.01-00            * 0x00000002   0x4D37        1192              0/0/0
R2.00-00              0x00000010   0xF4B9        1191              0/0/0
R3.00-00              0x00000002   0xD703        1195              0/0/0
```

IS-IS retains a separate database for L1 and L2 routing. Because IS-IS is a link-state protocol, the link-state database should be the same for the three routers.

As discussed earlier, if the priority for R1's FastEthernet 0/0 interface had not been increased, the DIS would have been elected on the basis of the highest SNPA. DIS election is preemptive, unlike OSPF behavior. The **isis priority 100** command ensured that R1 would be elected the DIS, regardless of router boot order. But how can it be determined from the **show isis database** output that R1 is indeed the DIS?

Look at the entries under the link-state protocol data unit ID (LSPID) column. The first six octets form the system ID. As mentioned earlier, because of the dynamic host mapping feature, the respective router names are listed instead of the numerical system ID. Following the system ID are two octets.

The first octet is the pseudonode ID, representing a LAN. The pseudonode ID is used to distinguish LAN IDs on the same DIS. When this value is non-zero, the associated LSP is a pseudonode LSP originating from the DIS. The DIS is the only system that originates pseudonode LSPs. The DIS creates one pseudonode LSP for L1 and one for L2, as shown in the previous output.

The pseudonode ID varies upon reboot of the router as a function of the creation or deletion of virtual interfaces, such as loopback interfaces. The system ID and pseudonode ID together are referred to as the circuit ID. An example is R1.01.

A non-pseudonode LSP represents a router and is distinguished by the fact that the two-byte value in the circuit ID is 00.

The second octet forms the LSP fragmentation number. The value 00 indicates that all data fits into a single LSP. If there had been more information that did not fit into the first LSP, IS-IS would have created additional LSPs with increasing LSP numbers, such as 01, 02, and so on. The asterisk (*) indicates that the LSP was originated by the local system.

Issue the **show clns interface fastethernet 0/0** command:

```
R1# show clns interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Checksums enabled, MTU 1497, Encapsulation SAP
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 8 seconds
  Routing Protocol: IS-IS
    Circuit Type: level-1-2
    Interface number 0x0, local circuit ID 0x1
    Level-1 Metric: 10, Priority: 100, Circuit ID: R1.01
    DR ID: R1.01
    Level-1 IPv6 Metric: 10
    Number of active level-1 adjacencies: 2
    Level-2 Metric: 10, Priority: 100, Circuit ID: R1.01
    DR ID: R1.01
    Level-2 IPv6 Metric: 10
    Number of active level-2 adjacencies: 2
    Next IS-IS LAN Level-1 Hello in 803 milliseconds
    Next IS-IS LAN Level-2 Hello in 2 seconds
```

Notice that the circuit ID, R1.01, which is made up of the system and pseudonode IDs, identifies the DIS. Circuit Types, Levels, Metric, and Priority information is also displayed.

You can obtain additional information about a specific LSP ID by appending the LSP ID and **detail** keyword to the **show isis database** command, as shown in the output. The hostname is case sensitive. You can also use this command to view the IS-IS database of a neighbor router by including its hostname in the command.

```
R1# show isis database R1.00-00 detail

IS-IS Level-1 LSP R1.00-00
LSPID            LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00       * 0x0000000B   0x0292        831               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname: R1
  IP Address:   192.168.10.1
  Metric: 10         IP 172.16.0.0 255.255.255.0
  Metric: 10         IP 192.168.10.0 255.255.255.0
  Metric: 10         IS R1.02
  Metric: 10         IS R1.01

IS-IS Level-2 LSP R1.00-00
LSPID            LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00       * 0x0000000D   0x4703        709               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname: R1
  IP Address:   192.168.10.1
  Metric: 10         IS R1.02
  Metric: 10         IS R1.01
  Metric: 20         IP 192.168.30.0 255.255.255.0
  Metric: 10         IP 192.168.10.0 255.255.255.0
  Metric: 10         IP 172.16.0.0 255.255.255.0
  Metric: 20         IP 192.168.20.0 255.255.255.0
```

The default IS-IS metric for every link is 10, but notice that the metrics for the 192.168.20.0 and 192.168.30.0 networks are both 20. This is because the networks are not directly connected, but are directly connected to neighbor routers.

Issue the **show isis topology** command to display the paths to the other intermediate systems:

```
R1# show isis topology

IS-IS paths to level-1 routers
System Id     Metric  Next-Hop        Interface    SNPA
R1            --
R2            10      R2              Fa0/0        0004.9ad2.d0c0
R3            10      R3              Fa0/0        0002.16f4.1ba0

IS-IS paths to level-2 routers
System Id     Metric  Next-Hop        Interface    SNPA
R1            --
R2            10      R2              Fa0/0        0004.9ad2.d0c0
R3            10      R3              Fa0/0        0002.16f4.1ba0
```

The highlighted entries in the SNPA column are the MAC addresses of the R2 and R3 FastEthernet 0/0 interfaces.

Issue the **show isis route** command to view the IS-IS L1 routing table:


```
R1# show isis route

IS-IS not running in OSI mode (*) (only calculating IP routes)

(*) Use "show isis topology" command to display paths to all routers
```

This command has no useful output because it is specific to OSI routing. Remember, IP IS-IS was enabled on each router. If CLNP were configured in the network, more interesting output would appear.

Issue the **show clns route** command to view the IS-IS L2 routing table:

```
R1# show clns route
Codes: C - connected, S - static, d - DecnetIV
       I - ISO-IGRP,  i - IS-IS,  e - ES-IS
       B - BGP,       b - eBGP-neighbor

C  49.0001.1111.1111.1111.00 [1/0], Local IS-IS NET
C  49.0001 [2/0], Local IS-IS Area
```

Again, there is no useful output because this command applies to OSI routing and not IP routing.

Issue the **show ip route** command to view the IP routing table:

```
R1# show ip route
<output omitted>

Gateway of last resort is not set

i L1 192.168.30.0/24 [115/20] via 172.16.0.3, FastEthernet0/0
C    192.168.10.0/24 is directly connected, Loopback0
     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.0.0 is directly connected, FastEthernet0/0
i L1 192.168.20.0/24 [115/20] via 172.16.0.2, FastEthernet0/0
```

Notice how the routes to the 192.168.30.0 and 192.168.20.0 networks were learned.

The **show clns neighbors, show isis database, show clns interface, show isis topology, show isis route,** and **show clns route** commands illustrate the somewhat confusing nature of IS-IS verification and troubleshooting. There is no clear pattern as to whether incorporation of the keyword **isis** or **clns** in a **show** command applies to IP routing or to OSI routing.

Step 4: Converting to the IS-IS Backbone

L1 routers communicate with other L1 routers in the same area, while L2 routers route between L1 areas, forming an interdomain routing backbone. This lab scenario does not illustrate the typical multi-area composition of the set of L2 routers in an IS-IS domain, because the routers all reside in Area 49.0001. Since the main function of the San Jose routers is to route between areas in the ITA internetwork, they should be configured as L2-only routers as follows:


```
R1(config)# router isis
R1(config-router)# is-type level-2-only

R2(config)# router isis
R2(config-router)# is-type level-2-only

R3(config)# router isis
R3(config-router)# is-type level-2-only
```

To see the effect of the **is-type** command, reenter the previous commands: **show ip protocols**, **show clns neighbors**, **show isis database**, **show clns interface fastethernet 0/0**, **show isis database R1.00-00 detail**, **show isis topology**, and **show ip route**. Here are the sample outputs:

```
R1# show ip protocols
Routing Protocol is "isis"
  Invalid after 0 seconds, hold down 0, flushed after 0
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: isis
  Address Summarization:
    None
  Maximum path: 4
  Routing for Networks:
    Loopback0
    FastEthernet0/0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.30.1         115      00:08:48
    192.168.20.1         115      00:00:09
  Distance: (default is 115)

R1# show clns neighbors

System Id     Interface    SNPA                State  Holdtime  Type Protocol
R2            Fa0/0        0004.9ad2.d0c0      Up     26        L2   IS-IS
R3            Fa0/0        0002.16f4.1ba0      Up     22        L2   IS-IS

R1# show isis database

IS-IS Level-2 Link State Database:
LSPID            LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00       * 0x00000001   0x623C        1086              0/0/0
R1.01-00       * 0x0000000F   0x3344        1092              0/0/0
R2.00-00         0x00000001   0x13AA        1091              0/0/0
R3.00-00         0x00000002   0xD703        1096              0/0/0
```

If the LSP ID is seen with an LSP Holdtime of 0 followed by a parenthetical value, that rogue entry can be purged with the **clear isis *** command.

```
R1# show clns interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Checksums enabled, MTU 1497, Encapsulation SAP
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 16 seconds
  Routing Protocol: IS-IS
```



```
Circuit Type: level-1-2
DR ID: R1.02
Level-2 IPv6 Metric: 10
Interface number 0x0, local circuit ID 0x1
Level-2 Metric: 10, Priority: 100, Circuit ID: R1.01
Number of active level-2 adjacencies: 2
Next IS-IS LAN Level-2 Hello in 2 seconds
```

Even though the Circuit Type is level-1-2, the entries following the Circuit Type show that only L2 operations are taking place.

```
R1# show isis database R1.00-00 detail

IS-IS Level-2 LSP R1.00-00
LSPID            LSP Seq Num   LSP Checksum   LSP Holdtime      ATT/P/OL
R1.00-00       * 0x00000001    0x623C         892               0/0/0
  Area Address: 49.0001
  NLPID:         0xCC
  Hostname: R1
  IP Address:    192.168.10.1
  Metric: 10          IS R1.02
  Metric: 10          IS R1.01
  Metric: 10          IP 192.168.10.0 255.255.255.0
  Metric: 10          IP 172.16.0.0 255.255.255.0
```

The output shows that the IDs, R1.02 and R.01, are used to number the router interfaces participating in IS-IS. This is also seen in the **show clns interface** output.

```
R1# show isis topology

IS-IS paths to level-2 routers
System Id     Metric  Next-Hop        Interface   SNPA
R1            --
R2            10      R2              Fa0/0       0004.9ad2.d0c0
R3            10      R3              Fa0/0       0002.16f4.1ba0

R1# show ip route
<output omitted>

Gateway of last resort is not set

i L2 192.168.30.0/24 [115/20] via 172.16.0.3, FastEthernet0/0
C    192.168.10.0/24 is directly connected, Loopback0
     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.0.0 is directly connected, FastEthernet0/0
i L2 192.168.20.0/24 [115/20] via 172.16.0.2, FastEthernet0/0
```

What types of routes are being placed into the routing table?

Step 5: Manipulating the IS-IS Interface Timers

The default value of the hello interval is 10 seconds, and the default value of the hello multiplier is 3. The hello multiplier specifies the number of IS-IS hello

PDUs a neighbor must miss before the router declares the adjacency as down. With the default hello interval of 10 seconds, it takes 30 seconds for an adjacency to be declared down due to missed hello PDUs. The analogous OSPF settings are controlled by the **ip ospf hello-interval** and **ip ospf dead-interval** interface commands.

A decision is made to adjust the IS-IS timers so that the core routers detect network failures in less time. This will increase traffic, but this is much less of a concern on the high-speed core Ethernet segment than on a busy WAN link. It is determined that the need for quick convergence on the core outweighs the negative effect of extra control traffic. Change the hello interval to 5 on all FastEthernet 0/0 interfaces, as shown below for the R1 router:

```
R1(config)# interface fastethernet 0/0
R1(config-if)# isis hello-interval 5
```

3. How long will it take for an adjacency to be declared down with the new hello interval of 5?

____

Step 6: Implementing IS-IS L2 Core Authentication

There should not be any unauthorized routers forming adjacencies within the IS-IS core. Adding authentication to each IS-IS enabled interface can help to ensure this.

Configure interface authentication on R1:

```
R1(config)# interface FastEthernet 0/0
R1(config-if)# isis password cisco level-2
```

This command prevents unauthorized routers from forming level-2 adjacencies with this router.

Important: Be sure to add the keyword **level-2**, which refers to the level-2 database, not an encryption level. If you do not specify a keyword, the default is level-1. Keep in mind that the passwords are exchanged in clear text and provide only limited security.

Wait 20 seconds and then issue the **show clns neighbors** command on R1.

4. Does R1 still show that it has IS-IS neighbors? Why or why not?

____

____

Issue the **debug isis adj-packets** command to verify that R1 does not recognize its neighbors, because it requires authentication that has not been configured on R2 and R3 yet.

```
R1# debug isis adj-packets
IS-IS Adjacency related packets debugging is on
03:22:28: ISIS-Adj: Sending L2 LAN IIH on FastEthernet0/0, length 1497
03:22:29: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
03:22:30: ISIS-Adj: Sending L2 LAN IIH on FastEthernet0/0, length 1497
03:22:31: ISIS-Adj: Rec L2 IIH from 0004.9ad2.d0c0 (FastEthernet0/0), cir type
L2, cir id 1111.1111.1111.01, length 1497
03:22:31: ISIS-Adj: Authentication failed
```

IS-IS routers do not communicate unless the authentication parameters match. However, many other interface-specific IS-IS parameters can vary on a given segment without disrupting communication, such as those set by the commands **isis hello-interval, isis hello-multiplier, isis retransmit-interval, isis retransmit-throttle-interval,** and **isis csnp-interval**. Of course, it makes sense for these parameters to coincide on a given segment.

Correct the authentication mismatch by configuring interface authentication on R2 and R3. After the configurations are complete, verify that the routers can communicate by using the **show clns neighbors** command on R1.

```
R2(config)# interface FastEthernet 0/0
R2(config-if)# isis password cisco level-2

R3(config)# interface FastEthernet 0/0
R3(config-if)# isis password cisco level-2

R1# show clns neighbors

System Id Interface   SNPA                State  Holdtime   Type Protocol
R2        Fa0/0       0004.9ad2.d0c0      Up     23         L2   IS-IS
R3        Fa0/0       0002.16f4.1ba0      Up     26         L2   IS-IS
```

In time, the system IDs resolve to the router names. This is done through the dynamic hostname mapping feature automatically enabled on Cisco routers. In the interim, the output may appear with the actual numerical ID for that system.

Step 7: Implementing IS-IS Domain Authentication

IS-IS provides two additional layers of authentication, area passwords for L1 and domain passwords for L2, to prevent unauthorized adjacencies between routers. The interface, area, and domain password options all use plain text authentication and, therefore, are of limited use. However, beginning with Cisco IOS Release 12.2(13)T, MD5 authentication is available for IS-IS.

The command for L1 password authentication is **area-password** *password*. Using this command on all routers in an area prevents unauthorized routers from injecting false routing information into the L1 database.

The command for L2 password authentication is **domain-password** *password*. Using this command on all L2 routers in a domain prevents unauthorized routers from injecting false routing information into the L2 database. Since the core routers are operating at L2, implement domain password authentication as follows:

```
R1(config)# router isis
R1(config-router)# domain-password cisco
```

The password is case-sensitive. Time permitting, intentionally configure mismatched interface passwords. Do the same for area, and domain passwords. By seeing the way in which the router responds, it will be easier for you to spot this error when you unintentionally mismatch passwords in a production network.

Refresh the IS-IS link-state database and recalculate all routes using the **clear isis *** command on all routers. It may take a minute or two for all routers to update their databases.

```
All_Router# clear isis *
```

Use the **show isis database** command to view the changes to the R1 link-state database:

```
R1# show isis database

IS-IS Level-2 Link State Database:
LSPID            LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00       * 0x00000004   0xDCB5        1155              0/0/0
R1.01-00       * 0x00000007   0xB4C1        1156              0/0/0
```

Change the other routers to reflect the new authentication policy:

```
R2(config)# router isis
R2(config-router)# domain-password cisco

R3(config)# router isis
R3(config-router)# domain-password cisco
```

View the R1 link-state database to verify that the LSPs were propagated:

```
R1# show isis database

IS-IS Level-2 Link State Database:
LSPID            LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00       * 0x00000001   0xE2B2        1189              0/0/0
R1.01-00       * 0x00000002   0xBEBC        1195              0/0/0
R2.00-00         0x00000002   0x5A59        1190              0/0/0
R3.00-00         0x00000002   0xF3DD        1185              0/0/0
```

The configuration of basic Integrated IS-IS routing protocol is now complete. In addition to enabling Integrated IS-IS, L2-specific routing was enabled, and the hello interval was changed to enable IS-IS to detect network failures faster. Two types of password authentication, interface and domain, were enabled to prevent unauthorized routers from forming adjacencies with these core routers.

Run the TCL script to verify full connectivity after implementing L2 authentication:

```
foreach address {
192.168.10.1
172.16.0.1
192.168.20.1
172.16.0.2
192.168.30.1
172.16.0.3 } { ping $address }
```

Save the R1 and R2 configurations for use with the next lab.

Appendix A: TCL Script Output

```
R1# tclsh
R1(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#172.16.0.1
+>(tcl)#192.168.20.1
+>(tcl)#172.16.0.2
+>(tcl)#192.168.30.1
+>(tcl)#172.16.0.3 } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
R1(tcl)# tclquit

R2# tclsh
R2(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#172.16.0.1
+>(tcl)#192.168.20.1
+>(tcl)#172.16.0.2
+>(tcl)#192.168.30.1
+>(tcl)#172.16.0.3 } { ping $address }
```



```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
R2(tcl)# tclquit

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
R3(tcl)# tclquit
```

Final Configurations

```
R1# show run
Building configuration...

Current configuration : 1290 bytes
!
version 12.4
!
hostname R1
!
```



```
interface Loopback0
 ip address 192.168.10.1 255.255.255.0
 ip router isis
!
interface FastEthernet0/0
 ip address 172.16.0.1 255.255.255.0
 ip router isis
 duplex auto
 speed auto
 isis password cisco level-2
 isis priority 100
 isis hello-interval 5
!
router isis
 net 49.0001.1111.1111.1111.00
 is-type level-2-only
 domain-password cisco
!
end


R2# show run
Building configuration...

Current configuration : 1044 bytes
!
version 12.4
!
hostname R2
!
interface Loopback0
 ip address 192.168.20.1 255.255.255.0
 ip router isis
!
interface FastEthernet0/0
 ip address 172.16.0.2 255.255.255.0
 ip router isis
 duplex auto
 speed auto
 isis password cisco level-2
 isis priority 100
 isis hello-interval 5
!
router isis
 net 49.0001.2222.2222.2222.00
 is-type level-2-only
 domain-password cisco
!
end

R3# show run
Building configuration...

Current configuration : 1182 bytes
!
version 12.4
!
hostname R3
!
interface Loopback0
 ip address 192.168.30.1 255.255.255.0
 ip router isis
!
```



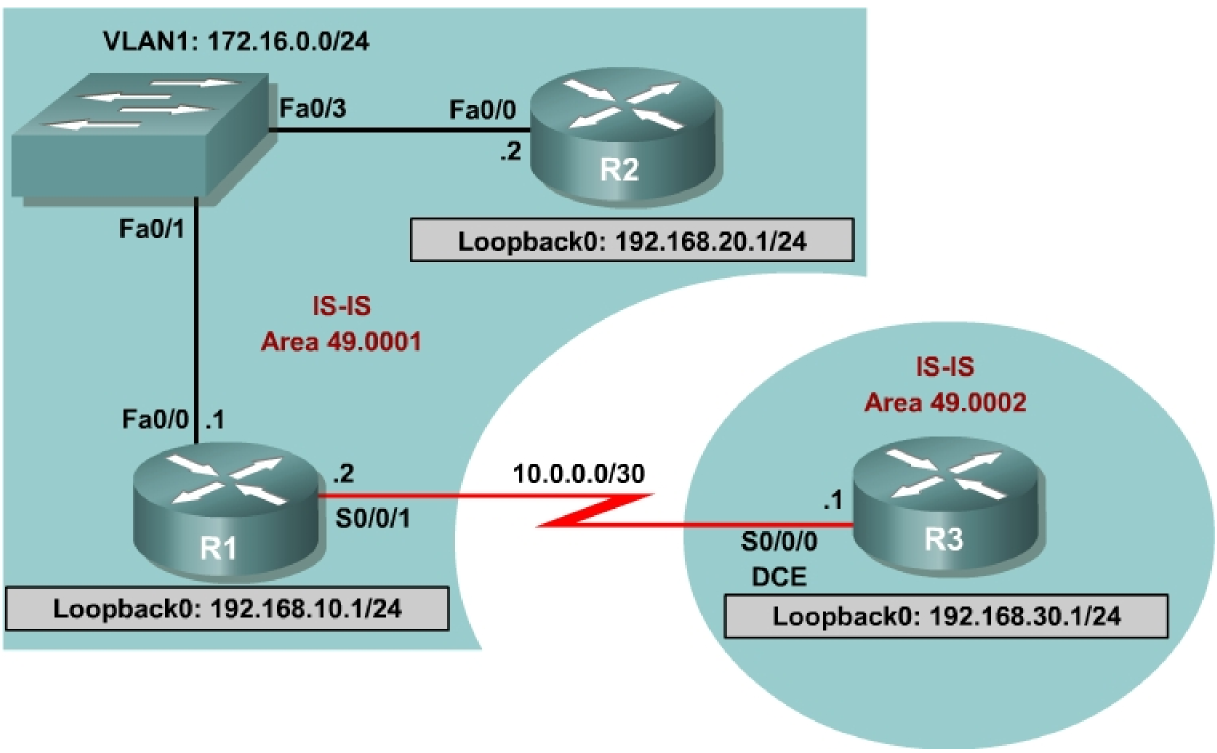
```
interface FastEthernet0/0
 ip address 172.16.0.3 255.255.255.0
 ip router isis
 duplex auto
 speed auto
 isis password cisco level-2
 isis priority 100
 isis hello-interval 5
!
router isis
 net 49.0001.3333.3333.3333.00
 is-type level-2-only
 domain-password cisco
!
end
```


Lab 4-2 Multi-Area Integrated IS-IS

Learning Objectives

- Configure multi-area integrated IS-IS
- Review configuration of IS-IS Level 1 and Level 2 intermediate systems
- Verify IS-IS adjacencies and view the IS-IS database
- Review IS-IS domain authentication
- Verify intra-area IS-IS operation

Topology Diagram



Scenario

Previous tests demonstrated that Integrated IS-IS works well with Level 2 routers in the International Travel Agency (ITA) Ethernet core. Management now wants to establish a point-to-point connection between a new R3 office and R1. R3 is in a different area from the core, so R2 will now be configured as an L1 router, R1 as an L1-L2 router, and R3 as an L2 router.

Start with the final configurations for R1 and R2 from the first IS-IS lab.

Step 1: Addressing and Initial Configuration

Load the R1 and R2 configurations from the previous lab. Add to the configuration of R1, the IP address for interface serial 0/0/1.

R1:

```
R1(config)# interface serial 0/0/1
R1(config-if)# ip address 10.0.0.2 255.255.255.252
R1(config-if)# no shutdown
R1(config-if)# exit
```

Do not load the R3 configurations from the previous lab. You should start with a fresh configuration on R3, so clear and reload the router that is to be used as R3. Configure the IP address and clock rate on R3's serial interface. Configure the hostname, turn off DNS lookup, configure the IP address on the serial interface, and configure the loopback IP address on R3.

R3:

```
Router(config)# hostname R3
R3(config)# no ip domain-lookup
R3(config)# interface serial 0/0/0
R3(config-if)# ip address 10.0.0.l 255.255.255.252
R3(config-if)# clockrate 128000
R3(config-if)# no shutdown
R3(config-if)# interface loopback 0
R3(config-if)# ip address 192.168.30.1 255.255.255.0
```

Use **ping** to verify connectivity between the directly connected interfaces. R1 should also be able to reach the loopback address of R2 and vice versa.

Step 2: Verify IS-IS Initial Operation

Recall from Lab 4.1 that R1 was configured to be the DIS by setting the **isis priority** to 100 on the FastEthernet 0/0 interface. R1 and R2 were also configured to be Level 2-only routers. Verify the configuration by issuing the **show clns neighbors** and **show isis database** commands on either router.

Note: It is recommended to issue a **clear isis *** command to force IS-IS to update its database. An alternative way to force IS-IS to update its database, is to save your configurations and reload the routers.

```
R1# show clns neighbors

System Id  Interface   SNPA                State  Holdtime   Type Protocol
R2         Fa0/0       0004.9ad2.d0c0      Up     12         L2   IS-IS


R1# show isis database

IS-IS Level-2 Link State Database:
LSPID             LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
```



```
R1.00-00      * 0x00000014   0xBCC5        409              0/0/0
R1.01-00      * 0x00000015   0x1B0D        819              0/0/0
R2.00-00        0x00000016   0x326D        698              0/0/0
```

Notice that the neighbor Type is still L2. There is only one L2 link-state database, and R1 is still the DIS. LSPID R1.01-00 has a non-zero pseudonode ID. The LSPID may appear as R1.02-00, depending on the timing of the configuration of the loopback interface.

Step 3: Configure IS-IS Area 2

Configure IS-IS on R3, area 2, and on the Serial 0/0/1 interface of R1:

R3:

```
R3(config)# router isis
R3(config-router)# net 49.0002.3333.3333.3333.00
R3(config-router)# interface serial 0/0/0
R3(config-if)# ip router isis
R3(config-if)# interface loopback 0
R3(config-if)# ip router isis
```

R1:

```
R1(config)# interface serial 0/0/1
R1(config-if)# ip router isis
```

Which IS-IS level is the link between R1 and R3?

Step 4: Verify IS-IS Multi-Area Operation

Verify IS-IS operation between R1 and R3 by pinging the loopback addresses on R1 and R2 from R3. The ping should be successful. Issue **show** commands on R3 as shown in the following examples.

```
R3# show clns neighbor

System Id      Interface   SNPA                State  Holdtime   Type Protocol
R1             Se0/0/0     *HDLC*              Up     28         L2   IS-IS
```

Because serial interfaces do not have a MAC address, the encapsulation type for the serial link is listed in the SNPA column.

```
R3# show isis database

IS-IS Level-1 Link State Database:
LSPID           LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R3.00-00      * 0x00000009   0x8FFA        1180              1/0/0
IS-IS Level-2 Link State Database:
LSPID           LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00        0x0000001C   0x25EC        1174              0/0/0
R1.01-00        0x00000017   0x170F        965               0/0/0
```



```
R2.00-00          0x00000018   0x2E6F        794              0/0/0
R3.00-00        * 0x00000008   0x4551        1176             0/0/0
```

By default, R3 is an L1-L2 router, so it retains a separate link-state database for each level. R1 is also identified as the DIS. R1 and R2 are not listed in the IS-IS Level 1 link-state database, because both were previously configured as L2-only routers.

```
R3# show clns interface serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Checksums enabled, MTU 1500, Encapsulation HDLC
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 26 seconds
  Routing Protocol: IS-IS
    Circuit Type: level-1-2
    Interface number 0x0, local circuit ID 0x100
    Neighbor System-ID: R1
    Level-1 Metric: 10, Priority: 64, Circuit ID: R3.00
    Level-1 IPv6 Metric: 10
    Number of active level-1 adjacencies: 0
    Level-2 Metric: 10, Priority: 64, Circuit ID: R3.00
    Level-2 IPv6 Metric: 10
    Number of active level-2 adjacencies: 1
    Next IS-IS Hello in 5 seconds
    if state UP
```

Note that the circuit ID is R3.00.

From R1, **ping 192.168.30.1** on R3. The ping should not be successful.

```
R1# ping 192.168.30.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
.....
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
```

Why do you think the ping was unsuccessful?

Check the IP routing table of R1 and R3:

```
R1# show ip route
<output omitted>

Gateway of last resort is not set

C    192.168.10.0/24 is directly connected, FastEthernet0/1
     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.0.0 is directly connected, FastEthernet0/0
i L2 192.168.20.0/24 [115/20] via 172.16.0.2, FastEthernet0/0
     10.0.0.0/30 is subnetted, 1 subnets
```



```
C       10.0.0.0 is directly connected, Serial0/0/1
```

```
R3# show ip route
<output omitted>

Gateway of last resort is not set

C    192.168.30.0/24 is directly connected, Loopback0
i L2 192.168.10.0/24 [115/20] via 10.0.0.2, Serial0/0/0
     172.16.0.0/24 is subnetted, 1 subnets
i L2    172.16.0.0 [115/20] via 10.0.0.2, Serial0/0/0
i L2 192.168.20.0/24 [115/30] via 10.0.0.2, Serial0/0/0
     10.0.0.0/30 is subnetted, 1 subnets
C       10.0.0.0 is directly connected, Serial0/0/0
```

Which IS-IS routes are missing on R1?

All prior checks indicated that IS-IS was working properly between R1 and R3. However, there is no entry in the routing table for the 192.168.30.0 network. The next step will demonstrate why this is the case.

Step 5: Configure IS-IS Domain Authentication

During Step 3, you may have seen the following output message:

```
R1#
*Oct  9 23:56:53.275: %CLNS-4-AUTH_FAIL: ISIS: LSP authentication failed
```

Recall that domain password authentication was configured on both R1 and R2. If domain authentication is to be retained, R3 also needs to be configured appropriately, as follows:

```
R3(config)# router isis
R3(config-router)# domain-password cisco
```

What is this password used to authenticate?

Now examine the routing table of either R1 or R2. A sample for R1 is shown:

```
R1# show ip route
<output omitted>

Gateway of last resort is not set

i L2 192.168.30.0/24 [115/20] via 10.0.0.1, Serial0/0/1
C    192.168.10.0/24 is directly connected, FastEthernet0/1
     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.0.0 is directly connected, FastEthernet0/0
```



```
i L2 192.168.20.0/24 [115/20] via 172.16.0.2, FastEthernet0/0
     10.0.0.0/30 is subnetted, 1 subnets
C       10.0.0.0 is directly connected, Serial0/0/1
```

The route to 192.168.30.0 now appears and a **ping** from R1 or R2 to 192.168.30.1 should be successful.

```
R1# ping 192.168.30.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
```

Step 6: Reconfigure IS-IS Area 1

In the current state of configuration, which IS-IS levels are each of the routers speaking?

R1:

R2:

R3:

In this topology, R1 is an L1-L2 router. However, R1 was previously configured as an L2-only router. Reconfigure R1 to be an L1-L2 router.

```
R1(config)# router isis
R1(config-router)# no is-type
R1(config-router)# ! this will set the router to its default level (L1L2)
or
R1(config-router)# is-type level-1-2
```

In this topology, R2 is a Level 1-only router. However, R2 was also configured as a Level 2-only router. Reconfigure R2 to be a Level 1-only router.

```
R2(config)# router isis
R2(config-router)# is-type level-1
```

Note that the **level-1** command does not use –**only**, which is required for the **is-type level-2-only** command

An interface password authentication for L2 was also configured on R1 and R2. Since R2 is now an L1-only router, making the link with R1 an L1 connection, the interface password authentication must be changed to L1.

```
R1(config)# interface fastethernet0/0
R1(config-if)# isis password cisco level-1

R2(config)# interface fastethernet0/0
R2(config-if)# isis password cisco level-1
```


Verify authentication from R1 with **ping 192.168.20.1**. The ping should be successful.

```
R1# ping 192.168.20.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
```

Issue the **clear isis *** command on all routers to force IS-IS to recalculate routers and to refresh its link-state databases. Wait a minute or two before issuing the **show** commands on R1 to verify that the changes were made.

```
Router# clear isis *

R1# show clns neighbors

System Id  Interface   SNPA                State  Holdtime  Type Protocol
R2         Fa0/0       0004.9ad2.d0c0      Up     14        L1   IS-IS
R3         Se0/0/1     *HDLC*              Up     23        L2   IS-IS
```

R2 is shown as an L1 router. Although R3 is an L1-L2 router, it shows up as type L2 because of the inter-area connection between R3 and R1.

```
R1# show isis database

IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00            * 0x00000002   0xDC22        1187              0/0/0
R1.01-00            * 0x00000002   0xBDFD        1188              0/0/0
R2.00-00              0x00000002   0x833B        1187              0/0/0
IS-IS Level-2 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00            * 0x00000005   0xD732        1198              0/0/0
R3.00-00              0x00000004   0xD7B9        1193              0/0/0
```

The presence of L1 and L2 link-state databases confirm that R1 is now an L1-L2 router.

```
R1# show clns interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Checksums enabled, MTU 1497, Encapsulation SAP
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 36 seconds
  Routing Protocol: IS-IS
    Circuit Type: level-1-2
    Interface number 0x0, local circuit ID 0x1
    Level-1 Metric: 10, Priority: 100, Circuit ID: R1.01
    DR ID: R1.02
    Level-1 IPv6 Metric: 10
    Number of active level-1 adjacencies: 1
    Level-2 Metric: 10, Priority: 100, Circuit ID: R1.01
    DR ID: 0000.0000.0000.00
    Level-2 IPv6 Metric: 10
    Number of active level-2 adjacencies: 0
```



```
    Next IS-IS LAN Level-1 Hello in 938 milliseconds
    Next IS-IS LAN Level-2 Hello in 74 milliseconds
```

In addition to confirming that R1 is an L1-L2 router, the priority of 100 and the R1.01 circuit ID indicate that R1 is the DIS. This would be the same for R1.02, as noted in Step 2.

Issue the **show clns neighbors** command to obtain neighbor adjacency information for R2:

```
R2# show clns neighbors

System Id  Interface   SNPA                State  Holdtime  Type Protocol
R1         Fa0/0       0002.16de.3440      Up     4         L1   IS-IS
```

Although R1 is an L1-L2 router, the adjacency is an L1 connection.

```
R2# show isis database

IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00              0x0000001C   0xB02C        1024              1/0/0
R1.01-00              0x0000001C   0x8918        1112              0/0/0
R2.00-00            * 0x0000001B   0x5154        554               0/0/0
```

Only an L1 link-state database is maintained, confirming that R2 is now an L1-only router.

```
R2# show clns interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Checksums enabled, MTU 1497, Encapsulation SAP
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 41 seconds
  Routing Protocol: IS-IS
    Circuit Type: level-1-2
    Interface number 0x1, local circuit ID 0x2
    Level-1 Metric: 10, Priority: 64, Circuit ID: R1.01
    Number of active level-1 adjacencies: 1
    Next IS-IS LAN Level-1 Hello in 2 seconds
```

In addition to confirming R2 is an L1-only router, the circuit ID shows that R1 is the DIS.

Step 7: Reconfigure R3 IS-IS Operation

Issue the **show clns interface serial0/0/0** command on the R3 router:

```
R3# show clns interface serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Checksums enabled, MTU 1500, Encapsulation HDLC
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 22 seconds
```



```
  Routing Protocol: IS-IS
    Circuit Type: level-1-2
    Interface number 0x0, local circuit ID 0x100
    Neighbor System-ID: 1111.1111.1111
    Level-1 Metric: 10, Priority: 64, Circuit ID: R3.00
    Level-1 IPv6 Metric: 10
    Number of active level-1 adjacencies: 0
    Level-2 Metric: 10, Priority: 64, Circuit ID: R3.00
    Level-2 IPv6 Metric: 10
    Number of active level-2 adjacencies: 1
    Next IS-IS Hello in 6 seconds
    if state UP
```

Since R3 is presently an L1-L2 router, it maintains information for both levels. This is unnecessary, since R3 should be an L2-only router. Configure R3 for L2-only routing:

```
R3(config)# router isis
R3(config-router)# is-type level-2-only
```

Verify the configuration with the **show clns interface serial0/0/0** or **show isis database** command:

```
R3# show clns interface serial0/0/0
Serial0/0/0 is up, line protocol is up
  Checksums enabled, MTU 1500, Encapsulation HDLC
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 24 seconds
  Routing Protocol: IS-IS
    Circuit Type: level-1-2
    Interface number 0x0, local circuit ID 0x100
    Neighbor System-ID: R1
    Level-2 Metric: 10, Priority: 64, Circuit ID: R3.00
    Level-2 IPv6 Metric: 10
    Number of active level-2 adjacencies: 1
    Next IS-IS Hello in 6 seconds
    if state UP


R3# show isis database

IS-IS Level-2 Link State Database:
LSPID           LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00          0x00000021   0x9F4E        1117              0/0/0
R3.00-00        * 0x00000021   0x9DD6        1119              0/0/0
```

Both outputs show only L2 information, confirming R3 is now an L2-only router.

A successful ping from R3 to 192.168.20.1 indicates that multi-area Integrated IS-IS with authentication has been properly configured:

```
R3# ping 192.168.20.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/15/16 ms
```


Step 8: Verify IS-IS Intra-Area Operation

Issue the **show ip route** command on R2:

```
R2# show ip route
<output omitted>

Gateway of last resort is 172.16.0.1 to network 0.0.0.0

i L1 192.168.10.0/24 [115/20] via 172.16.0.1, FastEthernet0/0
     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.0.0 is directly connected, FastEthernet0/0
C    192.168.20.0/24 is directly connected, Loopback0
     10.0.0.0/30 is subnetted, 1 subnets
i L1    10.0.0.0 [115/20] via 172.16.0.1, FastEthernet0/0
i*L1 0.0.0.0/0 [115/10] via 172.16.0.1, FastEthernet0/0
```

The R2 routing table shown would have included an entry for 192.168.30.0 as an L2 route if R2 had been left as an L2-only router. However, since it was changed to an L1-only router, it no longer has any L2 routes.

Note that the gateway of last resort has been set in the R2 routing table. L1-only routers, such as R2, always learn a default route from a neighboring L1-L2 router. In this case it was R1. This is a standard operating procedure for Integrated IS-IS. R2 learns to exit area 49.0001 via R1 because the attached bit (ATT) is set in the L1 non-pseudonode LSP sent by R1.

Issue the **show isis database** command on R2:

```
R2# show isis database

IS-IS Level-1 Link State Database:
LSPID                LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00             0x0000001F   0xAA2F        690               1/0/0
R1.01-00             0x0000001E   0x851A        900               0/0/0
R2.00-00           * 0x0000001E   0x4B57        934               0/0/0
```

The attached bit indicates that R1 is also an L2 router and can reach other areas.

The attached bit can also be seen in the R1 L1 link-state database:

```
R1#show isis database

IS-IS Level-1 Link State Database:
LSPID                LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00           * 0x0000001F   0xAA2F        640               1/0/0
R1.01-00           * 0x0000001E   0x851A        849               0/0/0
R2.00-00             0x0000001E   0x4B57        879               0/0/0
IS-IS Level-2 Link State Database:
LSPID                LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
R1.00-00           * 0x00000022   0x9D4F        583               0/0/0
R1.01-00           * 0x0000001D   0x5128        890               0/0/0
R3.00-00             0x00000022   0x9BD7        584               0/0/0
```

Verify that your configurations work completely with the following TCL script:


```
foreach address {
192.168.10.1
172.16.0.1
10.0.0.1
192.168.20.1
172.16.0.2
192.168.30.1
10.0.0.2 } { ping $address }
```

Save all configurations for future reference.

Reflection

Even though R2 and R3 were configured as L1-only and L2-only routers, respectively, they could have been left with the default setting of L1-L2. The result would have been each forming adjacencies for both levels, but unnecessarily. Why should unnecessary IS-IS adjacencies be eliminated?

Appendix A: TCL Script Output

```
R1# tclsh
R1(tcl)#
R1(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#172.16.0.1
+>(tcl)#10.0.0.1
+>(tcl)#192.168.20.1
+>(tcl)#172.16.0.2
+>(tcl)#192.168.30.1
+>(tcl)#10.0.0.2 } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/14/16 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/15/16 ms
```



```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/29/32 ms
R1(tcl)# tclquit
R1#

R2# tclsh
R2(tcl)#
R2(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#172.16.0.1
+>(tcl)#10.0.0.1
+>(tcl)#192.168.20.1
+>(tcl)#172.16.0.2
+>(tcl)#192.168.30.1
+>(tcl)#10.0.0.2 } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/13/16 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/14/16 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
R2(tcl)# tclquit
R2#

R3# tclsh
R3(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#172.16.0.1
+>(tcl)#10.0.0.1
+>(tcl)#192.168.20.1
+>(tcl)#172.16.0.2
+>(tcl)#192.168.30.1
+>(tcl)#10.0.0.2 } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/15/16 ms
```



```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/14/16 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/28/28 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/15/16 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/15/16 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/15/16 ms
R3(tcl)# tclquit
```

Final Configurations

```
R1# show run
Building configuration...
!
version 12.4
!
hostname R1
!
interface Loopback0
 ip address 192.168.10.1 255.255.255.0
 ip router isis
!
interface FastEthernet0/0
 ip address 172.16.0.1 255.255.255.0
 ip router isis
 isis password cisco
 isis priority 100
 isis hello-interval 5
 no shutdown
!
interface Serial0/0/1
 ip address 10.0.0.2 255.255.255.252
 ip router isis
 no shutdown
!
router isis
 net 49.0001.1111.1111.1111.00
 domain-password cisco
!
end

R2# show run
Building configuration...
!
version 12.4
```



```
!
hostname R2
!
interface Loopback0
 ip address 192.168.20.1 255.255.255.0
 ip router isis
!
interface FastEthernet0/0
 ip address 172.16.0.2 255.255.255.0
 ip router isis
 isis password cisco
 isis priority 100
 isis hello-interval 5
 no shutdown
!
router isis
 net 49.0001.2222.2222.2222.00
 is-type level-1
 domain-password cisco
!
end
```

```
R3# show run
Building configuration...
!
version 12.4
!
hostname R3
!
interface Loopback0
 ip address 192.168.30.1 255.255.255.0
 ip router isis
!
interface Serial0/0/0
 ip address 10.0.0.1 255.255.255.252
 ip router isis
 clock rate 128000
 no shutdown
!
router isis
 net 49.0002.3333.3333.3333.00
 is-type level-2-only
 domain-password cisco
!
end
```

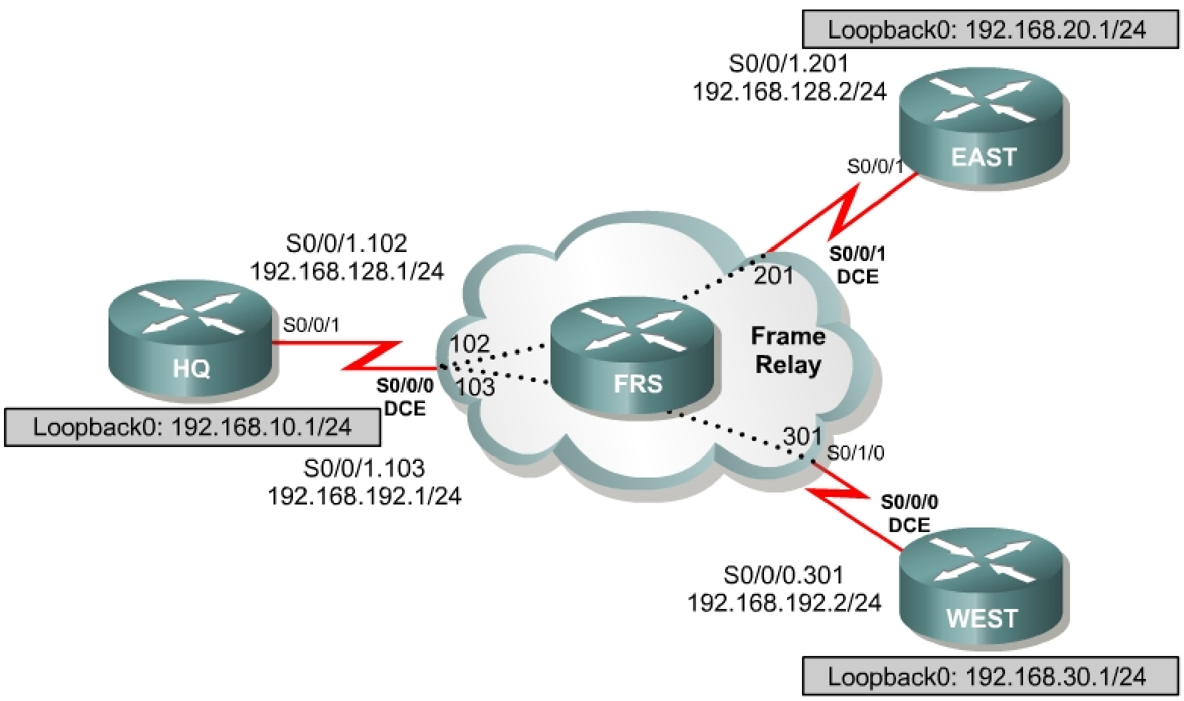

Lab 4-3a Configuring IS-IS over Frame Relay: Router Used As Frame Switch

Learning Objectives

- Configure and verify Frame Relay point-to-point subinterfaces
- Configure and verify the operation of Integrated IS-IS over Frame Relay point-to-point subinterfaces
- Demonstrate mismatched Frame Relay interface types in IS-IS adjacencies

Topology Diagram

Topology with a Cisco router acting as a Frame Relay switch (FRS)



Scenario

International Travel Agency has just connected two regional offices to the headquarters using Frame Relay in a hub-and-spoke topology. You are asked to configure IS-IS routing over this network.

Step 1: Addressing and Basic Configuration

Cable the network and configure the hostnames according to the diagram. Turn off DNS lookup, and configure the IP address on the Fast Ethernet or loopback interfaces, whichever option was selected. Do not configure the serial interfaces and IS-IS routing for now. Until you configure Frame Relay, you will not be able to use **ping** to test connectivity.

Step 2: Frame Relay Configuration

HQ acts as the hub in this hub-and-spoke network. It reaches EAST and WEST via two separate PVCs.

IS-IS can work only over NBMA clouds (such as Frame Relay) configured with a full mesh. Anything less than a full mesh can cause serious connectivity and routing issues. Even if a full mesh is configured, there is no guarantee that a full mesh will exist at all times. A failure in the underlying switched WAN network, or a misconfiguration on one or more routers, could break the full mesh either temporarily or permanently. Avoid NBMA multipoint configurations for IS-IS networks; use point-to-point subinterfaces instead.

Configure Frame Relay on HQ's serial interface as shown here:

```
HQ(config)# interface serial 0/0/1
HQ(config-if)# encapsulation frame-relay
HQ(config-if)# no shutdown
HQ(config-if)# interface s0/0/1.102 point-to-point
HQ(config-subif)# ip address 192.168.128.1 255.255.255.0
HQ(config-subif)# frame-relay interface-dlci 102
HQ(config-subif)# interface s0/0/1.103 point-to-point
HQ(config-subif)# ip address 192.168.192.1 255.255.255.0
HQ(config-subif)# frame-relay interface-dlci 103
```

Configure EAST's serial interface:

```
EAST(config)# interface serial 0/0/1
EAST(config-if)# encapsulation frame-relay
EAST(config-if)# no shutdown
EAST(config-if)# interface serial 0/0/1.201 point-to-point
EAST(config-subif)# ip address 192.168.128.2 255.255.255.0
EAST(config-subif)# frame-relay interface-dlci 201
```

Configure WEST's serial interface:

```
WEST(config)# interface serial 0/0/0
WEST(config-if)# encapsulation frame-relay
WEST(config-if)# no shutdown
WEST(config-if)# interface serial 0/0/0.301 point-to-point
WEST(config-subif)# ip address 192.168.192.2 255.255.255.0
WEST(config-subif)# frame-relay interface-dlci 301
```

Verify Frame Relay operation by pinging EAST and WEST from HQ.

Are you able to ping all the interfaces?

Issue **show frame-relay pvc** and **show frame-relay map** commands to troubleshoot connectivity problems.

```
HQ# show frame-relay pvc

PVC Statistics for interface Serial0/0/1 (Frame Relay DTE)

              Active     Inactive      Deleted       Static
  Local          2            0            0            0
  Switched       0            0            0            0
  Unused         0            0            0            0

DLCI = 102, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE =
Serial0/0/1.102

  input pkts 58            output pkts 52           in bytes 13130
  out bytes 13036          dropped pkts 0           in pkts dropped 0
  out pkts dropped 0                out bytes dropped 0
  in FECN pkts 0           in BECN pkts 0           out FECN pkts 0
  out BECN pkts 0          in DE pkts 0             out DE pkts 0
  out bcast pkts 32        out bcast bytes 10956
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
  pvc create time 00:37:48, last time pvc status changed 00:28:42

DLCI = 103, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE =
Serial0/0/1.103

  input pkts 46            output pkts 48           in bytes 10322
  out bytes 11684          dropped pkts 0           in pkts dropped 0
  out pkts dropped 0                out bytes dropped 0
  in FECN pkts 0           in BECN pkts 0           out FECN pkts 0
  out BECN pkts 0          in DE pkts 0             out DE pkts 0
  out bcast pkts 28        out bcast bytes 9604
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
  pvc create time 00:37:14, last time pvc status changed 00:24:54

HQ# show frame-relay map
Serial0/0/1.102 (up): point-to-point dlci, dlci 102(0x66,0x1860), broadcast
          status defined, active
Serial0/0/1.103 (up): point-to-point dlci, dlci 103(0x67,0x1870), broadcast
          status defined, active
```

Which OSI Layer 3 protocols are forwarded over the PVCs you configured? How does this differ from the way the output of the **show frame-relay map** command usually looks with multipoint subinterfaces configured? Refer to EIGRP Lab 2.4 if necessary.

Which transport protocol does IS-IS use?

Why will these packets be forwarded?

Step 3: Configure and Verify IS-IS over Frame Relay

Like OSPF, IS-IS is configured by enabling an IS-IS process and specifying which interfaces are to participate in the IS-IS process. Configure IS-IS to run over this point-to-point network with the following commands:

```
HQ(config)# router isis
HQ(config-router)# net 49.0001.1111.1111.1111.00
HQ(config-router)# interface serial 0/0/1.102
HQ(config-if)# ip router isis
HQ(config-if)# interface serial 0/0/1.103
HQ(config-if)# ip router isis
HQ(config-if)# interface loopback 0
HQ(config-if)# ip router isis

EAST(config)# router isis
EAST(config-router)# net 49.0001.2222.2222.2222.00
EAST(config-router)# int serial 0/0/1.201
EAST(config-if)# ip router isis
EAST(config-if)# int loopback 0
EAST(config-if)# ip router isis

WEST(config)# router isis
WEST(config-router)# net 49.0001.3333.3333.3333.00
WEST(config-router)# int serial 0/0/0.301
WEST(config-if)# ip router isis
WEST(config-if)# int loopback 0
WEST(config-if)# ip router isis
```

Verify your IS-IS configuration by issuing the **show ip route** command on each of the routers:

```
WEST# show ip route
<output omitted>

Gateway of last resort is not set

C    192.168.192.0/24 is directly connected, Serial0/0/0.301
C    192.168.30.0/24 is directly connected, Loopback0
i L1 192.168.128.0/24 [115/20] via 192.168.192.1, Serial0/0/0.301
i L1 192.168.10.0/24 [115/20] via 192.168.192.1, Serial0/0/0.301
i L1 192.168.20.0/24 [115/30] via 192.168.192.1, Serial0/0/0.301
```


If each router has a complete table, including routes to 192.168.10.0/24, 192.168.20.0/24, and 192.168.30.0/24, you have successfully configured IS-IS to operate over Frame Relay.

Test these routes by pinging the Fast Ethernet or loopback interfaces of each router from WEST's console.

Are you able to ping all the interfaces?

Finally, issue the **show isis database** and **show isis topology** commands:

```
HQ# show isis database

IS-IS Level-1 Link State Database:
LSPID           LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
HQ.00-00      * 0x00000007   0x3B7A        737               0/0/0
EAST.00-00      0x00000004   0xA0ED        736               0/0/0
WEST.00-00      0x00000003   0x7603        666               0/0/0
IS-IS Level-2 Link State Database:
LSPID           LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
HQ.00-00      * 0x00000009   0x2F3C        744               0/0/0
EAST.00-00      0x00000006   0x90E7        747               0/0/0
WEST.00-00      0x00000004   0x5B53        742               0/0/0

EAST# show isis topology

IS-IS paths to level-1 routers
System Id       Metric  Next-Hop        Interface   SNPA
HQ              10      HQ              Se0/0/1.201 DLCI 201
EAST            --
WEST            20      HQ              Se0/0/1.201 DLCI 201

IS-IS paths to level-2 routers
System Id       Metric  Next-Hop        Interface   SNPA
HQ              10      HQ              Se0/0/1.201 DLCI 201
EAST            --
WEST            20      HQ              Se0/0/1.201 DLCI 201
```

Note that no pseudonode LSPs (with non-zero circuit IDs) appear in the **show isis database** output because we are using point-to-point links to connect the routers.

How is the subnetwork point of attachment (SNPA) expressed in a Frame Relay network?

Step 4: Verify IS-IS Connectivity

Run the following TCL script on all routers to verify full connectivity:

```
foreach address {
192.168.10.1
192.168.128.1
192.168.192.1
192.168.20.1
192.168.128.2
192.168.30.1
192.168.192.2 } { ping $address }
```

If you have never used TCL scripts before or need a refresher, see the TCL lab in the routing module.

You should get ICMP echo replies for every address pinged. Check your TCL script output against the output in Appendix A. Make sure you run the TCL script on each router and get the output recorded in Appendix A before you continue with the lab.

Step 5: Demonstrate IS-IS Interface-Type Mismatch

A common error with IS-IS configuration is mismatched interface types in an NBMA environment (normally Frame Relay or ATM). To illustrate this, switch EAST's point-to-point interface to a multipoint interface. Remove the commands currently configured on Serial0/0/1.201 with their respective **no** commands. Then, create a multipoint subinterface on EAST named Serial0/0/1.2001. Place the same commands you removed from Serial0/0/1.201 on Serial0/0/1.2001.

```
EAST(config)# interface serial 0/0/1.201
EAST(config-subif)# no ip address
EAST(config-subif)# no ip router isis
EAST(config-subif)# no frame-relay interface-dlci 201
EAST(config-subif)# interface serial 0/0/1.2001 multipoint
EAST(config-subif)# ip address 192.168.128.2 255.255.255.0
EAST(config-subif)# ip router isis
EAST(config-subif)# frame-relay interface-dlci 201
```

Allow the Frame Relay PVC to become active. View the output of the **show clns neighbors** command on HQ and EAST:

```
HQ# show clns neighbors

System Id  Interface    SNPA              State  Holdtime  Type Protocol
WEST       Se0/0/1.103   DLCI 103          Up     27        L1L2 IS-IS

EAST# show clns neighbors

System Id  Interface    SNPA              State  Holdtime  Type Protocol
HQ         Se0/0/1.2001  DLCI 201          Up     258       IS   ES-IS
```

The output indicates mismatched interface types! Since Cisco IOS Release 12.1(1)T, an Integrated IS-IS mismatch is indicated in the following cases:

- EAST (multipoint) receives a point-to-point hello PDU, realizes it is the wrong hello type, and installs the neighbor as an ES. EAST shows HQ in the **show clns neighbors** command with protocol ES-IS.
- HQ (point-to-point) receives the LAN hello PDU, recognizes the mismatch, and ignores the neighbor. EAST does not appear in the output of the **show clns neighbors** command. The output of the **debug isis adj-packets** command shows the incoming LAN IIH PDU and EAST declaring the mismatch.

```
EAST# debug isis adj-packets
IS-IS Adjacency related packets debugging is on
00:31:58: ISIS-Adj: Sending L1 LAN IIH on Loopback0, length 1514
00:31:58: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
00:31:59: ISIS-Adj: Encapsulation failed for L2 LAN IIH on Serial0/0/1.2001
00:31:59: ISIS-Adj: Encapsulation failed for L1 LAN IIH on Serial0/0/1.2001
00:32:01: ISIS-Adj: Sending L1 LAN IIH on Loopback0, length 1514
00:32:01: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
00:32:02: ISIS-Adj: Encapsulation failed for L2 LAN IIH on Serial0/0/1.2001
00:32:03: ISIS-Adj: Encapsulation failed for L1 LAN IIH on Serial0/0/1.2001
00:32:04: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
00:32:04: ISIS-Adj: Sending L1 LAN IIH on Loopback0, length 1514
00:32:04: ISIS-Adj: Rec serial IIH from DLCI 201 (Serial0/0/1.2001), cir type
L1L2, cir id 00, length 1499
00:32:04: ISIS-Adj: Point-to-point IIH received on multi-point interface:
ignored IIH
00:32:05: ISIS-Adj: Encapsulation failed for L2 LAN IIH on Serial0/0/1.2001
00:32:06: ISIS-Adj: Encapsulation failed for L1 LAN IIH on Serial0/0/1.2001
```

This completes the IS-IS over Frame Relay lab. Integrated IS-IS can be easily configured over a Frame Relay cloud. The only caveat is that IS-IS NBMA configurations, unlike OSPF, are essentially limited to point-to-point implementations. In an NBMA environment, mismatched interface types are a common problem—the symptoms are reflected in the output of the **show clns neighbors** and **debug isis adj-packets** commands.

Router As Frame Relay Switch Configuration

The following configuration enables a 2800 router with two WIC-2A/Ss or WIC-2Ts to act as a Frame Relay switch for this lab. If you use a different model router (2600, 1700), the serial interfaces will be numbered differently.

```
FRS# show run
!
hostname FRS
!
no ip domain-lookup
!
frame-relay switching
!
interface Serial0/0/0
 no ip address
 encapsulation frame-relay
 clockrate 128000
 frame-relay intf-type dce
 frame-relay route 102 interface Serial0/0/1 201
 frame-relay route 103 interface Serial0/1/0 301
```



```
 no shutdown
!
interface Serial0/0/1
 no ip address
 encapsulation frame-relay
 clockrate 128000
 frame-relay intf-type dce
 frame-relay route 201 interface Serial0/0/0 102
 no shutdown
!
interface Serial0/1/0
 no ip address
 encapsulation frame-relay
 clockrate 128000
 frame-relay intf-type dce
 frame-relay route 301 interface Serial0/0/0 103
 no shutdown
!
end
```

Appendix A: TCL Script Output

```
HQ# tclsh
HQ(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#192.168.128.1
+>(tcl)#192.168.192.1
+>(tcl)#192.168.20.1
+>(tcl)#192.168.128.2
+>(tcl)#192.168.30.1
+>(tcl)#192.168.192.2 } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 112/113/120 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/60/68 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/60 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/56 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/29/32 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.2, timeout is 2 seconds:
```



```
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/67/216 ms
HQ(tcl)# tclquit

EAST# tclsh
EAST(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#192.168.128.1
+>(tcl)#192.168.192.1
+>(tcl)#192.168.20.1
+>(tcl)#192.168.128.2
+>(tcl)#192.168.30.1
+>(tcl)#192.168.192.2 } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/56 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/124/392 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/60 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 108/148/292 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/84/88 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/84/88 ms
EAST(tcl)# tclquit


WEST# tclsh
WEST(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#192.168.128.1
+>(tcl)#192.168.192.1
+>(tcl)#192.168.20.1
+>(tcl)#192.168.128.2
+>(tcl)#192.168.30.1
+>(tcl)#192.168.192.2 } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/30/32 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/30/32 ms
```



```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/30/32 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/85/88 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/121/268 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/59/68 ms
WEST(tcl)# tclquit
```

Final Configuration

```
HQ# show run
!
hostname HQ
!
no ip domain-lookup
!
interface Loopback0
 ip address 192.168.10.1 255.255.255.0
 ip router isis
!
interface Serial0/0/1
 no ip address
 encapsulation frame-relay
 no shutdown
!
interface Serial0/0/1.102 point-to-point
 ip address 192.168.128.1 255.255.255.0
 ip router isis
 frame-relay interface-dlci 102
!
interface Serial0/0/1.103 point-to-point
 ip address 192.168.192.1 255.255.255.0
 ip router isis
 frame-relay interface-dlci 103
!
router isis
 net 49.0001.1111.1111.1111.00
!
end
```

```
EAST# show run
!
hostname EAST
!
no ip domain-lookup
!
interface Loopback0
```



```
 ip address 192.168.20.1 255.255.255.0
 ip router isis
!
interface Serial0/0/1
 no ip address
 encapsulation frame-relay
 clock rate 64000
 no shutdown
!
interface Serial0/0/1.201 point-to-point
!
interface Serial0/0/1.2001 multipoint
 ip address 192.168.128.2 255.255.255.0
 ip router isis
 frame-relay interface-dlci 201
!
router isis
 net 49.0001.2222.2222.2222.00
!
end
```

```
WEST# show run
Building configuration...
!
hostname WEST
!
no ip domain-lookup
!
interface Loopback0
 ip address 192.168.30.1 255.255.255.0
 ip router isis
!
interface Serial0/0/0
 no ip address
 encapsulation frame-relay
 clock rate 2000000
 no shutdown
!
interface Serial0/0/0.301 point-to-point
 ip address 192.168.192.2 255.255.255.0
 ip router isis
 frame-relay interface-dlci 301
!
router isis
 net 49.0001.3333.3333.3333.00
!
end
```

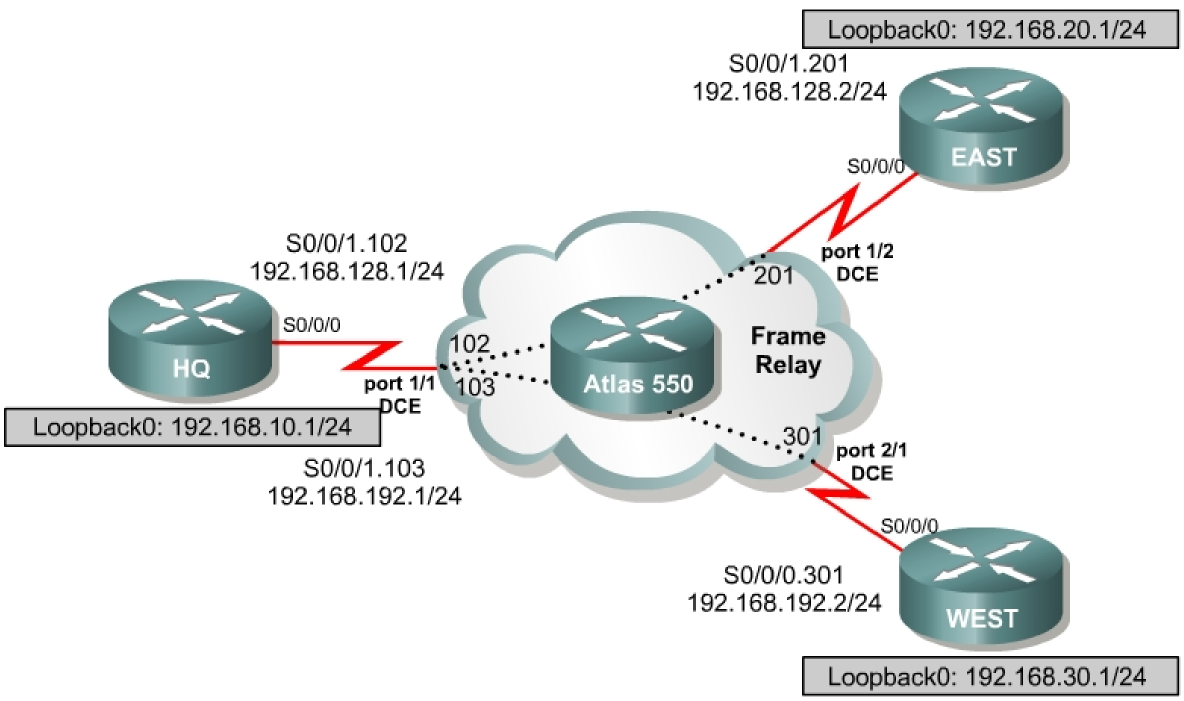

Lab 4-3b Configuring IS-IS over Frame Relay: Adtran Used As Frame Switch

Learning Objectives

- Configure and verify Frame Relay point-to-point subinterfaces
- Configure and verify the operation of Integrated IS-IS over Frame Relay point-to-point subinterfaces
- Demonstrate mismatched Frame Relay interface types in IS-IS adjacencies

Topology Diagram

Topology with a Cisco router acting as a Frame Relay switch (FRS)



Scenario

International Travel Agency has just connected two regional offices to the headquarters using Frame Relay in a hub-and-spoke topology. You are asked to configure IS-IS routing over this network.

Step 1: Addressing and Basic Configuration

Cable the network and configure the hostnames according to the diagram. Turn off DNS lookup, and configure the IP address on the Fast Ethernet or loopback interfaces, whichever option was selected. Do not configure the serial interfaces and IS-IS routing for now. Until you configure Frame Relay, you will not be able to use **ping** to test connectivity.

Step 2: Frame Relay Configuration

HQ acts as the hub in this hub-and-spoke network. It reaches EAST and WEST via two separate PVCs.

IS-IS can work only over NBMA clouds (such as Frame Relay) configured with a full mesh. Anything less than a full mesh can cause serious connectivity and routing issues. Even if a full mesh is configured, there is no guarantee that a full mesh will exist at all times. A failure in the underlying switched WAN network, or a misconfiguration on one or more routers, could break the full mesh either temporarily or permanently. Avoid NBMA multipoint configurations for IS-IS networks; use point-to-point subinterfaces instead.

Configure Frame Relay on HQ's serial interface as shown here:

```
HQ(config)# interface serial 0/0/1
HQ(config-if)# encapsulation frame-relay ietf
HQ(config-if)# no shutdown
HQ(config-if)# interface s0/0/1.102 point-to-point
HQ(config-subif)# ip address 192.168.128.1 255.255.255.0
HQ(config-subif)# frame-relay interface-dlci 102
HQ(config-subif)# interface s0/0/1.103 point-to-point
HQ(config-subif)# ip address 192.168.192.1 255.255.255.0
HQ(config-subif)# frame-relay interface-dlci 103
```

Configure EAST's serial interface:

```
EAST(config)# interface serial 0/0/1
EAST(config-if)# encapsulation frame-relay ietf
EAST(config-if)# no shutdown
EAST(config-if)# interface serial 0/0/1.201 point-to-point
EAST(config-subif)# ip address 192.168.128.2 255.255.255.0
EAST(config-subif)# frame-relay interface-dlci 201
```

Configure WEST's serial interface:

```
WEST(config)# interface serial 0/0/0
WEST(config-if)# encapsulation frame-relay ietf
WEST(config-if)# no shutdown
WEST(config-if)# interface serial 0/0/0.301 point-to-point
WEST(config-subif)# ip address 192.168.192.2 255.255.255.0
WEST(config-subif)# frame-relay interface-dlci 301
```

Verify Frame Relay operation by pinging EAST and WEST from HQ.

Are you able to ping all the interfaces?

Issue **show frame-relay pvc** and **show frame-relay map** commands to troubleshoot connectivity problems.

```
HQ# show frame-relay pvc

PVC Statistics for interface Serial0/0/1 (Frame Relay DTE)

              Active     Inactive      Deleted       Static
  Local          2            0            0            0
  Switched       0            0            0            0
  Unused         0            0            0            0

DLCI = 102, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE =
Serial0/0/1.102

  input pkts 58            output pkts 52           in bytes 13130
  out bytes 13036          dropped pkts 0           in pkts dropped 0
  out pkts dropped 0                out bytes dropped 0
  in FECN pkts 0           in BECN pkts 0           out FECN pkts 0
  out BECN pkts 0          in DE pkts 0             out DE pkts 0
  out bcast pkts 32        out bcast bytes 10956
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
  pvc create time 00:37:48, last time pvc status changed 00:28:42

DLCI = 103, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE =
Serial0/0/1.103

  input pkts 46            output pkts 48           in bytes 10322
  out bytes 11684          dropped pkts 0           in pkts dropped 0
  out pkts dropped 0                out bytes dropped 0
  in FECN pkts 0           in BECN pkts 0           out FECN pkts 0
  out BECN pkts 0          in DE pkts 0             out DE pkts 0
  out bcast pkts 28        out bcast bytes 9604
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
  pvc create time 00:37:14, last time pvc status changed 00:24:54

HQ# show frame-relay map
Serial0/0/1.102 (up): point-to-point dlci, dlci 102(0x66,0x1860), broadcast
          status defined, active
Serial0/0/1.103 (up): point-to-point dlci, dlci 103(0x67,0x1870), broadcast
          status defined, active
```

Which OSI Layer 3 protocols are forwarded over the PVCs you configured? How does this differ from the way the output of the **show frame-relay map** command usually looks with multipoint subinterfaces configured? Refer to EIGRP Lab 2.4 if necessary.

Which transport protocol does IS-IS use?

Why will these packets be forwarded?

Step 3: Configure and Verify IS-IS over Frame Relay

Like OSPF, IS-IS is configured by enabling an IS-IS process and specifying which interfaces are to participate in the IS-IS process. Configure IS-IS to run over this point-to-point network with the following commands:

```
HQ(config)# router isis
HQ(config-router)# net 49.0001.1111.1111.1111.00
HQ(config-router)# interface serial 0/0/1.102
HQ(config-if)# ip router isis
HQ(config-if)# interface serial 0/0/1.103
HQ(config-if)# ip router isis
HQ(config-if)# interface loopback 0
HQ(config-if)# ip router isis

EAST(config)# router isis
EAST(config-router)# net 49.0001.2222.2222.2222.00
EAST(config-router)# int serial 0/0/1.201
EAST(config-if)# ip router isis
EAST(config-if)# int loopback 0
EAST(config-if)# ip router isis

WEST(config)# router isis
WEST(config-router)# net 49.0001.3333.3333.3333.00
WEST(config-router)# int serial 0/0/0.301
WEST(config-if)# ip router isis
WEST(config-if)# int loopback 0
WEST(config-if)# ip router isis
```

Verify your IS-IS configuration by issuing the **show ip route** command on each of the routers:

```
WEST# show ip route
<output omitted>

Gateway of last resort is not set

C    192.168.192.0/24 is directly connected, Serial0/0/0.301
C    192.168.30.0/24 is directly connected, Loopback0
i L1 192.168.128.0/24 [115/20] via 192.168.192.1, Serial0/0/0.301
i L1 192.168.10.0/24 [115/20] via 192.168.192.1, Serial0/0/0.301
i L1 192.168.20.0/24 [115/30] via 192.168.192.1, Serial0/0/0.301
```


If each router has a complete table, including routes to 192.168.10.0/24, 192.168.20.0/24, and 192.168.30.0/24, you have successfully configured IS-IS to operate over Frame Relay.

Test these routes by pinging the Fast Ethernet or loopback interfaces of each router from WEST's console.

Are you able to ping all the interfaces?

Finally, issue the **show isis database** and **show isis topology** commands:

```
HQ# show isis database

IS-IS Level-1 Link State Database:
LSPID             LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
HQ.00-00        * 0x00000007   0x3B7A        737               0/0/0
EAST.00-00        0x00000004   0xA0ED        736               0/0/0
WEST.00-00        0x00000003   0x7603        666               0/0/0
IS-IS Level-2 Link State Database:
LSPID             LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
HQ.00-00        * 0x00000009   0x2F3C        744               0/0/0
EAST.00-00        0x00000006   0x90E7        747               0/0/0
WEST.00-00        0x00000004   0x5B53        742               0/0/0

EAST# show isis topology

IS-IS paths to level-1 routers
System Id         Metric  Next-Hop        Interface   SNPA
HQ                10      HQ              Se0/0/1.201 DLCI 201
EAST              --
WEST              20      HQ              Se0/0/1.201 DLCI 201

IS-IS paths to level-2 routers
System Id         Metric  Next-Hop        Interface   SNPA
HQ                10      HQ              Se0/0/1.201 DLCI 201
EAST              --
WEST              20      HQ              Se0/0/1.201 DLCI 201
```

Note that no pseudonode LSPs (with non-zero circuit IDs) appear in the **show isis database** output because we are using point-to-point links to connect the routers.

How is the subnetwork point of attachment (SNPA) expressed in a Frame Relay network?

Step 4: Verify IS-IS Connectivity

Run the following TCL script on all routers to verify full connectivity:

```
foreach address {
192.168.10.1
192.168.128.1
192.168.192.1
192.168.20.1
192.168.128.2
192.168.30.1
192.168.192.2 } { ping $address }
```

If you have never used TCL scripts before or need a refresher, see the TCL lab in the routing module.

You should get ICMP echo replies for every address pinged. Check your TCL script output against the output in Appendix A. Make sure you run the TCL script on each router and get the output recorded in Appendix A before you continue with the lab.

Step 5: Demonstrate IS-IS Interface-Type Mismatch

A common error with IS-IS configuration is mismatched interface types in an NBMA environment (normally Frame Relay or ATM). To illustrate this, switch EAST's point-to-point interface to a multipoint interface. Remove the commands currently configured on Serial0/0/1.201 with their respective **no** commands. Then, create a multipoint subinterface on EAST named Serial0/0/1.2001. Place the same commands you removed from Serial0/0/1.201 on Serial0/0/1.2001.

```
EAST(config)# interface serial 0/0/1.201
EAST(config-subif)# no ip address
EAST(config-subif)# no ip router isis
EAST(config-subif)# no frame-relay interface-dlci 201
EAST(config-subif)# interface serial 0/0/1.2001 multipoint
EAST(config-subif)# ip address 192.168.128.2 255.255.255.0
EAST(config-subif)# ip router isis
EAST(config-subif)# frame-relay interface-dlci 201
```

Allow the Frame Relay PVC to become active. View the output of the **show clns neighbors** command on HQ and EAST:

```
HQ# show clns neighbors

System Id  Interface    SNPA                State  Holdtime  Type Protocol
WEST       Se0/0/1.103   DLCI 103             Up     27         L1L2 IS-IS

EAST# show clns neighbors

System Id  Interface    SNPA                State  Holdtime  Type Protocol
HQ         Se0/0/1.2001  DLCI 201             Up     258        IS    ES-IS
```

The output indicates mismatched interface types! Since Cisco IOS Release 12.1(1)T, an Integrated IS-IS mismatch is indicated in the following cases:

- EAST (multipoint) receives a point-to-point hello PDU, realizes it is the wrong hello type, and installs the neighbor as an ES. EAST shows HQ in the **show clns neighbors** command with protocol ES-IS.
- HQ (point-to-point) receives the LAN hello PDU, recognizes the mismatch, and ignores the neighbor. EAST does not appear in the output of the **show clns neighbors** command. The output of the **debug isis adj-packets** command shows the incoming LAN IIH PDU and EAST declaring the mismatch.

```
EAST# debug isis adj-packets
IS-IS Adjacency related packets debugging is on
00:31:58: ISIS-Adj: Sending L1 LAN IIH on Loopback0, length 1514
00:31:58: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
00:31:59: ISIS-Adj: Encapsulation failed for L2 LAN IIH on Serial0/0/1.2001
00:31:59: ISIS-Adj: Encapsulation failed for L1 LAN IIH on Serial0/0/1.2001
00:32:01: ISIS-Adj: Sending L1 LAN IIH on Loopback0, length 1514
00:32:01: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
00:32:02: ISIS-Adj: Encapsulation failed for L2 LAN IIH on Serial0/0/1.2001
00:32:03: ISIS-Adj: Encapsulation failed for L1 LAN IIH on Serial0/0/1.2001
00:32:04: ISIS-Adj: Sending L2 LAN IIH on Loopback0, length 1514
00:32:04: ISIS-Adj: Sending L1 LAN IIH on Loopback0, length 1514
00:32:04: ISIS-Adj: Rec serial IIH from DLCI 201 (Serial0/0/1.2001), cir type
L1L2, cir id 00, length 1499
00:32:04: ISIS-Adj: Point-to-point IIH received on multi-point interface:
ignored IIH
00:32:05: ISIS-Adj: Encapsulation failed for L2 LAN IIH on Serial0/0/1.2001
00:32:06: ISIS-Adj: Encapsulation failed for L1 LAN IIH on Serial0/0/1.2001
```

This completes the IS-IS over Frame Relay lab. Integrated IS-IS can be easily configured over a Frame Relay cloud. The only caveat is that IS-IS NBMA configurations, unlike OSPF, are essentially limited to point-to-point implementations. In an NBMA environment, mismatched interface types are a common problem—the symptoms are reflected in the output of the **show clns neighbors** and **debug isis adj-packets** commands.

Appendix A: TCL Script Output

```
HQ# tclsh
HQ(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#192.168.128.1
+>(tcl)#192.168.192.1
+>(tcl)#192.168.20.1
+>(tcl)#192.168.128.2
+>(tcl)#192.168.30.1
+>(tcl)#192.168.192.2 } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 112/113/120 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.1, timeout is 2 seconds:
!!!!!
```



```
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/60/68 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/60 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/56 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/29/32 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/67/216 ms
HQ(tcl)# tclquit

EAST# tclsh
EAST(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#192.168.128.1
+>(tcl)#192.168.192.1
+>(tcl)#192.168.20.1
+>(tcl)#192.168.128.2
+>(tcl)#192.168.30.1
+>(tcl)#192.168.192.2 } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/56 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/124/392 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/60 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 108/148/292 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/84/88 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/84/88 ms
EAST(tcl)# tclquit
WEST# tclsh
WEST(tcl)#foreach address {
+>(tcl)#192.168.10.1
+>(tcl)#192.168.128.1
+>(tcl)#192.168.192.1
```



```
+>(tcl)#192.168.20.1
+>(tcl)#192.168.128.2
+>(tcl)#192.168.30.1
+>(tcl)#192.168.192.2 } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/30/32 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/30/32 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/30/32 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/85/88 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.128.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/121/268 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.192.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/59/68 ms
WEST(tcl)# tclquit
```

Final Configuration

```
HQ# show run
!
hostname HQ
!
no ip domain-lookup
!
interface Loopback0
 ip address 192.168.10.1 255.255.255.0
 ip router isis
!
interface Serial0/0/1
 no ip address
 encapsulation frame-relay ietf
 no shutdown
!
interface Serial0/0/1.102 point-to-point
 ip address 192.168.128.1 255.255.255.0
 ip router isis
 frame-relay interface-dlci 102
!
interface Serial0/0/1.103 point-to-point
 ip address 192.168.192.1 255.255.255.0
 ip router isis
 frame-relay interface-dlci 103
!
```



```
router isis
 net 49.0001.1111.1111.1111.00
!
end
```

```
EAST# show run
!
hostname EAST
!
no ip domain-lookup
!
interface Loopback0
 ip address 192.168.20.1 255.255.255.0
 ip router isis
!
interface Serial0/0/1
 no ip address
 encapsulation frame-relay ietf
 clock rate 64000
 no shutdown
!
interface Serial0/0/1.201 point-to-point
!
interface Serial0/0/1.2001 multipoint
 ip address 192.168.128.2 255.255.255.0
 ip router isis
 frame-relay interface-dlci 201
!
router isis
 net 49.0001.2222.2222.2222.00
!
end
```

```
WEST# show run
Building configuration...
!
hostname WEST
!
no ip domain-lookup
!
interface Loopback0
 ip address 192.168.30.1 255.255.255.0
 ip router isis
!
interface Serial0/0/0
 no ip address
 encapsulation frame-relay ietf
 clock rate 2000000
 no shutdown
!
interface Serial0/0/0.301 point-to-point
 ip address 192.168.192.2 255.255.255.0
 ip router isis
 frame-relay interface-dlci 301
!
router isis
 net 49.0001.3333.3333.3333.00
!
end
```

