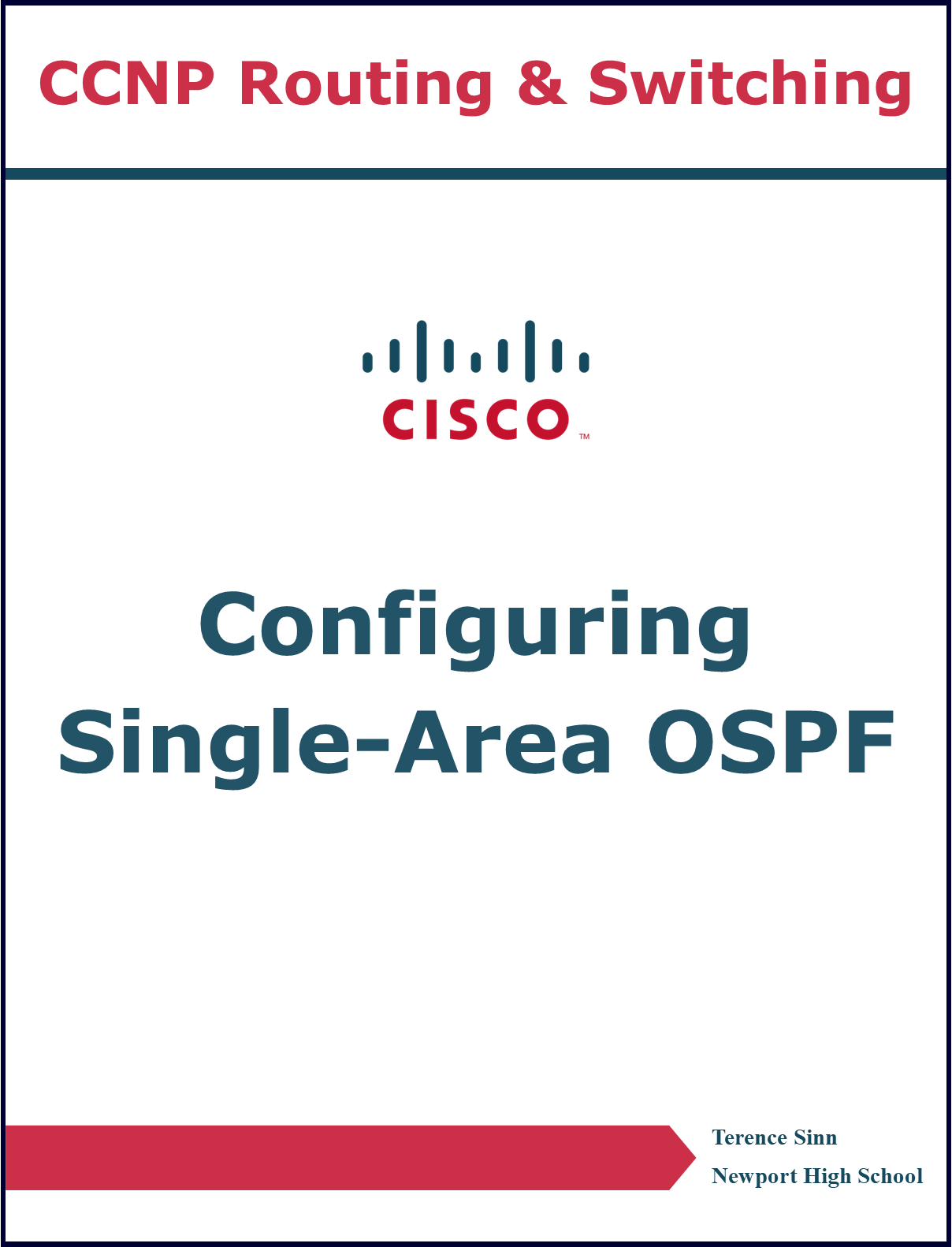
****

**Purpose**

The network built demonstrates the usage of dynamic routing protocol OSPF (Open Shortest Path First) in order to route packets through a series of networks. The routes through the networks were learned by the router without any statically configured routes from the administrator. Because of this, dynamic routing protocols like OSPF are favored in network maintenance to reduce the number of manual commands entered when adding new routers, reduce potential human misconfiguration errors or typos, and be more flexible when certain connections go down.

**Background Information**

In this lab, the dynamic routing protocol OSPF’s configurations and operation were explored. The version used in this lab is OSPFv2, meaning that it works with the familiar IPv4 addressing scheme, a way for networking devices and computers to have their own virtual mailing address.

The IPv4 addressing scheme works with a unique combination of 4 numbers from 0-255 (8 bits in binary) separated by dots in order to denote the IPv4 address. An example IPv4 address would be 192.168.0.1. However, different networks are separated from each other, and 4 simple numbers delimited by dots cannot identify what network the devices belong to. To accommodate this, the IPv4 addressing scheme uses a subnet mask to denote which part of the IPv4 address represents the network it belongs to and which part of the address represents which host it is within that network. Since IPv4 addresses are binary based, the subnet mask separates network parts from host parts by denoting whether a certain bit belongs to the network or not. A sample subnet mask is 255.255.255.0, which donates that the first 3 numbers (24 bits) of the address belong to the network and the last number (8 bits) belongs to the host. Combined with the earlier 192.168.0.1 IPv4 address, the network address would be 192.168.0.0 and the host portion would be .1 within the network. This could also be written as 192.168.0.1/24 to show the IPv4 address and the subnet mask.

With that in mind, the first step of the OSPF routing process is to make sure every router has a virtual mailing address for every connection it has. Every router represents the intersection between networks, so the router with 4 connections would be connected to 4 networks and would require 4 separate IPv4 addresses and subnet mask pairs. Afterwards, OSPF is configured on every router to advertise every connection it has with other routers. The configuration consists of configuring every router to be included in the same OSPF area, the domain which routers can advertise in. Then, the connected networks to be advertised are configured using the IPv4 address of the networks and a wildcard mask. The wildcard mask is the opposite of the subnet mask as when the subnet mask shows which part of the IPv4 address is the network address, the wildcard mask shows which parts are the host portion. For the earlier sample of the subnet mask, the 255.255.255.0 has the counterpart wildcard mask of 0.0.0.255, effectively flipping the binary bits.

After configuring OSPF, other routers receive this network information and now know how to reach certain networks through other learned routers. All routers having to advertise at the same time can flood the networks and routers with information, so OSPF implements a system to select a single router to facilitate all the distribution of information. This router acts as a middleman between other routers. OSPF also implements a backup router to perform this task if this single middleman router fails to be connected. Once all router information is shared between all connected OSPF enabled routers, they run a shortest path algorithm to find the fastest way to reach all advertised networks. The shortest path is determined by the bandwidths from the source to destination, making a connection with 10 Mb/s have a higher cost than one with 1000 Mb/s. The shortest path to all advertised networks is stored in the router through a routing table and will be used to make forwarding decisions when receiving data to be transmitted.

**Lab Summary**

5 routers were connected to each other in a straight-line using copper cross-over cables. Gigabit ethernet interfaces were used for all router connections. Every router was configured with /30 networks to accommodate single connections with other networks. OSPFv2 was used to create dynamic routes between the routers. Process-ID of 10 and the backbone area 0 was used to configure a single-area OSPF. Passive interfaces, auto-cost reference bandwidths, hello timers, dead timers, and LANs were not configured in this lab.

**Lab Commands**

**Router (config) # router ospf <process-id>**

Enables OSPF on the router and enters OSPF configuration mode. The process-id is significant to the router itself only and helps to distinguish one OSPF configuration from another.

**Router# show ip ospf route**

Shows all learned routes through OSPF and the costs to get to each network. Includes the area number, process ID, interfaces activated in OSPF, and networks configured locally on the router.

**Router# show ip protocols**

Shows all the configured IP protocols on the router, including OSPF’s configured area number, process ID, administrative distance, reference bandwidth, and passive-interfaces.

**Router# show ip ospf neighbor**

Shows all connected and adjacent OSPF enabled routers, including the connected interfaces, the IP addresses, OSPF link-state, and the OSPF hello and dead timers used for maintaining adjacencies.

**Router# show ip ospf database**

Shows the OSPF topology table, which includes router ID and other information about all OSPF enabled routers in the area.

**Router (config-router) # network <network-address> <wildcard mask> area <number>**

Enables the specified network for OSPF advertisement. The network address is the IPv4 address of a specified network, and the wildcard mask is the inverse of the subnet mask. For example, the corresponding wildcard mask of the subnet mask 255.255.255.0 would be 0.0.0.255 as it would be flipping every binary bit in the subnet mask. The area number specifies the group of routers OSPF can be advertised within. When working with single-area OSPF, area 0 must be used.

**Router (config-if) #ip ospf <process-id> area <area number>**

Enables the specified interface for OSPF advertisement. The process-id is significant to the router itself and helps to distinguish separate OSPF configurations. The area number specifies the group of routers OSPF can be advertised within. When working with single-area OSPF, area 0 must be used.

**Router# clear ip ospf process**

Restarts the OSPF processes without having to reload the entire router. Clearing the OSPF processes is used to reset any faulty or premature elections of the Designated and Backup Designated Router as it restarts the entire election process.

**Router (config-router) # auto-cost reference-bandwidth <bandwidth in Mb/s>**

Sets the reference bandwidth used to calculate the cost of traversing a link. The bandwidth is measured in megabits per second and the cost of a link, if not manually configured, is calculated through dividing the reference bandwidth with the link’s maximum bandwidth. The default reference bandwidth is 10 megabits per second. Calculations are rounded up, so if a gigabit ethernet port (1000 megabits per second) was assigned a cost through the default reference bandwidth, 10 / 1000 rounds up to 1. It is good practice to set the reference bandwidth to be the maximum bandwidth of the largest link.

**Router (config-if) # ip ospf cost <cost of link>**

Manually sets the cost to traverse a link. Cost is used to determine the shortest path through an OSPF enabled network of routers.

**Network Diagram with IP’s**

Diagram

Description automatically generated

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Router Name** | Interface | IP Address | Network Address | Subnet Mask |
| **R2** | G0/0/0 | 192.168.0.21 | 192.168.0.20/30 | 255.255.255.252 |
|  | G0/0/1 | N/A | N/A | N/A |
|  | Loopback0 | 192.168.0.1 | 192.168.0.0/30 | 255.255.255.252 |
|  |  |  |  |  |
| **R3** | G0/0/0 | 192.168.0.22 | 192.168.0.20/30 | 255.255.255.252 |
|  | G0/0/1 | 192.168.0.25 | 192.168.0.24/30 | 255.255.255.252 |
|  | Loopback0 | 192.168.0.5 | 192.168.0.4/30 | 255.255.255.252 |
|  |  |  |  |  |
| **R4** | G0/0/0 | 192.168.0.29 | 192.168.0.28/30 | 255.255.255.252 |
|  | G0/0/1 | 192.168.0.26 | 192.168.0.24/30 | 255.255.255.252 |
|  | Loopback0 | 192.168.0.9 | 192.168.0.8/30 | 255.255.255.252 |
|  |  |  |  |  |
| **R5** | G0/0/0 | 192.168.0.30 | 192.168.0.28/30 | 255.255.255.252 |
|  | G0/0/1 | 192.168.0.33 | 192.168.0.32/30 | 255.255.255.252 |
|  | Loopback0 | 192.168.0.13 | 192.168.0.12/30 | 255.255.255.252 |
|  |  |  |  |  |
| **R6** | G0/0/0 | N/A | N/A | N/A |
|  | G0/0/1 | 192.168.0.34 | 192.168.0.32/30 | 255.255.255.252 |
|  | Loopback0 | 192.168.0.17 | 192.168.0.16/30 | 255.255.255.252 |

**Configurations**

**Router 2**

**R2#show running-config**

Current configuration : 3575 bytes

version 16.9

service timestamps debug datetime msec

service timestamps log datetime msec

platform qfp utilization monitor load 80

no platform punt-keepalive disable-kernel-core

hostname R2

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

ip dhcp pool webuidhcp

subscriber templating

multilink bundle-name authenticated

crypto pki trustpoint TP-self-signed-2219300048

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-2219300048

revocation-check none

rsakeypair TP-self-signed-2219300048

crypto pki certificate chain TP-self-signed-2219300048

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D 43657274

69666963 6174652D 32323139 33303030 3438301E 170D3231 30393130 31353135

30335A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 32313933

30303034 38308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 0100BC99 E5078694 B4FC4D5A B6622F0F 745272DE 5AA86BF6 DD5DF399

FB8E7513 2111823B D7F5FD85 285007BD 0D32A120 662B1D24 099AB113 79C49E2D

B19739FE 8A99194C 9BB90957 2A88B2D7 C42DF134 6CDEFB40 EA565745 6345F404

BE4800ED 071EB95E 4E6F0A67 7DD47AC7 82F79920 6BFB59CF 2246E800 C5FFAE5F

689C100B 424BC070 5347BDA4 1DA6F382 2A14BC4D DD6D5FFF 4569A7ED B49D7216

6BFE0D85 BCC75F85 13182919 33ABE194 F6069E55 E8B5EC95 3A120A9F 36FB61ED

2C1DB937 ADF21A35 66C9C3B7 7A5B14F7 D61D3BF0 2646B4F6 45696B92 F3553902

1121FF2F 34A53AE4 174681FE 8E2D5286 FF943A5C 9DDD3CE5 8145CAB9 8F263551

D36E951E BC710203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 145D44F8 98A24A48 57E1AD50 7C908A85 3DA4D077

1A301D06 03551D0E 04160414 5D44F898 A24A4857 E1AD507C 908A853D A4D0771A

300D0609 2A864886 F70D0101 05050003 82010100 83ED693E 46385563 E8E1C8B2

3DE2A08A AED0F36C DB41EBD1 5295A88E 7BEEC54B 0DDD6822 8EAFD90B D420CD14

61D6180F 866FE08B 88FCCF7A 0F1A71B5 FDEC5A84 D6A58E1B C5EEC841 8A3EC545

D79F2926 9A1EC96A 5416B43C 449488FF 87B3B1C9 337A0544 3ED01AC8 A6A337E8

E601F99E 3404D600 2CC075A8 ADD238AC 77531A03 604C5193 EC1F945A 5DBB594C

B6137375 8C31C8B0 A30BDCD7 5FFB0B44 A0DADAB5 318AFE56 666798A4 C427CC81

5E8E21B9 2D006EF5 AABBC909 9888E563 ABAE094E 9DD29814 16E9D5BA 319F5BCD

C5795F12 FD2866B0 107A8AED 0928CF31 9FF713CD F914E172 A3C805B2 2F2D5570

C6D6F16F 02D803DA 28010D64 863BFF49 9FF26FD9

quit

license udi pid ISR4321/K9 sn FLM240607T3

no license smart enable

diagnostic bootup level minimal

spanning-tree extend system-id

redundancy

mode none

interface Loopback0

ip address 192.168.0.1 255.255.255.252

ip ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 192.168.0.21 255.255.255.252

ip ospf 10 area 0

negotiation auto

interface GigabitEthernet0/0/1

no ip address

shutdown

negotiation auto

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

router ospf 10

ip forward-protocol nd

ip http server

ip http authentication local

ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

**R2#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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

192.168.0.0/24 is variably subnetted, 11 subnets, 2 masks

C 192.168.0.0/30 is directly connected, Loopback0

L 192.168.0.1/32 is directly connected, Loopback0

O 192.168.0.5/32

[110/2] via 192.168.0.22, 00:12:57, GigabitEthernet0/0/0

O 192.168.0.9/32

[110/3] via 192.168.0.22, 00:12:10, GigabitEthernet0/0/0

O 192.168.0.13/32

[110/4] via 192.168.0.22, 00:12:10, GigabitEthernet0/0/0

O 192.168.0.17/32

**R2#show ip interface brief**

Interface IP-Address OK? Method Status Protocol

GigabitEthernet0/0/0 192.168.0.21 YES manual up up

GigabitEthernet0/0/1 unassigned YES unset administratively down down

GigabitEthernet0 unassigned YES unset administratively down down

Loopback0 192.168.0.1 YES manual up up

**Router 3**

**R3#show running-config**

Current configuration : 1582 bytes

Last configuration change at 15:34:38 UTC Fri Sep 10 2021

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

hostname R3

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214421BY

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.5 255.255.255.252

ip ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 192.168.0.22 255.255.255.252

ip ospf 10 area 0

negotiation auto

interface GigabitEthernet0/0/1

ip address 192.168.0.25 255.255.255.252

ip ospf 10 area 0

negotiation auto

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**R3#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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

192.168.0.0/24 is variably subnetted, 12 subnets, 2 masks

O 192.168.0.1/32

[110/2] via 192.168.0.21, 00:10:38, GigabitEthernet0/0/0

C 192.168.0.4/30 is directly connected, Loopback0

L 192.168.0.5/32 is directly connected, Loopback0

O 192.168.0.9/32

[110/2] via 192.168.0.26, 00:09:51, GigabitEthernet0/0/1

O 192.168.0.13/32

[110/3] via 192.168.0.26, 00:09:51, GigabitEthernet0/0/1

O 192.168.0.17/32

[110/4] via 192.168.0.26, 00:00:45, GigabitEthernet0/0/1

C 192.168.0.20/30 is directly connected, GigabitEthernet0/0/0

L 192.168.0.22/32 is directly connected, GigabitEthernet0/0/0

C 192.168.0.24/30 is directly connected, GigabitEthernet0/0/1

L 192.168.0.25/32 is directly connected, GigabitEthernet0/0/1

O 192.168.0.28/30

[110/2] via 192.168.0.26, 00:12:33, GigabitEthernet0/0/1

O 192.168.0.32/30

[110/3] via 192.168.0.26, 00:01:39, GigabitEthernet0/0/1

**R3#show ip ospf route**

OSPF Router with ID (192.168.0.22) (Process ID 10)

Base Topology (MTID 0)

Area BACKBONE(0)

Intra-area Route List

\* 192.168.0.24/30, Intra, cost 1, area 0, Connected

via 192.168.0.25, GigabitEthernet0/0/1

\* 192.168.0.20/30, Intra, cost 1, area 0, Connected

via 192.168.0.22, GigabitEthernet0/0/0

\*> 192.168.0.28/30, Intra, cost 2, area 0

via 192.168.0.26, GigabitEthernet0/0/1

\*> 192.168.0.32/30, Intra, cost 3, area 0

via 192.168.0.26, GigabitEthernet0/0/1

\*> 192.168.0.1/32, Intra, cost 2, area 0

via 192.168.0.21, GigabitEthernet0/0/0

\* 192.168.0.5/32, Intra, cost 1, area 0, Connected

via 192.168.0.5, Loopback0

\*> 192.168.0.9/32, Intra, cost 2, area 0

via 192.168.0.26, GigabitEthernet0/0/1

\*> 192.168.0.13/32, Intra, cost 3, area 0

via 192.168.0.26, GigabitEthernet0/0/1

\*> 192.168.0.17/32, Intra, cost 4, area 0

via 192.168.0.26, GigabitEthernet0/0/1

First Hop Forwarding Gateway Tree

192.168.0.21 on GigabitEthernet0/0/0, count 1

192.168.0.22 on GigabitEthernet0/0/0, count 1

192.168.0.25 on GigabitEthernet0/0/1, count 1

192.168.0.26 on GigabitEthernet0/0/1, count 5

192.168.0.5 on Loopback0, count 1

**R3#show ip interface brief**

Interface IP-Address OK? Method Status Protocol

GigabitEthernet0/0/0 192.168.0.22 YES manual up up

GigabitEthernet0/0/1 192.168.0.25 YES manual up up

Serial0/1/0 unassigned YES unset administratively down down

Serial0/1/1 unassigned YES unset administratively down down

GigabitEthernet0/2/0 unassigned YES unset administratively down down

GigabitEthernet0/2/1 unassigned YES unset administratively down down

GigabitEthernet0 unassigned YES unset administratively down down

Loopback0 192.168.0.5 YES manual up up

Vlan1 unassigned YES unset administratively down down

**Router 4**

**R4#show running-config**

Current configuration : 1582 bytes

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

hostname R4

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214913GF

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.9 255.255.255.252

ip ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 192.168.0.29 255.255.255.252

ip ospf 10 area 0

negotiation auto

interface GigabitEthernet0/0/1

ip address 192.168.0.26 255.255.255.252

ip ospf 10 area 0

negotiation auto

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**R4#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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

192.168.0.0/24 is variably subnetted, 12 subnets, 2 masks

O 192.168.0.1/32

[110/3] via 192.168.0.25, 00:14:52, GigabitEthernet0/0/1

O 192.168.0.5/32

[110/2] via 192.168.0.25, 00:14:52, GigabitEthernet0/0/1

C 192.168.0.8/30 is directly connected, Loopback0

L 192.168.0.9/32 is directly connected, Loopback0

O 192.168.0.13/32

[110/2] via 192.168.0.30, 00:14:05, GigabitEthernet0/0/0

O 192.168.0.17/32

[110/3] via 192.168.0.30, 00:04:59, GigabitEthernet0/0/0

O 192.168.0.20/30

[110/2] via 192.168.0.25, 00:16:47, GigabitEthernet0/0/1

C 192.168.0.24/30 is directly connected, GigabitEthernet0/0/1

L 192.168.0.26/32 is directly connected, GigabitEthernet0/0/1

C 192.168.0.28/30 is directly connected, GigabitEthernet0/0/0

L 192.168.0.29/32 is directly connected, GigabitEthernet0/0/0

O 192.168.0.32/30

[110/2] via 192.168.0.30, 00:05:54, GigabitEthernet0/0/0

**R4#show ip ospf route**

OSPF Router with ID (192.168.0.29) (Process ID 10)

Base Topology (MTID 0)

Area BACKBONE(0)

Intra-area Route List

\* 192.168.0.24/30, Intra, cost 1, area 0, Connected

via 192.168.0.26, GigabitEthernet0/0/1

\* 192.168.0.28/30, Intra, cost 1, area 0, Connected

via 192.168.0.29, GigabitEthernet0/0/0

\*> 192.168.0.32/30, Intra, cost 2, area 0

via 192.168.0.30, GigabitEthernet0/0/0

\*> 192.168.0.20/30, Intra, cost 2, area 0

via 192.168.0.25, GigabitEthernet0/0/1

\*> 192.168.0.1/32, Intra, cost 3, area 0

via 192.168.0.25, GigabitEthernet0/0/1

\*> 192.168.0.5/32, Intra, cost 2, area 0

via 192.168.0.25, GigabitEthernet0/0/1

\* 192.168.0.9/32, Intra, cost 1, area 0, Connected

via 192.168.0.9, Loopback0

\*> 192.168.0.13/32, Intra, cost 2, area 0

via 192.168.0.30, GigabitEthernet0/0/0

\*> 192.168.0.17/32, Intra, cost 3, area 0

via 192.168.0.30, GigabitEthernet0/0/0

First Hop Forwarding Gateway Tree

192.168.0.29 on GigabitEthernet0/0/0, count 1

192.168.0.30 on GigabitEthernet0/0/0, count 3

192.168.0.25 on GigabitEthernet0/0/1, count 3

192.168.0.26 on GigabitEthernet0/0/1, count 1

192.168.0.9 on Loopback0, count 1

**R4#show ip interface brief**

Interface IP-Address OK? Method Status Protocol

GigabitEthernet0/0/0 192.168.0.29 YES manual up up

GigabitEthernet0/0/1 192.168.0.26 YES manual up up

Serial0/1/0 unassigned YES unset administratively down down

Serial0/1/1 unassigned YES unset administratively down down

GigabitEthernet0/2/0 unassigned YES unset administratively down down

GigabitEthernet0/2/1 unassigned YES unset administratively down down

GigabitEthernet0 unassigned YES unset administratively down down

Loopback0 192.168.0.9 YES manual up up

Vlan1 unassigned YES unset administratively down down

**Router 5**

**R5#show running-config**

Current configuration : 1619 bytes

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

hostname R5

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21482HYV

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.13 255.255.255.252

ip ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 192.168.0.30 255.255.255.252

negotiation auto

interface GigabitEthernet0/0/1

ip address 192.168.0.33 255.255.255.252

negotiation auto

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

network 192.168.0.28 0.0.0.3 area 0

network 192.168.0.32 0.0.0.3 area 0

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**R5#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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

192.168.0.0/24 is variably subnetted, 12 subnets, 2 masks

O 192.168.0.1/32

[110/4] via 192.168.0.29, 00:12:08, GigabitEthernet0/0/0

O 192.168.0.5/32

[110/3] via 192.168.0.29, 00:12:08, GigabitEthernet0/0/0

O 192.168.0.9/32

[110/2] via 192.168.0.29, 00:11:21, GigabitEthernet0/0/0

C 192.168.0.12/30 is directly connected, Loopback0

L 192.168.0.13/32 is directly connected, Loopback0

O 192.168.0.17/32

**R5#show ip ospf route**

OSPF Router with ID (192.168.0.30) (Process ID 10)

Base Topology (MTID 0)

Area BACKBONE(0)

Intra-area Route List

\* 192.168.0.32/30, Intra, cost 1, area 0, Connected

via 192.168.0.33, GigabitEthernet0/0/1

\* 192.168.0.28/30, Intra, cost 1, area 0, Connected

via 192.168.0.30, GigabitEthernet0/0/0

\*> 192.168.0.24/30, Intra, cost 2, area 0

via 192.168.0.29, GigabitEthernet0/0/0

\*> 192.168.0.20/30, Intra, cost 3, area 0

via 192.168.0.29, GigabitEthernet0/0/0

\*> 192.168.0.1/32, Intra, cost 4, area 0

via 192.168.0.29, GigabitEthernet0/0/0

\*> 192.168.0.5/32, Intra, cost 3, area 0

via 192.168.0.29, GigabitEthernet0/0/0

**R5#show ip interface brief**

Interface IP-Address OK? Method Status Protocol

GigabitEthernet0/0/0 192.168.0.30 YES manual up up

GigabitEthernet0/0/1 192.168.0.33 YES manual up up

Serial0/1/0 unassigned YES unset administratively down down

Serial0/1/1 unassigned YES unset administratively down down

GigabitEthernet0/2/0 unassigned YES unset administratively down down

GigabitEthernet0/2/1 unassigned YES unset administratively down down

GigabitEthernet0 unassigned YES unset administratively down down

Loopback0 192.168.0.13 YES manual up up

Vlan1 unassigned YES unset administratively down down

**Router 6**

**R6#show running-config**

Current configuration : 1414 bytes

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

hostname R6

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214333H6

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.17 255.255.255.252

ip ospf 10 area 0

interface GigabitEthernet0/0/0

no ip address

shutdown

negotiation auto

interface GigabitEthernet0/0/1

ip address 192.168.0.34 255.255.255.252

negotiation auto

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

network 192.168.0.32 0.0.0.3 area 0

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**R6#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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

192.168.0.0/24 is variably subnetted, 4 subnets, 2 masks

C 192.168.0.16/30 is directly connected, Loopback0

L 192.168.0.17/32 is directly connected, Loopback0

C 192.168.0.32/30 is directly connected, GigabitEthernet0/0/1

L 192.168.0.34/32 is directly connected, GigabitEthernet0/0/1

**R6#show ip ospf route**

OSPF Router with ID (192.168.0.17) (Process ID 10)

Base Topology (MTID 0)

Area BACKBONE(0)

Intra-area Route List

\* 192.168.0.32/30, Intra, cost 1, area 0, Connected

via 192.168.0.34, GigabitEthernet0/0/1

\* 192.168.0.17/32, Intra, cost 1, area 0, Connected

via 192.168.0.17, Loopback0

First Hop Forwarding Gateway Tree

192.168.0.17 on Loopback0, count 1

192.168.0.34 on GigabitEthernet0/0/1, count 1

**R6#show ip interface brief**

Interface IP-Address OK? Method Status Protocol

GigabitEthernet0/0/0 unassigned YES unset administratively down down

GigabitEthernet0/0/1 192.168.0.34 YES manual up up

Serial0/1/0 unassigned YES unset administratively down down

Serial0/1/1 unassigned YES unset administratively down down

GigabitEthernet0 unassigned YES unset administratively down down

Loopback0 192.168.0.17 YES manual up up

Vlan1 unassigned YES unset administratively down down

**Problems**

A problem encountered was that after configuring OSPF on each router, **show ip route** had not generated any OSPF routes. To test the connectivity, ping tests were used from router R2 to R6 and from Router R2 to R3. Both tests failed, with the R2 to R6 ping suggesting that OSPF indeed was not working properly and R2 to R3 suggesting that the routers were either not on the same network or the interfaces were down. This was quickly verified through using the **show ip interface brief** command to check the state of the interfaces on each router and making sure that all interfaces were up. It was found that router R3 had both its G0/0/0 and G0/0/1 interfaces administratively down and the simple fix of running the command **no shutdown** (or **no shut** for short) on both interfaces fixed the connectivity issues. Another fixed problem related to **no shutdown** was that after loading in the running configuration from global configuration mode, the OSPF and connectivity had not been established. Again, going through every participating interface and running **no shutdown** solved the problem, and now it is known that pasting in the running configuration does not apply the previously applied **no shutdown** commands. An unresolved problem was that the **show ip ospf route** worked for every router except router 2. A speculative explanation for this is the different version number of the router resulting in slightly different available commands.

**Conclusion**

This lab demonstrated the usefulness of OSPF. It allows simple configurations in order to create complete connectivity among networks of routers. It also avoids many static routing errors. Exploration of all OSPF commands and configurations reveals much more than a simple dynamic routing protocol with OSPF packed with ways to configure costs and hierarchical area structures. The natural next step would be to configure a multi-area OSPF to realize the full features of the OSPF protocol. Although the command **show ip ospf route** not working on router 2 was puzzling, the overall lab’s configurations and troubleshooting processes went incredibly well. A big takeaway is to make sure to document, test, and verify as many steps of the way as possible to smoothen the lab process.