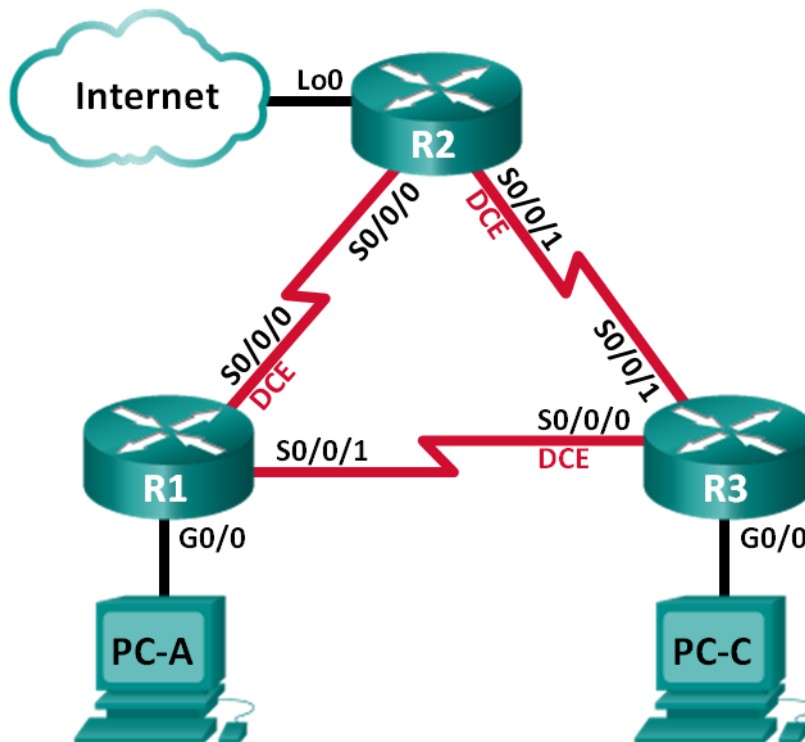


Lab - Configuring OSPFv2 Advanced Features (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.1.1	255.255.255.0	N/A
	S0/0/0 (DCE)	192.168.12.1	255.255.255.252	N/A
	S0/0/1	192.168.13.1	255.255.255.252	N/A
R2	Lo0	209.165.200.225	255.255.255.252	N/A
	S0/0/0	192.168.12.2	255.255.255.252	N/A
	S0/0/1 (DCE)	192.168.23.1	255.255.255.252	N/A
R3	G0/0	192.168.3.1	255.255.255.0	N/A
	S0/0/0 (DCE)	192.168.13.2	255.255.255.252	N/A
	S0/0/1	192.168.23.2	255.255.255.252	N/A
PC-A	NIC	192.168.1.3	255.255.255.0	192.168.1.1
PC-C	NIC	192.168.3.3	255.255.255.0	192.168.3.1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure and Verify OSPF Routing

Part 3: Change OSPF Metrics

Part 4: Configure and Propagate a Static Default Route

Part 5: Configure OSPF Authentication

Background / Scenario

Open Shortest Path First (OSPF) has advanced features to allow changes to be made to control metrics, default route propagation, and security.

In this lab, you will adjust OSPF metrics on the router interfaces, configure OSPF route propagation, and use Message Digest 5 (MD5) authentication to secure OSPF routing information.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). Other routers and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports

- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings on the PC hosts and routers.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers as necessary.

Step 3: Configure basic settings for each router.

- Disable DNS lookup.
- Configure device name as shown in the topology.
- Assign **class** as the privileged EXEC password.
- Assign **cisco** as the console and vty passwords.
- Encrypt the clear text passwords.
- Configure a MOTD banner to warn users that unauthorized access is prohibited.
- Configure **logging synchronous** for the console line.
- Configure the IP addresses listed in the Addressing Table for all interfaces.
- Set the clock rate for all DCE serial interfaces at 128000.
- Copy the running configuration to the startup configuration.

Step 4: Configure PC hosts.

Refer to the Addressing Table for PC host address information.

Step 5: Test connectivity.

At this point, the PCs are unable to ping each other. However, the routers should be able to ping the directly connected neighbor interfaces, and the PCs should be able to ping their default gateway. Verify and troubleshoot if necessary.

Part 2: Configure and Verify OSPF Routing

In Part 2, you will configure OSPFv2 routing on all routers in the network and then verify that routing tables are updated correctly.

Step 1: Configure the router ID on all routers.

Assign 1 as the process ID for this OSPF process. Each router should be given the following router ID assignments:

- R1 Router ID: **1.1.1.1**
- R2 Router ID: **2.2.2.2**
- R3 Router ID: **3.3.3.3**

```
R1(config)# router ospf 1
```

```
R1(config-router)# router-id 1.1.1.1
```

```
R2(config)# router ospf 1
R2(config-router)# router-id 2.2.2.2
```

```
R3(config)# router ospf 1
R3(config-router)# router-id 3.3.3.3
```

Step 2: Configure OSPF network information on the routers.

```
R1(config)# router ospf 1
R1(config-router)# network 192.168.1.0 0.0.0.255 area 0
R1(config-router)# network 192.168.12.0 0.0.0.3 area 0
R1(config-router)# network 192.168.13.0 0.0.0.3 area 0
```

```
R2(config)# router ospf 1
R2(config-router)# network 192.168.12.0 0.0.0.3 area 0
R2(config-router)# network 192.168.23.0 0.0.0.3 area 0
```

```
R3(config)# router ospf 1
R3(config-router)# network 192.168.3.0 0.0.0.255 area 0
R3(config-router)# network 192.168.13.0 0.0.0.3 area 0
R3(config-router)# network 192.168.23.0 0.0.0.3 area 0
```

Step 3: Verify OSPF routing.

- a. Issue the **show ip ospf neighbor** command to verify that each router is listing the other routers in the network.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
3.3.3.3	0	FULL/ -	00:00:36	192.168.13.2	Serial0/0/1
2.2.2.2	0	FULL/ -	00:00:33	192.168.12.2	Serial0/0/0

- b. Issue the **show ip route ospf** command to verify that all OSPF networks are present in the routing table on all routers.

```
R1# show ip route ospf
```

```
Codes: L - local, 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, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

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

```
O       192.168.3.0/24 [110/65] via 192.168.13.2, 00:00:20, Serial0/0/1
        192.168.23.0/30 is subnetted, 1 subnets
O       192.168.23.0 [110/128] via 192.168.13.2, 00:12:58, Serial0/0/1
```

```
[110/128] via 192.168.12.2, 00:03:38, Serial0/0/0
R2# show ip route ospf
Codes: L - local, 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, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
O      192.168.1.0/24 [110/65] via 192.168.12.1, 00:06:18, Serial0/0/0
O      192.168.3.0/24 [110/65] via 192.168.23.2, 00:03:38, Serial0/0/1
      192.168.13.0/30 is subnetted, 1 subnets
O      192.168.13.0 [110/128] via 192.168.23.2, 00:03:38, Serial0/0/1
      [110/128] via 192.168.12.1, 00:04:20, Serial0/0/0
```

```
R3# show ip route ospf
Codes: L - local, 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, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
O      192.168.1.0/24 [110/65] via 192.168.13.1, 00:16:12, Serial0/0/0
      192.168.12.0/30 is subnetted, 1 subnets
O      192.168.12.0 [110/128] via 192.168.23.1, 00:06:52, Serial0/0/1
      [110/128] via 192.168.13.1, 00:16:12, Serial0/0/0
```

Step 4: Test end-to-end connectivity.

Ping PC-C from PC-A to verify end-to-end connectivity. The pings should be successful. If they are not, troubleshoot as necessary.

Note: It may be necessary to disable the PC firewall for the pings to be successful.

Part 3: Change OSPF Metrics

In Part 3, you will change OSPF metrics using the **bandwidth** command, the **auto-cost reference-bandwidth** command, and the **ip ospf cost** command. Making these changes will provide more accurate metrics to OSPF.

Note: All DCE interfaces should have been configured with a clocking rate of 128000 in Part 1.

Step 1: Change the bandwidth on all serial interfaces to 128Kb/s.

- a. Issue the **show ip ospf interface brief** command to view the default cost settings on the router interfaces.

```
R1# show ip ospf interface brief
```

Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs	F/C
Se0/0/1	1	0	192.168.13.1/30	64	P2P	1/1	
Se0/0/0	1	0	192.168.12.1/30	64	P2P	1/1	
Gi0/0	1	0	192.168.1.1/24	1	DR	0/0	

- b. Use the **bandwidth 128** interface command on all serial interfaces.

```
R1(config)# interface s0/0/0
R1(config-if)# bandwidth 128
R1(config)# interface s0/0/1
R1(config-if)# bandwidth 128
```

```
R2(config)# interface s0/0/0
R2(config-if)# bandwidth 128
R2(config)# interface s0/0/1
R2(config-if)# bandwidth 128
```

```
R3(config)# interface s0/0/0
R3(config-if)# bandwidth 128
R3(config)# interface s0/0/1
R3(config-if)# bandwidth 128
```

- c. Issue the **show ip ospf interface brief** command to view the new cost settings.

```
R1# show ip ospf interface brief
```

Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs	F/C
Se0/0/1	1	0	192.168.13.1/30	781	P2P	1/1	
Se0/0/0	1	0	192.168.12.1/30	781	P2P	1/1	
Gi0/0	1	0	192.168.1.1/24	1	DR	0/0	

Step 2: Change the reference bandwidth on the routers.

- a. Issue the **auto-cost reference-bandwidth 1000** command on the routers to change the default reference bandwidth setting to account for Gigabit Ethernet Interfaces.

```
R1(config)# router ospf 1
R1(config-router)# auto-cost reference-bandwidth 1000
% OSPF: Reference bandwidth is changed.
Please ensure reference bandwidth is consistent across all routers.
```

```
R2(config)# router ospf 1
R2(config-router)# auto-cost reference-bandwidth 1000
% OSPF: Reference bandwidth is changed.
Please ensure reference bandwidth is consistent across all routers.
```

```
R3(config)# router ospf 1
R3(config-router)# auto-cost reference-bandwidth 1000
```

% OSPF: Reference bandwidth is changed.

Please ensure reference bandwidth is consistent across all routers.

- b. Re-issue the **show ip ospf interface brief** command to view how this command has changed cost values.

R1# **show ip ospf interface brief**

Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs	F/C
Se0/0/1	1	0	192.168.13.1/30	7812	P2P	0/0	
Se0/0/0	1	0	192.168.12.1/30	7812	P2P	0/0	
Gi0/0	1	0	192.168.1.1/24	1	DR	0/0	

Note: If the router had Fast Ethernet interfaces instead of Gigabit Ethernet interfaces, then the cost would now be 10 on those interfaces.

Step 3: Change the route cost.

- a. Issue the **show ip route ospf** command to display the current OSPF routes on R1. Notice that there are currently two routes in the table that use the S0/0/1 interface.

R1# **show ip route ospf**

Codes: L - local, 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, H - NHRP, l - LISP
+ - replicated route, % - next hop override

Gateway of last resort is not set

```
O      192.168.3.0/24 [110/7822] via 192.168.13.2, 00:00:12, Serial0/0/1
      192.168.23.0/30 is subnetted, 1 subnets
O      192.168.23.0 [110/15624] via 192.168.13.2, 00:00:12, Serial0/0/1
                        [110/15624] via 192.168.12.2, 00:20:03, Serial0/0/0
```

- b. Apply the **ip ospf cost 16000** command to the S0/0/1 interface on R1. A cost of 16,000 is higher than the accumulated cost of the route through R2 which is 15,624.

R1(config)# **int s0/0/1**

R1(config-if)# **ip ospf cost 16000**

- c. Issue the **show ip ospf interface brief** command on R1 to view the cost change to S0/0/1.

R1# **show ip ospf interface brief**

Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs	F/C
Se0/0/1	1	0	192.168.13.1/30	16000	P2P	1/1	
Se0/0/0	1	0	192.168.12.1/30	7812	P2P	1/1	
Gi0/0	1	0	192.168.1.1/24	1	DR	0/0	

- d. Re-issue the **show ip route ospf** command on R1 to display the effect this change has made on the routing table. All OSPF routes for R1 are now being routed through R2.

R1# **show ip route ospf**

Codes: L - local, 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, H - NHRP, l - LISP
+ - replicated route, % - next hop override

Gateway of last resort is not set

```
O      192.168.3.0/24 [110/15625] via 192.168.12.2, 00:05:31, Serial0/0/0
      192.168.23.0/30 is subnetted, 1 subnets
O      192.168.23.0 [110/15624] via 192.168.12.2, 01:14:02, Serial0/0/0
```

Explain why the route to the 192.168.3.0/24 network on R1 is now going through R2?

OSPF will choose the route with the least accumulated cost. The route with the lowest accumulated cost is: R1-S0/0/0 + R2-S0/0/1 + R3-G0/0, or $7812 + 7812 + 1 = 15,625$. This metric is smaller than the accumulated cost of R1-S0/0/1 + R3-G0/0, or $16,000 + 1 = 16,001$.

Part 4: Configure and Propagate a Static Default Route

In Part 4, you will use a loopback interface on R2 to simulate an ISP connection to the Internet. You will create a static default route on R2, and then OSPF will propagate that route to the other two routers on the network.

Step 1: Configure a static default route on R2 to loopback 0.

Configure a default route using the loopback interface configured in Part 1, to simulate a connection to an ISP.

```
R2(config)# ip route 0.0.0.0 0.0.0.0 loopback0
```

Step 2: Have OSPF propagate the default static route.

Issue the **default-information originate** command to include the static default route in the OSPF updates that are sent from R2.

```
R2(config)# router ospf 1
R2(config-router)# default-information originate
```

Step 3: Verify OSPF static route propagation.

- Issue the **show ip route static** command on R2.

```
R2# show ip route static
Codes: L - local, 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, H - NHRP, l - LISP
- + - replicated route, % - next hop override

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

S* 0.0.0.0/0 is directly connected, Loopback0

- b. Issue the **show ip route** command on R1 to verify the propagation of the static route from R2.

R1# **show ip route**

Codes: L - local, 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, H - NHRP, l - LISP
+ - replicated route, % - next hop override

Gateway of last resort is 192.168.12.2 to network 0.0.0.0

O*E2 0.0.0.0/0 [110/1] via 192.168.12.2, 00:02:57, Serial0/0/0

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.1.0/24 is directly connected, GigabitEthernet0/0
L 192.168.1.1/32 is directly connected, GigabitEthernet0/0
O 192.168.3.0/24 [110/15634] via 192.168.12.2, 00:03:35, Serial0/0/0
192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.12.0/30 is directly connected, Serial0/0/0
L 192.168.12.1/32 is directly connected, Serial0/0/0
192.168.13.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.13.0/30 is directly connected, Serial0/0/1
L 192.168.13.1/32 is directly connected, Serial0/0/1
192.168.23.0/30 is subnetted, 1 subnets
O 192.168.23.0 [110/15624] via 192.168.12.2, 00:05:18, Serial0/0/0

- c. Verify end-to-end connectivity by issuing a ping from PC-A to the ISP interface address 209.165.200.225.

Were the pings successful? _____ Yes

Part 5: Configure OSPF Authentication

OSPF authentication can be set up at the link level or the area level. There are three authentication types available for OSPF authentication: Null, plain text, or MD5. In Part 5, you will set up OSPF MD5 authentication, which is the strongest available.

Step 1: Set up MD5 OSPF authentication on a single link.

- a. Issue the **debug ip ospf adj** command on R2 to view OSPF adjacency messages.

R2# **debug ip ospf adj**

OSPF adjacency debugging is on

- b. Assign an MD5 key for OSPF Authentication on R1, interface S0/0/0.

R1(config)# **interface s0/0/0**

```
R1(config-if)# ip ospf message-digest-key 1 md5 MD5KEY
```

- c. Activate MD5 authentication on R1, interface S0/0/0.

```
R1(config-if)# ip ospf authentication message-digest
```

OSPF debug messages informing you of a Mismatched Authentication type displays on R2.

```
*Mar 19 00:03:18.187: OSPF-1 ADJ   Se0/0/0: Rcv pkt from 192.168.12.1 : Mismatched
Authentication type. Input packet specified type 2, we use type 0
```

- d. Issue the **u all** command, which is the shortest version of the **undebg all** command on R2 to disable debugging.
- e. Configure OSPF authentication on R2, interface S0/0/0. Use the same MD5 password you entered for R1.
- f. Issue a **show ip ospf interface s0/0/0** command on R2. This command displays the type of authentication at the bottom of the output.

```
R2# show ip ospf interface s0/0/0
```

```
Serial0/0/0 is up, line protocol is up
  Internet Address 192.168.12.2/30, Area 0, Attached via Network Statement
  Process ID 1, Router ID 2.2.2.2, Network Type POINT_TO_POINT, Cost: 7812
  Topology-MTID      Cost      Disabled      Shutdown      Topology Name
    0                7812        no           no            Base
  Transmit Delay is 1 sec, State POINT_TO_POINT
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:03
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  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 1.1.1.1
  Suppress hello for 0 neighbor(s)
  Message digest authentication enabled
  Youngest key id is 1
```

Step 2: Set up OSPF authentication at the area level.

- a. Issue the **area 0 authentication** command to set MD5 authentication for OSPF Area 0 on R1.

```
R1(config)# router ospf 1
```

```
R1(config-router)# area 0 authentication message-digest
```

- b. This option still requires that you assign the MD5 password at the interface level.

```
R1(config)# interface s0/0/1
```

```
R1(config-if)# ip ospf message-digest-key 1 md5 MD5KEY
```

- c. Issue the **show ip ospf neighbor** command on R3. R1 no longer has an adjacency with R3.

```
R3# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.2.2	0	FULL/ -	00:00:31	192.168.23.1	Serial0/0/1

- d. Set up area authentication on R3 and assign the same MD5 password to interface S0/0/0.

```
R3(config)# router ospf 1
R3(config-router)# area 0 authentication message-digest
R3(config-router)# interface s0/0/0
R3(config-if)# ip ospf message-digest-key 1 md5 MD5KEY
```

- e. Issue the **show ip ospf neighbor** command on R3. Notice that R1 is now showing as a neighbor, but R2 is missing.

```
R3# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
1.1.1.1	0	FULL/ -	00:00:38	192.168.13.1	Serial0/0/0

Why is R2 no longer showing as an OSPF neighbor?

R2 currently is only configured with OSPF authentication on S0/0/0. For R2 to form an adjacency with R3 again, interface S0/0/1 must also perform OSPF authentication.

- f. Configure R2 to perform area-level MD5 authentication.

```
R2(config)# router ospf 1
R2(config-router)# area 0 authentication message-digest
```

- g. Assign **MD5KEY** as the MD5 password for the link between R2 and R3.

```
R2(config-router)# interface s0/0/1
R2(config-if)# ip ospf message-digest-key 1 md5 MD5KEY
```

```
R3(config-router)# interface s0/0/1
R3(config-if)# ip ospf message-digest-key 1 md5 MD5KEY
```

- h. Issue the **show ip ospf neighbor** command on all routers to verify that all adjacencies have been re-established.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
3.3.3.3	0	FULL/ -	00:00:39	192.168.13.2	Serial0/0/1
2.2.2.2	0	FULL/ -	00:00:35	192.168.12.2	Serial0/0/0

```
R2# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
3.3.3.3	0	FULL/ -	00:00:36	192.168.23.2	Serial0/0/1
1.1.1.1	0	FULL/ -	00:00:32	192.168.12.1	Serial0/0/0

```
R3# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
-------------	-----	-------	-----------	---------	-----------

2.2.2.2	0	FULL/	-	00:00:33	192.168.23.1	Serial0/0/1
1.1.1.1	0	FULL/	-	00:00:39	192.168.13.1	Serial0/0/0

Reflection

1. What is the easiest and preferred method of manipulating OSPF route costs?

Using the **ip ospf cost** command overrides the cost calculation completely and sets the link cost to the desired amount.

2. What does the **default-information originate** command do for a network using the OSPF routing protocol?

The **default-information originate** command is used to inject a default route into an OSPF area which will propagate the default route to other OSPF routers.

3. Why is it a good idea to use OSPF authentication?

Routing protocols are used to exchange reachability information between routers. Routing information learned from peers is used to determine the next hop toward the destination. To route traffic correctly, it is necessary to prevent malicious or incorrect routing information from being introduced into the routing table. You should enable authentication in OSPF in order to exchange routing information in a secure manner.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	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. There is no way to effectively list all the 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 may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1 (After parts 1 and 2 of this lab)

```
R1#sh run
Building configuration...

Current configuration : 1557 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
ip cef
!
```

Lab - Configuring OSPFv2 Advanced Features

```
no ip domain lookup
no ipv6 cef
multilink bundle-name authenticated
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
ip address 192.168.1.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
ip address 192.168.12.1 255.255.255.252
clock rate 128000
!
interface Serial0/0/1
ip address 192.168.13.1 255.255.255.252
!
router ospf 1
router-id 1.1.1.1
network 192.168.1.0 0.0.0.255 area 0
network 192.168.12.0 0.0.0.3 area 0
network 192.168.13.0 0.0.0.3 area 0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
banner motd ^C
  Unauthorized Access is Prohibited!
^C
!
line con 0
password 7 01100F175804
logging synchronous
login
line aux 0
line 2
```

```
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 045802150C2E
login
transport input all
scheduler allocate 20000 1000
!
end
```

Router R2 (After parts 1 and 2 of this lab)

```
R2#sh run
Building configuration...

Current configuration : 1572 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
ip cef
!
no ip domain lookup
no ipv6 cef
multilink bundle-name authenticated
!
interface Loopback0
 ip address 209.165.200.225 255.255.255.252
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
```

Lab - Configuring OSPFv2 Advanced Features

```
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
ip address 192.168.12.2 255.255.255.252
!
interface Serial0/0/1
ip address 192.168.23.1 255.255.255.252
clock rate 128000
!
router ospf 1
router-id 2.2.2.2
network 192.168.12.0 0.0.0.3 area 0
network 192.168.23.0 0.0.0.3 area 0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
banner motd ^C
  Unauthorized Access is Prohibited!
^C
!
line con 0
password 7 01100F175804
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 030752180500
login
```



```
transport input all
scheduler allocate 20000 1000
!
end
```

Router R3 (After parts 1 and 2 of this lab)

```
R3#sh run
Building configuration...

Current configuration : 1596 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R3
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
ip cef
!
no ip domain lookup
no ipv6 cef
multilink bundle-name authenticated
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 ip address 192.168.3.1 255.255.255.0
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0/0
 ip address 192.168.13.2 255.255.255.252
```

Lab - Configuring OSPFv2 Advanced Features

```
clock rate 128000
!
interface Serial0/0/1
 ip address 192.168.23.2 255.255.255.252
!
router ospf 1
 router-id 3.3.3.3
 network 192.168.3.0 0.0.0.255 area 0
 network 192.168.13.0 0.0.0.3 area 0
 network 192.168.23.0 0.0.0.3 area 0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
banner motd ^C
  Unauthorized Access is Prohibited!
^C
!
line con 0
 password 7 01100F175804
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password 7 05080F1C2243
 login
 transport input all
scheduler allocate 20000 1000
!
End
```

Router R1 (Final)

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

Current configuration : 1895 bytes
!
version 15.2
```

Lab - Configuring OSPFv2 Advanced Features

```
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
ip cef
!
no ip domain lookup
no ipv6 cef
multilink bundle-name authenticated
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 ip address 192.168.1.1 255.255.255.0
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0/0
 bandwidth 128
 ip address 192.168.12.1 255.255.255.252
 ip ospf authentication message-digest
 ip ospf message-digest-key 1 md5 7 013E2251702E3F
 clock rate 128000
!
interface Serial0/0/1
 bandwidth 128
 ip address 192.168.13.1 255.255.255.252
 ip ospf message-digest-key 1 md5 7 12342142392E35
 ip ospf cost 16000
!
router ospf 1
```

```
router-id 1.1.1.1
auto-cost reference-bandwidth 1000
area 0 authentication message-digest
network 192.168.1.0 0.0.0.255 area 0
network 192.168.12.0 0.0.0.3 area 0
network 192.168.13.0 0.0.0.3 area 0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
banner motd @   Unauthorized Access is Prohibited! @
!
line con 0
password 7 01100F175804
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 045802150C2E
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R2 (Final)

```
R2# show run
Building configuration...

Current configuration : 1878 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R2
```

Lab - Configuring OSPFv2 Advanced Features

```
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
memory-size iomem 15  
!  
ip cef  
!  
no ip domain lookup  
no ipv6 cef  
multilink bundle-name authenticated  
!  
interface Loopback0  
 ip address 209.165.200.225 255.255.255.252  
!  
interface Embedded-Service-Engine0/0  
 no ip address  
 shutdown  
!  
interface GigabitEthernet0/0  
 no ip address  
 shutdown  
 duplex auto  
 speed auto  
!  
interface GigabitEthernet0/1  
 no ip address  
 shutdown  
 duplex auto  
 speed auto  
!  
interface Serial0/0/0  
 bandwidth 128  
 ip address 192.168.12.2 255.255.255.252  
 ip ospf authentication message-digest  
 ip ospf message-digest-key 1 md5 7 002937532F7E32  
!  
interface Serial0/0/1  
 bandwidth 128  
 ip address 192.168.23.1 255.255.255.252  
 ip ospf message-digest-key 1 md5 7 1328334720293D  
 clock rate 128000  
!  
router ospf 1  
 router-id 2.2.2.2  
 auto-cost reference-bandwidth 1000
```

```
area 0 authentication message-digest
network 192.168.12.0 0.0.0.3 area 0
network 192.168.23.0 0.0.0.3 area 0
default-information originate
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 0.0.0.0 0.0.0.0 Loopback0
!
control-plane
!
banner motd @   Unauthorized Access is Prohibited! @
!
line con 0
password 7 01100F175804
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password 7 030752180500
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R3 (Final)

```
R3# show run
Building configuration...

Current configuration : 1904 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R3
```

Lab - Configuring OSPFv2 Advanced Features

```
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
memory-size iomem 15  
!  
ip cef  
!  
no ip domain lookup  
no ipv6 cef  
!  
multilink bundle-name authenticated  
!  
interface Embedded-Service-Engine0/0  
no ip address  
shutdown  
!  
interface GigabitEthernet0/0  
ip address 192.168.3.1 255.255.255.0  
duplex auto  
speed auto  
!  
interface GigabitEthernet0/1  
no ip address  
shutdown  
duplex auto  
speed auto  
!  
interface Serial0/0/0  
bandwidth 128  
ip address 192.168.13.2 255.255.255.252  
ip ospf message-digest-key 1 md5 7 10632D4C2E322B  
clock rate 128000  
!  
interface Serial0/0/1  
bandwidth 128  
ip address 192.168.23.2 255.255.255.252  
ip ospf message-digest-key 1 md5 7 10632D4C2E322B  
!  
router ospf 1  
router-id 3.3.3.3  
auto-cost reference-bandwidth 1000  
area 0 authentication message-digest  
network 192.168.3.0 0.0.0.255 area 0  
network 192.168.13.0 0.0.0.3 area 0  
network 192.168.23.0 0.0.0.3 area 0
```

Lab - Configuring OSPFv2 Advanced Features

```
!  
ip forward-protocol nd  
!  
no ip http server  
no ip http secure-server  
!  
control-plane  
!  
banner motd @  Unauthorized Access is Prohibited!  @  
!  
line con 0  
  password 7 01100F175804  
  logging synchronous  
  login  
line aux 0  
line 2  
  no activation-character  
  no exec  
  transport preferred none  
  transport input all  
  transport output pad telnet rlogin lapb-ta mop udptn v120 ssh  
  stopbits 1  
line vty 0 4  
  password 7 05080F1C2243  
  login  
  transport input all  
!  
scheduler allocate 20000 1000  
!  
end
```