CIS 83 LAB 2 - Single Area OSPF
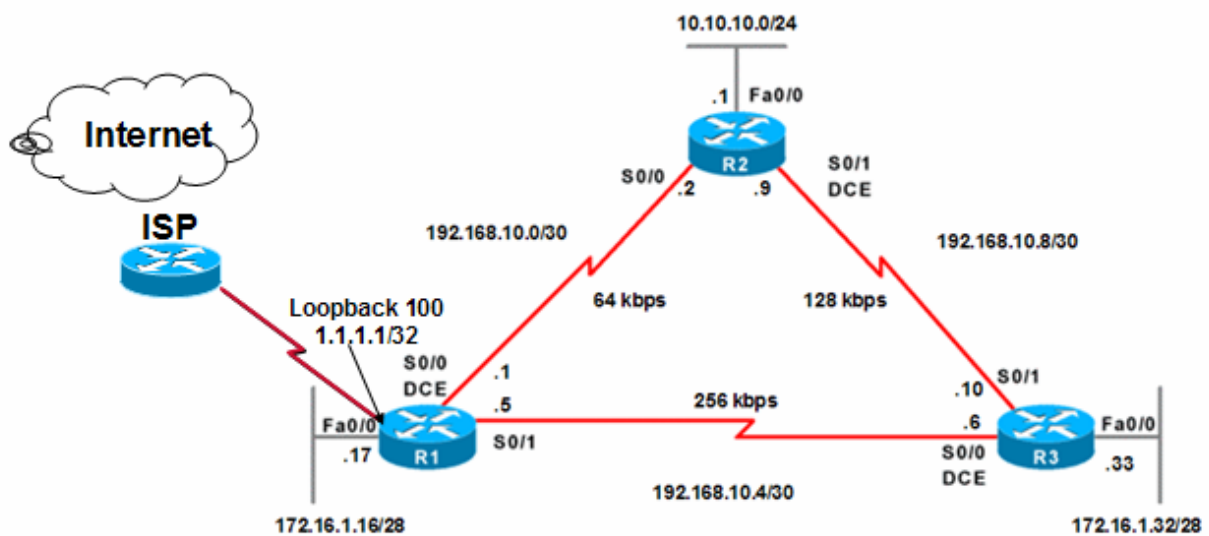# Rich Simms
September 12, 2006

Objective

The objective of this lab is to become familiar setting up and configuring OSPF on three routers for a single area. OSPF is our first encounter with a link-state routing protocol as opposed to RIP which is a distance-vector protocol.

Scenario

This lab was done using the basic router pod on NETLAB. NETLAB lets you remotely access a pod of Cisco routers. The three Cisco routers were configured as shown below.

Topology

Final Running Configurations

R1	R2	R3
R1#show run Building configuration... Current configuration : 1326 bytes ! version 12.2 service timestamps debug uptime service timestamps log uptime no service password-encryption ! hostname R1 ! memory-size iomem 10 ip subnet-zero ! no ip domain-lookup ! call rsvp-sync ! interface Loopback0 ip address 10.1.1.1 255.255.255.255 ! interface Loopback100 ip address 1.1.1.1 255.255.255.255 ! interface FastEthernet0/0 ip address 172.16.1.17 255.255.255.240 ip ospf message-digest-key 1 md5 7 itsasecret duplex auto speed auto ! interface Serial0/0 bandwidth 64 ip address 192.168.10.1 255.255.255.252 ip ospf message-digest-key 1 md5 7 itsasecret ip ospf hello-interval 5 clockrate 64000 ! interface BRI0/0 no ip address encapsulation hdlc shutdown ! interface FastEthernet0/1 no ip address shutdown duplex auto speed auto ! interface Serial0/1 bandwidth 256 ip address 192.168.10.5 255.255.255.252 ip ospf message-digest-key 1 md5 7 itsasecret ! ! router ospf 1	R2#show run Building configuration... Current configuration : 1195 bytes ! version 12.2 service timestamps debug uptime service timestamps log uptime no service password-encryption ! hostname R2 ! memory-size iomem 10 ip subnet-zero ! no ip domain-lookup ! call rsvp-sync ! interface Loopback0 ip address 10.2.2.2 255.255.255.255 ! ! ! ! ! ! interface FastEthernet0/0 ip address 10.10.10.1 255.255.255.0 ip ospf message-digest-key 1 md5 7 itsasecret duplex auto speed auto ! interface Serial0/0 bandwidth 64 ip address 192.168.10.2 255.255.255.252 ip ospf message-digest-key 1 md5 7 itsasecret ip ospf hello-interval 5 ! ! interface BRI0/0 no ip address encapsulation hdlc shutdown ! interface FastEthernet0/1 no ip address shutdown duplex auto speed auto ! interface Serial0/1 bandwidth 128 ip address 192.168.10.9 255.255.255.252 ip ospf message-digest-key 1 md5 7 itsasecret clockrate 64000 ! router ospf 1	R3#show run Building configuration... Current configuration : 1175 bytes ! version 12.2 service timestamps debug uptime service timestamps log uptime no service password-encryption ! hostname R3 ! memory-size iomem 10 ip subnet-zero ! no ip domain-lookup ! call rsvp-sync ! interface Loopback0 ip address 10.3.3.3 255.255.255.255 ! ! ! ! ! ! interface FastEthernet0/0 ip address 172.16.1.33 255.255.255.248 ip ospf message-digest-key 1 md5 7 itsasecret duplex auto speed auto ! interface Serial0/0 bandwidth 256 ip address 192.168.10.6 255.255.255.252 ip ospf message-digest-key 1 md5 7 itsasecret clockrate 256000 ! ! interface BRI0/0 no ip address encapsulation hdlc shutdown ! interface FastEthernet0/1 no ip address shutdown duplex auto speed auto ! interface Serial0/1 bandwidth 128 ip address 192.168.10.10 255.255.255.252 ip ospf message-digest-key 1 md5 7 itsasecret ! ! router ospf 1

<table>
<tr><td>

```
 log-adjacency-changes
 area 0 authentication
message-digest
 network 172.16.1.16 0.0.0.15
area 0
 network 192.168.10.0 0.0.0.3
area 0
 network 192.168.10.4 0.0.0.3
area 0
 default-information originate
!
ip classless
ip route 0.0.0.0 0.0.0.0
Loopback100
no ip http server
!
dial-peer cor custom
!
line con 0
 exec-timeout 0 0
 logging synchronous
line aux 0
line vty 0 4
 login
!
end

R1#
```

</td><td>

```
 log-adjacency-changes
 area 0 authentication
message-digest
 network 10.10.10.0 0.0.0.255
area 0
 network 192.168.10.0 0.0.0.3
area 0
 network 192.168.10.8 0.0.0.3
area 0
!
!
ip classless
no ip http server
!
!
!
dial-peer cor custom
!
line con 0
 exec-timeout 0 0
 logging synchronous
line aux 0
line vty 0 4
 login
!
end

R2#
```

</td><td>

```
 log-adjacency-changes
 area 0 authentication
message-digest
 network 172.16.1.32 0.0.0.15
area 0
 network 192.168.10.4 0.0.0.3
area 0
 network 192.168.10.8 0.0.0.3
area 0
!
!
ip classless
no ip http server
!
!
!
dial-peer cor custom
!
line con 0
 exec-timeout 0 0
 logging synchronous
line aux 0
line vty 0 4
 login
!
end

R3#
```

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Final Routing Tables

R1	
| | ```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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 0.0.0.0 to network 0.0.0.0

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback100
     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/0
C       192.168.10.4 is directly connected, Serial0/1
O       192.168.10.8 [110/1171] via 192.168.10.6, 00:00:08, Serial0/1
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O       172.16.1.32/29 [110/400] via 192.168.10.6, 00:00:08, Serial0/1
C       172.16.1.16/28 is directly connected, FastEthernet0/0
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
O       10.10.10.0/24 [110/1181] via 192.168.10.6, 00:00:09, Serial0/1
C       10.1.1.1/32 is directly connected, Loopback0
S*   0.0.0.0/0 is directly connected, Loopback100
R1#
``` |
| R2 | ```
R2#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
``` |

| | ```
                i - IS-IS, 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 192.168.10.10 to network 0.0.0.0

      192.168.10.0/30 is subnetted, 3 subnets
C        192.168.10.0 is directly connected, Serial0/0
O        192.168.10.4 [110/1171] via 192.168.10.10, 00:00:15, Serial0/1
C        192.168.10.8 is directly connected, Serial0/1
      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O        172.16.1.32/29 [110/791] via 192.168.10.10, 00:00:15, Serial0/1
O        172.16.1.16/28 [110/1181] via 192.168.10.10, 00:00:15, Serial0/1
      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.2.2.2/32 is directly connected, Loopback0
C        10.10.10.0/24 is directly connected, FastEthernet0/0
O*E2 0.0.0.0/0 [110/1] via 192.168.10.10, 00:00:17, Serial0/1
R2#
``` |
| R3 | ```
R3#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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 192.168.10.5 to network 0.0.0.0

      192.168.10.0/30 is subnetted, 3 subnets
O        192.168.10.0 [110/1952] via 192.168.10.5, 00:00:23, Serial0/0
C        192.168.10.4 is directly connected, Serial0/0
C        192.168.10.8 is directly connected, Serial0/1
      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.16.1.32/29 is directly connected, FastEthernet0/0
O        172.16.1.16/28 [110/400] via 192.168.10.5, 00:00:23, Serial0/0
      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.3.3.3/32 is directly connected, Loopback0
O        10.10.10.0/24 [110/791] via 192.168.10.9, 00:00:24, Serial0/1
O*E2 0.0.0.0/0 [110/1] via 192.168.10.5, 00:00:24, Serial0/0
R3#
``` |

Summary

This lab started with configuring OPSF. Note that Cisco routers use the crazy wildcard mask to specify subnet masks. This is the same as when configuring Access Control Lists. It is important to us the same Area for each router. The process IP does not have to be the same on each router. This just identifies the OSPF process that is locally running and its database. It is possible to have more that one OSPF running on the same router but Rick's advice is to not tdo this.

Next we used the following commands to verify OSPF is working correctly:
- show ip protocols
- show ip ospf
- show ip ospf neighbor
- show ip ospf interface
- show ip ospf interface serial 0/0

Next we modified timers and security settings. We changed hello-interval and dead-interval timers. They need to be the same between neighbors or it breaks. For security we set passwords encrypted with MD5. We also activated debug tracing to see what was going on.

We then modified route costs using two methods. The first was to set the bandwidth of a link. The second was to set the cost directly. The commands used for this are:

- interface serial n
- bandwidth xx (cost =100,000,000/xx000)
- ip ospf cost xxxx (cost=xxxx, useful in multi-vendor environments)

To make sure default routes were communicated between routers one must use the default-information originate command on the router with the default gateway.

Commands

```
! Configuring OSPF (uses wildcard masks)
R1#conf t
R1(config)#router ospf 1
R1(config-router)#network 172.16.1.16 0.0.0.15 area 0
R1(config-router)#network 192.168.10.0 0.0.0.3 area 0
R1(config-router)#network 192.168.10.4 0.0.0.3 area 0

! Verifying OSPF
R1#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 10.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    172.16.1.16 0.0.0.15 area 0
    192.168.10.0 0.0.0.3 area 0
    192.168.10.4 0.0.0.3 area 0
  Routing Information Sources:
    Gateway          Distance      Last Update
    10.2.2.2               110      00:26:07
    10.3.3.3               110      00:26:07
    10.1.1.1               110      00:26:07
  Distance: (default is 110)

! Verifying OSPF
R1#show ip ospf
 Routing Process "ospf 1" with ID 10.1.1.1
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
```

```
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 3
        Area has no authentication
        SPF algorithm executed 9 times
        Area ranges are
        Number of LSA 3. Checksum Sum 0x017332
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0

! Verifying OSPF
R1#show ip ospf neighbor

Neighbor ID      Pri   State           Dead Time   Address         Interface
10.3.3.3           1   FULL/  -        00:00:30    192.168.10.6    Serial0/1
10.2.2.2           1   FULL/  -        00:00:36    192.168.10.2    Serial0/0
R1#

! Verifying OSPF
R1#show ip ospf interface
Serial0/1 is up, line protocol is up
  Internet Address 192.168.10.5/30, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT_TO_POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:03
  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 10.3.3.3
  Suppress hello for 0 neighbor(s)
Serial0/0 is up, line protocol is up
  Internet Address 192.168.10.1/30, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT_TO_POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:06
  Index 2/2, 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 10.2.2.2
  Suppress hello for 0 neighbor(s)
FastEthernet0/0 is up, line protocol is up
  Internet Address 172.16.1.17/28, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 10.1.1.1, Interface address 172.16.1.17
  No backup designated router on this network
```

```
   Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
     Hello due in 00:00:04
   Index 1/1, flood queue length 0
   Next 0x0(0)/0x0(0)
   Last flood scan length is 0, maximum is 0
   Last flood scan time is 0 msec, maximum is 0 msec
   Neighbor Count is 0, Adjacent neighbor count is 0
   Suppress hello for 0 neighbor(s)

! For single interface
R1#show ip ospf interface serial 0/0
Serial0/0 is up, line protocol is up
   Internet Address 192.168.10.1/30, Area 0
   Process ID 1, Router ID 10.1.1.1, Network Type POINT_TO_POINT, Cost: 64
   Transmit Delay is 1 sec, State POINT_TO_POINT,
   Timer intervals configured, Hello 5, Dead 20, Wait 20, Retransmit 5
     Hello due in 00:00:02
   Index 2/2, 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 0, Adjacent neighbor count is 0
   Suppress hello for 0 neighbor(s)
R1#


! Modifying OSPF timers
R1(config)#interface serial 0/0
R1(config-if)#ip ospf hello-interval 5
R1(config-if)#ip ospf dead-interval 20

! Debug tracing for OSPF
R1#debug ip ospf events
OSPF events debugging is on
R1#
06:37:25: OSPF: Rcv hello from 10.2.2.2 area 0 from Serial0/0 192.168.10.2
06:37:25: OSPF: Mismatched hello parameters from 192.168.10.2
06:37:25: OSPF: Dead R 40 C 20, Hello R 10 C 5

R1#undebug all

! Setup authentication with password="itsasecret"
R1(config)#interface serial 0/0
R1(config-if)#ip ospf message-digest-key 1 md5 7 itsasecret
R1(config)#interface serial 0/1
R1(config-if)#ip ospf message-digest-key 1 md5 7 itsasecret
R1(config)#interface fa 0/0
R1(config-if)#ip ospf message-digest-key 1 md5 7 itsasecret

R1(config-if)#router ospf 1
R1(config-router)#area 0 authentication message-digest

! Configuring bandwidth
R1#show interface s 0/0
Serial0/0 is up, line protocol is up
   Hardware is PowerQUICC Serial
   Internet address is 192.168.10.1/30
```

```
   MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
   <text omitted>
R1(config)#interface serial 0/0
R1(config-if)#bandwidth 64

! Configuring cost
! An alternative method to using the bandwidth command is o use the ip ospf
! cost command.  This command can be useful in multivendor environments when
! the non-Cisco routers use a metric other than bandwidth.  This command can
! also be used instead of the bandwidth command, but specifying the cost of
! that interface.  Here are examples for R1.

! bandwidth Commands

R1(config)#interface serial 0/0
R1(config-if)#bandwidth 64
R1(config)#interface serial 0/1
R1(config-if)#bandwidth 256

! ip ospf cost Commands

R1(config)#interface serial 0/0
R1(config-if)#ip ospf cost 1562
R1(config)#interface serial 0/1
R1(config-if)# ip ospf cost 390

! Calculating cost

R1#show interface s 0/1
Serial0/1 is up, line protocol is up
  Hardware is PowerQUICC Serial
  Internet address is 192.168.10.5/30
  MTU 1500 bytes, BW 256 Kbit, DLY 20000 usec,

R3#show inter s 0/1
Serial0/1 is administratively down, line protocol is down
  Hardware is PowerQUICC Serial
  MTU 1500 bytes, BW 128 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set

R2#show interface fa 0/0
FastEthernet0/0 is administratively down, line protocol is down
  Hardware is AmdFE, address is 000c.3010.9280 (bia 000c.3010.9280)
  MTU 1500 bytes, BW 10000 Kbit, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set

! R1 Serial 0/1 interface:
!     = (100,000,000 / 256,000)
!     = 390
! R3 Serial 0/1 interface:
!     = (100,000,000 / 128,000)
!     = 781
! R2 FastEthernet 0/0 interface, operating at 10 Mpbs
!     = (100,000,000 / 10,000,000!
!      = 10
```

```
! Adding up the interface costs:
!      390
!      781
!    + 10
!      ---
!     1181

! We can also determine the cost by examining using the
! show ip ospf interface command:

R1#show ip ospf interface serial 0/1
Serial0/1 is up, line protocol is up
  Internet Address 192.168.10.5/30, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT_TO_POINT, Cost: 390
  <text omitted>

R3#show ip ospf interface serial 0/1
Serial0/1 is up, line protocol is up
  Internet Address 192.168.10.10/30, Area 0
  Process ID 1, Router ID 10.3.3.3, Network Type POINT_TO_POINT, Cost: 781
  <text omitted>

R2#show ip ospf interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Internet Address 10.10.10.1/24, Area 0
  Process ID 1, Router ID 10.2.2.2, Network Type BROADCAST, Cost: 10
  <text omitted>

! Adding up the interface costs:
!      390
!      781
!    + 10
!      ---
!     1181

! Configuring a default route
Router(config)#ip route 0.0.0.0 0.0.0.0 loopback 100

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