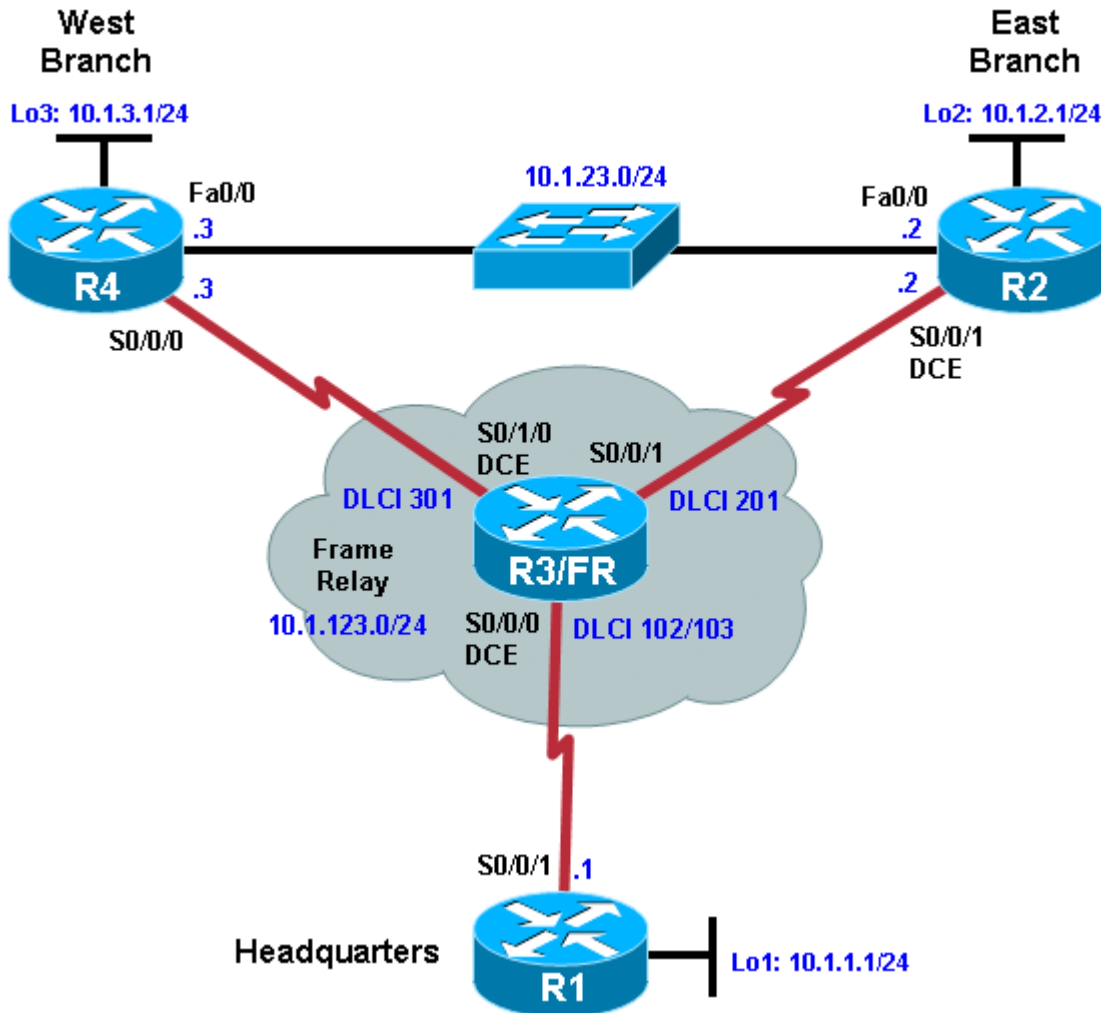


Chapter 3 Lab 3-4, OSPF over Frame Relay

Topology



Objectives

- Configure OSPF over Frame Relay.
- Use non-broadcast and point-to-multipoint OSPF network types.
- Modify default OSPF timers.

Background

You are responsible for configuring the new network to connect your company's East branch and West branch through the company headquarters represented by loopback interfaces on each of the three routers. The physical devices have just been installed and connected over Frame Relay hub-and-spoke topology. Configure OSPF to allow full connectivity between all departments.

To simulate the Frame Relay WAN connections, use a router with three serial ports to act as a Frame Relay switch. The configuration of the router as a Frame Relay switch is described in Step 2. The Fast Ethernet connection between router EAST and router WEST represents a backup link from a service provider.

In real-world Frame Relay deployments, a modem or CSU/DSU normally provides the clocking functions (DCE) for each serial link. However, in this lab, R2 interface Serial0/0/1 is configured as the DCE for compatibility with other labs. If you are uncertain which side of the connection is the DCE, use the **show controllers serial interface-number** command:

```
FRS# show controllers serial0/0/0
Interface Serial0/0/0
Hardware is GT96K
DCE V.35, clock rate 64000
```

Note: In this lab, router R3 acts as the Frame Relay switch and requires two serial interface cards. If you are using an Adtran as a Frame Relay switch, see Appendix A for the Adtran configuration. When using the Adtran as the Frame Relay switch, the clock (DCE) is provided for each serial link.

Note: This lab uses Cisco 1841 routers with Cisco IOS Release 12.4(24)T1 and the Advanced IP Services image c1841-advipservicesk9-mz.124-24.T1.bin. The switch is a Cisco WS-C2960-24TT-L with the Cisco IOS image c2960-lanbasek9-mz.122-46.SE.bin. You can use other routers (such as a 2801 or 2811) and Cisco IOS Software versions if they have comparable capabilities and features. Depending on the router or switch model and Cisco IOS Software version, the commands available and output produced might vary from what is shown in this lab.

Required Resources

- 4 routers (Cisco 1841 with Cisco IOS Release 12.4(24)T1 Advanced IP Services or comparable)
- 1 switch (Cisco 2960 with the Cisco IOS Release 12.2(46)SE C2960-LANBASEK9-M image or comparable)
- Serial and Ethernet cables

Step 1: Configure Frame Relay and addressing on the HQ, EAST, and WEST routers.

- a. Configure the router physical interfaces with IP addresses. On the interfaces connected to the Frame Relay switch, configure Frame Relay encapsulation with Inverse ARP disabled. Inverse ARP is disabled in this lab so that you have exclusive control over the IP/DLCI mappings. Use **frame relay map** statements to configure local Frame Relay maps so that you can ping the router's interface. Also set up the loopback interfaces.

Router R1 (Hostname HQ)

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

```
Router(config)# hostname HQ
HQ(config)# interface loopback 1
HQ(config-if)# ip address 10.1.1.1 255.255.255.0
HQ(config-if)# interface serial 0/0/1
HQ(config-if)# ip address 10.1.123.1 255.255.255.0
HQ(config-if)# encapsulation frame-relay ietf
HQ(config-if)# no frame-relay inverse-arp
HQ(config-if)# frame-relay map ip 10.1.123.1 102
HQ(config-if)# frame-relay map ip 10.1.123.2 102
HQ(config-if)# frame-relay map ip 10.1.123.3 103
HQ(config-if)# no shutdown
```

Router R2 (Hostname EAST)

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

Router(config)# hostname EAST
EAST(config)# interface loopback 2
EAST(config-if)# ip address 10.1.2.1 255.255.255.0
EAST(config-if)# interface serial 0/0/1
EAST(config-if)# ip address 10.1.123.2 255.255.255.0
EAST(config-if)# clock rate 64000
EAST(config-if)# encapsulation frame-relay ietf
EAST(config-if)# no frame-relay inverse-arp
EAST(config-if)# frame-relay map ip 10.1.123.1 201
EAST(config-if)# frame-relay map ip 10.1.123.2 201
EAST(config-if)# frame-relay map ip 10.1.123.3 201
EAST(config-if)# no shutdown
EAST(config-if)# interface FastEthernet 0/0
EAST(config-if)# ip address 10.1.23.2 255.255.255.0
EAST(config-if)# no shutdown
```

Router R4 (Hostname WEST)

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

Router(config)# hostname WEST
WEST(config)# interface loopback 3
WEST(config-if)# ip address 10.1.3.1 255.255.255.0
WEST(config-if)# interface serial 0/0/0
WEST(config-if)# ip address 10.1.123.3 255.255.255.0
WEST(config-if)# encapsulation frame-relay ietf
WEST(config-if)# no frame-relay inverse-arp
WEST(config-if)# frame-relay map ip 10.1.123.1 301
WEST(config-if)# frame-relay map ip 10.1.123.2 301
WEST(config-if)# frame-relay map ip 10.1.123.3 301
WEST(config-if)# no shutdown
WEST(config-if)# interface FastEthernet 0/0
WEST(config-if)# ip address 10.1.23.3 255.255.255.0
WEST(config-if)# no shutdown
```

- b. Verify that you have local subnet connectivity with **ping**.

Step 2: Configure the Frame Relay switch.

Use a fourth Cisco router with three serial interfaces as a Frame Relay switch, and cable the routers according to the diagram. Configure the Frame Relay switch to have the DLCIs indicated in the diagram between HQ and EAST and HQ and WEST.

Router R3 (FRS)

```
hostname FRS
!
frame-relay switching
interface Serial0/0/0
 no ip address
 encapsulation frame-relay ietf
 no ip route-cache
 clock rate 64000
 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 ietf
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 ietf
no ip route-cache
frame-relay intf-type dce
clock rate 64000
frame-relay route 301 interface Serial0/0/0 103
no shutdown

```

Step 3: Configure OSPF network type NBMA.

Frame Relay is inherently a non-broadcast multi-access (NBMA) network. In this step, you configure OSPF for hub-and-spoke over Frame Relay using the NBMA OSPF network type, which is the default for Frame Relay physical interfaces and multipoint-type subinterfaces. HQ is the hub; EAST and WEST are the spokes.

- a. Create OSPF process 1. Add the Frame Relay interfaces on each router into area 0 with the **network** command. Add the loopback interfaces on each router into area 0, and then change the network type to allow the correct subnet mask to be advertised.

```

HQ(config)# router ospf 1
HQ(config-router)# network 10.1.123.0 0.0.0.255 area 0
HQ(config-router)# network 10.1.1.0 0.0.0.255 area 0
HQ(config-router)# exit
HQ(config)# interface loopback 1
HQ(config-if)# ip ospf network point-to-point

EAST(config)# router ospf 1
EAST(config-router)# network 10.1.123.0 0.0.0.255 area 0
EAST(config-router)# network 10.1.2.0 0.0.0.255 area 0
EAST(config-router)# exit
EAST(config)# interface loopback 2
EAST(config-if)# ip ospf network point-to-point

WEST(config)# router ospf 1
WEST(config-router)# network 10.1.123.0 0.0.0.255 area 0
WEST(config-router)# network 10.1.3.0 0.0.0.255 area 0
WEST(config-router)# exit
WEST(config)# interface loopback 3
WEST(config-if)# ip ospf network point-to-point

```

- b. On EAST and WEST, change the Frame Relay interfaces to have OSPF priority 0. This priority ensures that HQ becomes the DR.

```

EAST(config)# interface serial 0/0/1
EAST(config-if)# ip ospf priority 0

WEST(config)# interface serial 0/0/0
WEST(config-if)# ip ospf priority 0

```

- c. No OSPF Frame Relay adjacencies will be established yet because the default network type is nonbroadcast. You can change this by adding **neighbor** statements. Configure **neighbor** statements on HQ pointing toward EAST and WEST. Only the router starting the exchange needs the statements (HQ in this case). However, it is considered best practice to also specify HQ as a neighbor on the EAST and WEST routers. Because the hello timers are longer on serial nonbroadcast links, the neighbor adjacencies might take longer to come up.

```
HQ(config)# router ospf 1
HQ(config-router)# neighbor 10.1.123.2
HQ(config-router)# neighbor 10.1.123.3

EAST(config)# router ospf 1
EAST(config-router)# neighbor 10.1.123.1

WEST(config)# router ospf 1
WEST(config-router)# neighbor 10.1.123.1
```

Note: Neighbor commands shown for the EAST and WEST routers will not appear in the running config. This is because the local router's OSPF priority has been set to 0 on the interface which would be used to communicate with the designated neighbor.

- d. You can verify adjacency states with the **show ip ospf neighbor** command.

```
HQ# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.1.2.1	0	FULL/DROTHER	00:01:57	10.1.123.2	Serial0/0/1
10.1.3.1	0	FULL/DROTHER	00:01:57	10.1.123.3	Serial0/0/1

Step 4: Change the network type to point-to-multipoint.

Point-to-multipoint is an OSPF network type that lends itself well to a hub-and-spoke topology. Point-to-multipoint does not elect DRs or BDRs, so it does not need interface priorities. Instead, it treats the network as a collection of point-to-point networks and advertises host routes for any neighbors that it has.

- a. To configure point-to-multipoint links, remove the previously configured **neighbor** statements and interface priorities..

```
HQ(config)# router ospf 1
HQ(config-router)# no neighbor 10.1.123.2
HQ(config-router)# no neighbor 10.1.123.3

EAST(config)# interface serial 0/0/1
EAST(config-if)# no ip ospf priority 0
EAST(config-if)# exit
EAST(config)# router ospf 1
EAST(config-router)# no neighbor 10.1.123.1

WEST(config)# interface serial 0/0/0
WEST(config-if)# no ip ospf priority 0
WEST(config-if)# exit
WEST(config)# router ospf 1
WEST(config-router)# no neighbor 10.1.123.1
```

- b. Use the interface command **ip ospf network point-to-multipoint** and reapply the Frame Relay maps using the **broadcast** option. Reset the OSPF process using the **clear ip ospf process** command. Verify that the adjacencies are active with the **show ip ospf neighbor** command.

```
HQ(config)# interface serial 0/0/1
HQ(config-if)# ip ospf network point-to-multipoint
HQ(config-if)# frame-relay map ip 10.1.123.2 102 broadcast
HQ(config-if)# frame-relay map ip 10.1.123.3 103 broadcast
```

```
EAST(config)# interface serial 0/0/1
EAST(config-if)# ip ospf network point-to-multipoint
EAST(config-if)# frame-relay map ip 10.1.123.1 201 broadcast
EAST(config-if)# frame-relay map ip 10.1.123.3 201 broadcast
```

```
WEST(config)# interface serial 0/0/0
WEST(config-if)# ip ospf network point-to-multipoint
WEST(config-if)# frame-relay map ip 10.1.123.1 301 broadcast
WEST(config-if)# frame-relay map ip 10.1.123.2 301 broadcast
```

```
HQ# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.1.3.1	0	FULL/ -	00:01:34	10.1.123.3	Serial0/0/1
10.1.2.1	0	FULL/ -	00:01:45	10.1.123.2	Serial0/0/1

- c. Observe the routing table on one of the spoke routers. Notice how the routing table has host routes in it. This is part of point-to-multipoint behavior.

```
EAST# show ip route
```

```
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route
```

```
Gateway of last resort is not set
```

```
10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
O    10.1.3.0/24 [110/129] via 10.1.123.1, 00:01:07, Serial0/0/1
C    10.1.2.0/24 is directly connected, Loopback2
O    10.1.1.0/24 [110/65] via 10.1.123.1, 00:01:07, Serial0/0/1
C    10.1.23.0/24 is directly connected, FastEthernet0/0
C    10.1.123.0/24 is directly connected, Serial0/0/1
O    10.1.123.1/32 [110/64] via 10.1.123.1, 00:01:07, Serial0/0/1
O    10.1.123.3/32 [110/128] via 10.1.123.1, 00:01:07, Serial0/0/1
```

- d. Look at the output of the `show ip ospf interface interface` command on your routers. Notice that the interface type is point-to-multipoint.

```
EAST# show ip ospf interface serial 0/0/1
```

```
Serial0/0/1 is up, line protocol is up
Internet Address 10.1.123.2/24, Area 0
Process ID 1, Router ID 10.1.2.1, Network Type POINT_TO_MULTIPPOINT, Cost:
64
Transmit Delay is 1 sec, State POINT_TO_MULTIPPOINT,
Timer intervals configured, Hello 30, Dead 120, Wait 120, Retransmit 5
oob-resync timeout 120
Hello due in 00:00:16
Supports Link-local Signaling (LLS)
Index 1/1, flood queue length 0
```

```

Next 0x0(0)/0x0(0)
Last flood scan length is 1, maximum is 1
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
  Adjacent with neighbor 10.1.1.1
Suppress hello for 0 neighbor(s)

```

Step 5: Change OSPF timers.

- a. Add the Ethernet link connecting EAST and WEST to the OSPF process using the **network** command.

```

EAST(config)# router ospf 1
EAST(config-router)# network 10.1.23.0 0.0.0.255 area 0

```

```

WEST(config)# router ospf 1
WEST(config-router)# network 10.1.23.0 0.0.0.255 area 0

```

- b. Look at the interface OSPF properties with the **show ip ospf interface interface** command.

```

EAST# show ip ospf interface FastEthernet 0/0
FastEthernet0/0 is up, line protocol is up
Internet Address 10.1.23.2/24, Area 0
Process ID 1, Router ID 10.1.2.1, Network Type BROADCAST, Cost: 1
Transmit Delay is 1 sec, State BDR, Priority 1
Designated Router (ID) 10.1.3.1, Interface address 10.1.23.3
Backup Designated router (ID) 10.1.2.1, Interface address 10.1.23.2
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  oob-resync timeout 40
  Hello due in 00:00:00
Supports Link-local Signaling (LLS)
Index 3/3, flood queue length 0
Next 0x0(0)/0x0(0)
Last flood scan length is 1, maximum is 1
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
  Adjacent with neighbor 10.1.3.1 (Designated Router)
Suppress hello for 0 neighbor(s)

```

Because it is a Fast Ethernet link, the default network type is broadcast and the default network timers are those associated with a broadcast network. You might want to change the default timers to allow for better network convergence. Neighbors that go down are detected more quickly with lower dead timers. The disadvantage of lower dead timers is higher router CPU utilization and more bandwidth being consumed by hello packets.

- c. Use the **ip ospf hello-interval seconds** command to change the default hello timer interval to 5 seconds on both sides. Change the dead timer to 15 seconds with the **ip ospf dead-interval seconds** command.

```

EAST(config)# interface FastEthernet 0/0
EAST(config-if)# ip ospf hello-interval 5
EAST(config-if)# ip ospf dead-interval 15

```

```

WEST(config)# interface FastEthernet 0/0
WEST(config-if)# ip ospf hello-interval 5
WEST(config-if)# ip ospf dead-interval 15

```

- d. Verify the changes with the **show ip ospf interface interface** command.

```

EAST# show ip ospf int Fa0/0
FastEthernet0/0 is up, line protocol is up
Internet Address 10.1.23.2/24, Area 0

```

```
Process ID 1, Router ID 10.1.2.1, Network Type BROADCAST, Cost: 1
Transmit Delay is 1 sec, State BDR, Priority 1
Designated Router (ID) 10.1.3.1, Interface address 10.1.23.3
Backup Designated router (ID) 10.1.2.1, Interface address 10.1.23.2
Timer intervals configured, Hello 5, Dead 15, Wait 15, Retransmit 5
  oob-resync timeout 40
  Hello due in 00:00:01
Supports Link-local Signaling (LLS)
Index 3/3, flood queue length 0
Next 0x0(0)/0x0(0)
Last flood scan length is 1, maximum is 1
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
  Adjacent with neighbor 10.1.3.1 (Designated Router)
  Suppress hello for 0 neighbor(s)
```

What are some disadvantages to changing the timers if they are not tuned correctly?

- e. Use the following Tcl script to verify connectivity to all addresses in the topology.

```
HQ# tclsh
HQ(tcl)#

foreach address {
10.1.1.1
10.1.2.1
10.1.3.1
10.1.123.1
10.1.123.2
10.1.123.3
10.1.23.2
10.1.23.3
} {
ping $address }
```

Challenge: Minimal Hello Intervals

Configure the Fast Ethernet link between EAST and WEST to lower the convergence time using the **ip ospf dead-interval minimal hello-multiplier multiplier** command. This command sets the dead interval to 1 second. Hellos will be sent at the rate of *multiplier* per second.

Note: The use of this command overrides hello and dead intervals configured on EAST and WEST Fa0/0 in Step 5.

- a. Configure the routers to send five hellos a second.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1700	Fast Ethernet 0 (FA0)	Fast Ethernet 1 (FA1)	Serial 0 (S0)	Serial 1 (S1)
1800	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2600	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0 (S0/0)	Serial 0/1 (S0/1)
2800	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. Rather than list all combinations of configurations for each router class, this table includes identifiers for the possible combinations of Ethernet and serial interfaces in the device. The table does not include any other type of interface, even though a specific router might contain one. For example, for an ISDN BRI interface, the string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A: Adtran Frame Relay Switch Configuration

If an Adtran Atlas 550 is used for the Frame Relay switch, connect the serial cable from each router interface in the topology diagram to the Adtran interface indicated in the table below. The Adtran is preconfigured to simulate a Frame Relay service that provides the following PVCs.

Frame Relay Switching Configuration

Connected Router	Router Interface	Adtran Interface	Ingress DLCI	Egress DLCI	Egress Router
HQ	S0/0/1 DTE	port 1/1	102	201	EAST
HQ	S0/0/1 DTE	port 1/1	103	301	WEST
EAST	S0/0/1 DTE	port 1/2	201	102	HQ
WEST	S0/0/0 DTE	port 2/1	301	103	HQ

The Adtran Frame Relay switch interfaces all provide the DCE clock. Be sure to use the appropriate cable between each router and the Adtran. All the router interfaces are DTE, and the cable to the Adtran interface should be serial to V.35 DCE. Use the **show controllers** command to verify which cable type is connected to a given router interface.

```
HQ# show controllers s0/0/1
Interface Serial0/0/1
Hardware is GT96K
DTE V.35 TX and RX clocks detected.
```

<output omitted>