**Network Administration Portfolio**



**By: Derek Liu**

**Table of Contents**

Open Shortest Path First (OSPF)............................................ 3

Multi-Area OSPF.................................................................... 26

Border Gateway Protocol (BGP)............................................ 61

Internal Border Gateway Protocol (iBGP)............................. 113

Voice over IP (VoIP)............................................................... 181

Virtual Routing & Forwarding (VRF).................................... 195

Gateway Load Balancing Protocol (GLBP)........................... 221

Multiprotocol Label Switching (MPLS)................................ 235



**Implementing OSPF (5 routers)***Derek Liu*

Purpose

The purpose of this lab is to refresh the skills needed to configure routers and set up OSPF. This touches upon the subjects of routing tables, partial mesh networks, and also interaction between Cisco equipment. In this lab, OSPF and OSPFv3 was configured for 5 routers in both ipv4 and ipv6.

Background Information

OSPF or Open Shortest Path First is a protocol used to fill out the routing table of a router. In other words, it will automatically recognize and document paths within a network within a few seconds. It is more efficient than creating static routes on each router and allows the network to be easily expandable such as when adding new routers to the network. OSPF uses the shorted path first which means the routes will be shorter. OSPF is also not Cisco proprietary which means that it can be implemented in a large variety of networks. During OSPF, each router communicates with other routers or neighbors to create a routing table that looks the same. Originally, each router only has knowledge of networks directly connected to it but with algorithms they are shared so routers can know about networks not directly connected. This also allows different routes to be created using the shortest path to different networks. OSPF was created by the IETF in order to have a open vendor protocol that can be used to create routing tables. OSPF is a very useful protocol, and it is essential to recognizing its use.

Lab Summary

We connected five Cisco 4321 routers together using the gigabit ethernet interface g0/0/0 and g0/0/1. We set router IDs for OSPF on each router and assigned different subnets of /30 between each router. We put the entire OSPF network in the backbone area 0 and with a process ID of 10. For routers 1 and 5 we created loopback interfaces on g0/0/1 and g0/0/0 respectively as to avoid creating a full mesh. The networks that each router was connected to was created using “network” statements under OSPF and advertised across the network. OSPFv3 was created in a similar manner however it required the command of “ipv6 unicast-routing” in order to enable ipv6 routing. Another difference was that “network” statement weren’t required for OSPF but link-local addressed need to be configured. Once OSPF and OSPFv3 were set up, pings were sent across the network to confirm functionality.

Lab Commands

**Configuration for router 1: (bolded comments are not part of the commands used and are just comments)**

en

config t

router ospf 10

router-id 1.1.1.1 **(router id will vary based on router. ID used for router 2 was 2.2.2.2, router 3 was 3.3.3.3, etc.)**

network 10.1.1.0 0.0.0.3 area 0

network 10.1.1.18 0.0.0.3 area 0

ipv6 unicast-routing

ipv6 router ospf 10

router-id 1.1.1.1

int g0/0/0

ip address 10.1.1.1 255.255.255.252 **(ipv4 address for each interface of the router is different, see network diagrams with ip for reference)**

ip ospf 10 area 0

no shut

ipv6 address 2001:db8:acad:1::1/64 **(ipv4 address for each interface of the router is different, see network diagrams with ip for reference)**

ipv6 address fe80::1 link-local **(link-local addresses will also vary. See network diagrams with ip)**

ipv6 ospf 10 area 0

int lo0

ip address 10.1.1.18 255.255.255.252

ip ospf 10 area 0

no shut

ipv6 address 2001:db8:acad:5::2/64

ipv6 address fe80::2 link-local

Network Diagrams with IP

IPv4

A picture containing screenshot, line, diagram, text

Description automatically generated

IPv6

R1:

g0/0/0 - 2001:db8:acad:1::1 fe80::1

Lo0 - 2001:db8:acad:5::2 fe80::2

R2:

g0/0/0 - 2001:db8:acad:2::1 fe80::1

g0/0/1 - 2001:db8:acad:1::2 fe80::2

R3:

g0/0/0 - 2001:db8:acad:3::1 fe80::1

g0/0/1 - 2001:db8:acad:2::2 fe80::2

R4:

g0/0/0 - 2001:db8:acad:4::1 fe80::1

g0/0/1 - 2001:db8:acad:3::2 fe80::2

R5:

Lo0 - 2001:db8:acad:5::1 fe80::1

g0/0/1 - 2001:db8:acad:4::2 fe80::2

Configurations

***Pings (ipv4):***

r1#ping 10.1.1.18

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.1.18, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 10.1.1.17

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.1.17, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 10.1.1.14

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.1.14, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 10.1.1.13

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.1.13, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 10.1.1.10

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.1.10, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 10.1.1.9

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.1.9, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 10.1.1.6

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.1.6, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 10.1.1.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.1.2, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 10.1.1.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.1.1, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

***Pings (ipv6):***

r1#ping 2001:DB8:ACAD:2::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:2::1, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 2001:DB8:ACAD:1::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:1::2, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 2001:DB8:ACAD:3::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:3::1, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 2001:DB8:ACAD:2::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:2::2, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 2001:DB8:ACAD:4::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:4::1, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 2001:DB8:ACAD:3::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:3::2, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 2001:DB8:ACAD:5::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:5::1, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r1#ping 2001:DB8:ACAD:4::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:4::2, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

***Ip routes:***

IPV4 Routes:

-----------

R1:

10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks

C 10.1.1.0/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.1/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.4/30 [110/2] via 10.1.1.2, 00:50:49, GigabitEthernet0/0/0

O 10.1.1.8/30 [110/3] via 10.1.1.17, 00:38:10, GigabitEthernet0/0/1

[110/3] via 10.1.1.2, 00:35:33, GigabitEthernet0/0/0

O 10.1.1.12/30 [110/2] via 10.1.1.17, 00:38:50, GigabitEthernet0/0/1

C 10.1.1.16/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.18/32 is directly connected, GigabitEthernet0/0/1

R2:

10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks

C 10.1.1.0/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.2/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.5/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.8/30 [110/2] via 10.1.1.6, 00:32:03, GigabitEthernet0/0/0

O 10.1.1.12/30 [110/3] via 10.1.1.6, 00:32:03, GigabitEthernet0/0/0

[110/3] via 10.1.1.1, 00:35:20, GigabitEthernet0/0/1

O 10.1.1.16/30 [110/2] via 10.1.1.1, 00:47:19, GigabitEthernet0/0/1

R3:

10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks

O 10.1.1.0/30 [110/2] via 10.1.1.5, 00:31:17, GigabitEthernet0/0/1

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.6/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.8/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.9/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.12/30 [110/2] via 10.1.1.10, 00:33:25, GigabitEthernet0/0/0

O 10.1.1.16/30 [110/3] via 10.1.1.10, 00:33:25, GigabitEthernet0/0/0

[110/3] via 10.1.1.5, 00:31:17, GigabitEthernet0/0/1

R4:

10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks

O 10.1.1.0/30 [110/2] via 10.1.1.18, 00:40:13, GigabitEthernet0/0/0

O 10.1.1.4/30 [110/3] via 10.1.1.18, 00:40:13, GigabitEthernet0/0/0

[110/3] via 10.1.1.13, 00:25:40, GigabitEthernet0/0/1

O 10.1.1.8/30 [110/2] via 10.1.1.13, 00:28:15, GigabitEthernet0/0/1

C 10.1.1.12/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.14/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.16/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.17/32 is directly connected, GigabitEthernet0/0/0

R5:

10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks

O 10.1.1.0/30 [110/2] via 10.1.1.18, 00:40:13, GigabitEthernet0/0/0

O 10.1.1.4/30 [110/3] via 10.1.1.18, 00:40:13, GigabitEthernet0/0/0

[110/3] via 10.1.1.13, 00:25:40, GigabitEthernet0/0/1

O 10.1.1.8/30 [110/2] via 10.1.1.13, 00:28:15, GigabitEthernet0/0/1

C 10.1.1.12/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.14/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.16/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.17/32 is directly connected, GigabitEthernet0/0/0

IPV6 Routes:

-----------

R1:

C 2001:DB8:ACAD:1::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:1::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:2::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

O 2001:DB8:ACAD:3::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:ACAD:4::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:5::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:5::2/128 [0/0]

via GigabitEthernet0/0/1, receive

L FF00::/8 [0/0]

via Null0, receive

R2:

C 2001:DB8:ACAD:1::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:1::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:2::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:2::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:3::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

O 2001:DB8:ACAD:4::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

via FE80::2, GigabitEthernet0/0/0

O 2001:DB8:ACAD:5::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

L FF00::/8 [0/0]

via Null0, receive

R3:

O 2001:DB8:ACAD:1::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:2::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:2::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:3::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:3::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:4::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

O 2001:DB8:ACAD:5::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R4:

O 2001:DB8:ACAD:1::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:ACAD:2::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:3::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:3::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:4::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:4::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:5::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R5:

O 2001:DB8:ACAD:1::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

O 2001:DB8:ACAD:2::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:ACAD:3::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:4::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:4::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:5::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:5::1/128 [0/0]

via GigabitEthernet0/0/0, receive

L FF00::/8 [0/0]

via Null0, receive

***Router 1 Config:***

hostname r1

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21400XZX

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 10.1.1.18 255.255.255.252

ip ospf 10 area 0

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:5::2/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 10.1.1.1 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:1::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

no ip address

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

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

network 10.1.1.0 0.0.0.3 area 0

network 10.1.1.16 0.0.0.3 area 0

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 route 2001:DB8:ACAD:5::/64 GigabitEthernet0/0/1

ipv6 route ::/0 GigabitEthernet0/0/1

ipv6 router ospf 1

router-id 1.1.1.1

ipv6 router ospf 10

router-id 1.1.1.1

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 2 Config:***

hostname r2

boot-start-marker

boot-end-marker

rf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21491FHX

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

ip address 10.1.1.5 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:2::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

ip address 10.1.1.2 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:1::2/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/1/0

no ip address

shutdown

negotiation auto

interface GigabitEthernet0/1/1

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 1

router-id 2.2.2.2

network 192.168.10.0 0.0.0.3 area 0

network 192.168.10.8 0.0.0.3 area 0

router ospf 10

network 10.1.1.0 0.0.0.3 area 0

network 10.1.1.4 0.0.0.3 area 0

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 2.2.2.2

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

***Router 3 Config:***

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

ipv6 unicast-routing

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214421CU

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface GigabitEthernet0/0/0

ip address 10.1.1.9 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:3::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

ip address 10.1.1.6 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:2::2/64

ipv6 ospf 10 area 0

interface Serial0/1/0

interface Serial0/1/1

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

router-id 3.3.3.3

network 10.1.1.4 0.0.0.3 area 0

network 10.1.1.8 0.0.0.3 area 0

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 3.3.3.3

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 4 Config:***

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

ipv6 unicast-routing

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420G3

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface GigabitEthernet0/0/0

ip address 10.1.1.13 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:4::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

ip address 10.1.1.10 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:3::2/64

ipv6 ospf 10 area 0

interface Serial0/1/0

interface Serial0/1/1

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

router-id 4.4.4.4

network 10.1.1.8 0.0.0.3 area 0

network 10.1.1.12 0.0.0.3 area 0

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 4.4.4.4

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 5 Config:***

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

login on-success log

subscriber templating

ipv6 unicast-routing

multilink bundle-name authenticated

crypto pki trustpoint TP-self-signed-3458782570

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-3458782570

revocation-check none

rsakeypair TP-self-signed-3458782570

crypto pki certificate chain TP-self-signed-3458782570

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

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

69666963 6174652D 33343538 37383235 3730301E 170D3232 30393038 31353335

35345A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D33 34353837

38323537 30308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 0100B44B F4278297 DA1BFB79 6B524933 4F0DC4F8 3ADB865E 073D2A73

1E877AFE FDEE8044 A476D5A2 5FE6FA8C 55BC1A5E 41EA0416 0C67B96D 4D568EEE

E83D193F 7AC6B208 19A35706 4E6D96E7 722E8163 E279BC82 FA826DA2 452F08A0

23CEF075 76C668A7 23CD9F3C D891225D 5EF1ECE4 4AD51EAC 0A5D737E D9C59EE2

32F3983A 336846B5 941686D2 628DEC7E 6748B33C 24651C09 ED241C35 FB196C4A

67991767 05FA2D5F 6EC4E5BA 1E463E2E 15449CA1 FF99A45A 3AC96DE6 FD95C5D8

CF0568D0 1E2184F2 AFACFD4D 118A9AC0 D1B23D75 3A5EB199 2D55AB18 DB847BE6

753F99FC 0FE65DCC 7B1D9A88 D457DAFF BCA3105D 25671AE7 989724A9 2DC22D6C

E3AE572A C5A50203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 14A4142F 49009CBD 6FF5914B F68AF0D3 74946CF2

19301D06 03551D0E 04160414 A4142F49 009CBD6F F5914BF6 8AF0D374 946CF219

300D0609 2A864886 F70D0101 05050003 82010100 55A7C631 B6E189DE 539ABBFE

AF64F1C0 73C4883D 96C30F9D 7FF10FDB 71DF75A8 E9885421 68C6088D 223AA75A

5DAF3FE0 1FE7B045 54483484 EFD0744D 067926D8 A938E202 2AA3F245 DB0412B6

8717D55C 25452986 886EBAC1 17CE6094 42885BF8 BF28AEB6 7F3932AE 19E6DF39

3972370E 61C28A4B 60DDC770 43170CD7 446FEE7E FDB70A21 C9A3461D E5660D78

D81291ED A4900DDD 6CE43EB3 03D73DA1 0960365C 1801C369 7E80A444 01B2287C

11990900 DF44FEB3 FD1706E5 037D0025 BDD1FF51 60C351D4 3B8D1FE1 5FCAE1ED

52385CE6 3DAD8B72 FE9CE6C9 F2D4D3D3 76E3501F A8244B83 F351F6AB 653AA8B2

A6EBFABA C7753BFF E4CDAC4D 4BC7F57E 632760C8

quit

license udi pid ISR4321/K9 sn FLM240800D6

no license smart enable

diagnostic bootup level minimal

spanning-tree extend system-id

redundancy

mode none

interface Loopback0

ip address 10.1.1.17 255.255.255.252

ip ospf 10 area 0

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:5::1/64

ipv6 ospf 10 area

interface GigabitEthernet0/0/0

no ip address

ip ospf 10 area 0

negotiation auto

interface GigabitEthernet0/0/1

ip address 10.1.1.14 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:4::2/64

ipv6 ospf 10 area 0

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

router ospf 10

network 10.1.1.12 0.0.0.3 area 0

network 10.1.1.16 0.0.0.3 area 0

ip forward-protocol nd

ip http server

ip http authentication local

ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 5.5.5.5

control-plane

line con 0

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

Problems

Originally made a full mesh network with the routers, meaning that we connected router 1 to router 5 making a circle. This will not work well as it meant that we couldn’t ping with OSPFv3 in the 2001:db8:acad:5::/64 network. We solved this by disconnecting the loop and then creating loopback interfaces rather than a directly connected one. These loopback interfaces can also be configured to connect to two end devices and allow them to ping across the network. OSPF works best in a partial mesh. Another problem we had was with the subnets. Early in the lab, we created subnets that overlapped, and error messages appeared on the terminal warning of overlapping subnets. We recreated our subnets to both a smaller size and made them non overlapping. The networks between each router have to be in different subnets in order for it to work.

Conclusion

In this lab, we created an OSPF and OSPFv3 network with 5 routers. All of it was placed into the backbone area 0 for simplicity and then pings were sent across the network to confirm functionality. The thing that originally went wrong was a full mesh network created by linking router 1 and router 5 and also overlapping subnets between routers. We learned that OSPF will function under a full mesh network but will not completely function (some pings will not go through). I relearned how to set up OSPF and OSPFv3 again and also more detailed ideas such as the simplicity of setting up OSPF but also the complexity it can allow for with different process IDs, router IDs, and area numbers. I also learned that when creating a full mesh network, OSPF will function but is not the best option to use when filling out a routing table. In the end, we were successful in configuring OSPF and functionality was confirmed through successful pings throughout the network.



**Implementing multi-area OSPF (6 router)***Derek Liu*

Purpose

The purpose of this lab was to expand upon the process of implementing OSPF specifically by also incorporating OSPF areas for OSPFv2 and OSPFv3. This type of configuration of OSPF would work better for larger networks but may not necessarily required for SOHO networks.

Background Information

OSPF or Open Shortest Path First is a protocol used to fill out the routing table of a router. In other words, it will automatically recognize and document paths within a network within a few seconds. It is more efficient than creating static routes on each router and allows the network to be easily expandable such as when adding new routers to the network. OSPF uses the shorted path first which means the routes will be shorter. OSPF is also not Cisco proprietary which means that it can be implemented in a large variety of networks. During OSPF, each router communicates with other routers or neighbors to create a routing table that looks the same. Originally, each router only has knowledge of networks directly connected to it but with algorithms they are shared so routers can know about networks not directly connected. This also allows different routes to be created using the shortest path to different networks. OSPF was created by the IETF in order to have an open vendor protocol that can be used to create routing tables. OSPF is a very useful protocol, and it is essential to recognizing its use.

The major differences between single area OSPF and multi area OSPF is that in single area OSPF, all routers are placed into the backbone area (area 0) while in multi area OSPF, there are multiple areas connected to the backbone area with area border routers (ABR). This allows for reduced frequency of OSPF calculations, smaller routing tables and reduced LSU overhead. This means that if a routing problem occurs in an area such as a link going down, the other areas will not be affected. Routing tables, as seen in the IP routes section of this lab will be separated into intra area OSPF routes. Multi area OSPF is usually used in larger networks since it would allow for easier scalability as well as faster convergence speeds. While the configuration of multi area OSPF is not much different from single OSPF as in the commands are very similar, multi area OSPF is not necessary for smaller networks. A good way to know how many routers should be in each area would be to refer to OSPF best practices which states that there should be no more than 50 routers in each area, including the backbone area.

Lab Summary

Using six Cisco 4321 routers connected in a linear fashion using the gigabit ethernet interface g0/0/0 and g0/0/1/ We set router IDs for OSPF on each router and assigned different subnets of /30 between each router. Rather than placing all the routers in backbone area, we implemented the backbone area (area 0) between routers 3 and 4 and configured routers 1-3 to be in area 1 and routers 4-6 in area 2. They all had a process ID of 10 and for routers 1 and 6 we connected it to end devices (PC) to avoid creating a full mesh and allow pings to go across the network. The networks that each router was connected to was created using “network” statements under OSPF and advertised across the network. OSPFv3 was created in a similar manner however it required the command of “ipv6 unicast-routing” in order to enable ipv6 routing. Another difference was that “network” statement weren’t required for OSPF but link-local addressed need to be configured. Once OSPF and OSPFv3 were set up, pings were sent across the network to confirm functionality.

Lab Commands (**comments in parathesis**)

en

config t

hostname r1 (**hostname will vary based on router e.g. r2 for router 2**)

router ospf 10

router-id 1.1.1.1 (**router id will vary based on router e.g. 2.2.2.2 for router 2**)

network 10.1.1.0 0.0.0.3 area 1 (**network and area will vary based on interface and router, see network diagrams with IP for more information**)

network 10.1.1.4 0.0.0.3 area 1

ipv6 unicast-routing

ipv6 router ospf 10

router-id 1.1.1.1

int g0/0/0

ip address 10.1.1.5 255.255.255.252 (**ip addresses will vary based on router and interface. See network diagrams with IP for more information**)

ip ospf 10 area 1

no shut

ipv6 address 2001:db8:acad:2::1/64

ipv6 address fe80::1 link-local

ipv6 ospf 10 area 1

int g0/0/1

ip address 10.1.1.2 255.255.255.252

ip ospf 10 area 1

no shut

ipv6 address 2001:db8:acad:1::2/64

ipv6 address fe80::2 link-local

ipv6 ospf 10 area 1

Network Diagrams with IP

A picture containing circle, diagram, line

Description automatically generated

Configurations

***Pings (ipv4):***

C:\Users\user>ping 10.1.1.2

Pinging 10.1.1.2 with 32 bytes of data:

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Ping statistics for 10.1.1.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.5

Pinging 10.1.1.5 with 32 bytes of data:

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Ping statistics for 10.1.1.5:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.6

Pinging 10.1.1.6 with 32 bytes of data:

Reply from 10.1.1.6: bytes=32 time=1ms TTL=254

Reply from 10.1.1.6: bytes=32 time<1ms TTL=254

Reply from 10.1.1.6: bytes=32 time<1ms TTL=254

Reply from 10.1.1.6: bytes=32 time<1ms TTL=254

Ping statistics for 10.1.1.6:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.9

Pinging 10.1.1.9 with 32 bytes of data:

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Ping statistics for 10.1.1.9:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.10

Pinging 10.1.1.10 with 32 bytes of data:

Reply from 10.1.1.10: bytes=32 time=1ms TTL=253

Reply from 10.1.1.10: bytes=32 time<1ms TTL=253

Reply from 10.1.1.10: bytes=32 time<1ms TTL=253

Reply from 10.1.1.10: bytes=32 time<1ms TTL=253

Ping statistics for 10.1.1.10:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.13

Pinging 10.1.1.13 with 32 bytes of data:

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Ping statistics for 10.1.1.13:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.14

Pinging 10.1.1.14 with 32 bytes of data:

Reply from 10.1.1.14: bytes=32 time=1ms TTL=252

Reply from 10.1.1.14: bytes=32 time<1ms TTL=252

Reply from 10.1.1.14: bytes=32 time<1ms TTL=252

Reply from 10.1.1.14: bytes=32 time<1ms TTL=252

Ping statistics for 10.1.1.14:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.17

Pinging 10.1.1.17 with 32 bytes of data:

Reply from 10.1.1.17: bytes=32 time=1ms TTL=252

Reply from 10.1.1.17: bytes=32 time<1ms TTL=252

Reply from 10.1.1.17: bytes=32 time<1ms TTL=252

Reply from 10.1.1.17: bytes=32 time<1ms TTL=252

Ping statistics for 10.1.1.17:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.18

Pinging 10.1.1.18 with 32 bytes of data:

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Ping statistics for 10.1.1.18:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 10.1.1.21

Pinging 10.1.1.21 with 32 bytes of data:

Reply from 10.1.1.21: bytes=32 time=1ms TTL=251

Reply from 10.1.1.21: bytes=32 time=1ms TTL=251

Reply from 10.1.1.21: bytes=32 time<1ms TTL=251

Reply from 10.1.1.21: bytes=32 time=1ms TTL=251

Ping statistics for 10.1.1.21:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.22

Pinging 10.1.1.22 with 32 bytes of data:

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Ping statistics for 10.1.1.22:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 10.1.1.25

Pinging 10.1.1.25 with 32 bytes of data:

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Ping statistics for 10.1.1.25:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 10.1.1.26

Pinging 10.1.1.26 with 32 bytes of data:

Reply from 10.1.1.26: bytes=32 time=1ms TTL=122

Reply from 10.1.1.26: bytes=32 time=1ms TTL=122

Reply from 10.1.1.26: bytes=32 time=1ms TTL=122

Reply from 10.1.1.26: bytes=32 time=1ms TTL=122

Ping statistics for 10.1.1.26:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

***Pings (ipv6):***

C:\Users\user>ping 2001:db8:acad:1::2

Pinging 2001:db8:acad:1::2 with 32 bytes of data:

Reply from 2001:db8:acad:1::2: time<1ms

Reply from 2001:db8:acad:1::2: time<1ms

Reply from 2001:db8:acad:1::2: time<1ms

Reply from 2001:db8:acad:1::2: time<1ms

Ping statistics for 2001:db8:acad:1::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:2::1

Pinging 2001:db8:acad:2::1 with 32 bytes of data:

Reply from 2001:db8:acad:2::1: time=2ms

Reply from 2001:db8:acad:2::1: time<1ms

Reply from 2001:db8:acad:2::1: time<1ms

Reply from 2001:db8:acad:2::1: time<1ms

Ping statistics for 2001:db8:acad:2::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 2ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:2::2

Pinging 2001:db8:acad:2::2 with 32 bytes of data:

Reply from 2001:db8:acad:2::2: time=6ms

Reply from 2001:db8:acad:2::2: time<1ms

Reply from 2001:db8:acad:2::2: time<1ms

Reply from 2001:db8:acad:2::2: time<1ms

Ping statistics for 2001:db8:acad:2::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 6ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:3::1

Pinging 2001:db8:acad:3::1 with 32 bytes of data:

Reply from 2001:db8:acad:3::1: time<1ms

Reply from 2001:db8:acad:3::1: time<1ms

Reply from 2001:db8:acad:3::1: time=1ms

Reply from 2001:db8:acad:3::1: time<1ms

Ping statistics for 2001:db8:acad:3::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:3::2

Pinging 2001:db8:acad:3::2 with 32 bytes of data:

Reply from 2001:db8:acad:3::2: time=8ms

Reply from 2001:db8:acad:3::2: time<1ms

Reply from 2001:db8:acad:3::2: time<1ms

Reply from 2001:db8:acad:3::2: time<1ms

Ping statistics for 2001:db8:acad:3::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 8ms, Average = 2ms

C:\Users\user>ping 2001:db8:acad:4::1

Pinging 2001:db8:acad:4::1 with 32 bytes of data:

Reply from 2001:db8:acad:4::1: time<1ms

Reply from 2001:db8:acad:4::1: time=1ms

Reply from 2001:db8:acad:4::1: time<1ms

Reply from 2001:db8:acad:4::1: time<1ms

Ping statistics for 2001:db8:acad:4::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:4::2

Pinging 2001:db8:acad:4::2 with 32 bytes of data:

Reply from 2001:db8:acad:4::2: time=8ms

Reply from 2001:db8:acad:4::2: time=1ms

Reply from 2001:db8:acad:4::2: time=1ms

Reply from 2001:db8:acad:4::2: time=1ms

Ping statistics for 2001:db8:acad:4::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 8ms, Average = 2ms

C:\Users\user>ping 2001:db8:acad:5::1

Pinging 2001:db8:acad:5::1 with 32 bytes of data:

Reply from 2001:db8:acad:5::1: time=1ms

Reply from 2001:db8:acad:5::1: time<1ms

Reply from 2001:db8:acad:5::1: time=1ms

Reply from 2001:db8:acad:5::1: time=1ms

Ping statistics for 2001:db8:acad:5::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:5::2

Pinging 2001:db8:acad:5::2 with 32 bytes of data:

Reply from 2001:db8:acad:5::2: time=8ms

Reply from 2001:db8:acad:5::2: time=1ms

Reply from 2001:db8:acad:5::2: time=1ms

Reply from 2001:db8:acad:5::2: time=1ms

Ping statistics for 2001:db8:acad:5::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 8ms, Average = 2ms

C:\Users\user>ping 2001:db8:acad:6::1

Pinging 2001:db8:acad:6::1 with 32 bytes of data:

Reply from 2001:db8:acad:6::1: time=1ms

Reply from 2001:db8:acad:6::1: time=1ms

Reply from 2001:db8:acad:6::1: time=1ms

Reply from 2001:db8:acad:6::1: time=1ms

Ping statistics for 2001:db8:acad:6::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:6::2

Pinging 2001:db8:acad:6::2 with 32 bytes of data:

Reply from 2001:db8:acad:6::2: time=5ms

Reply from 2001:db8:acad:6::2: time=1ms

Reply from 2001:db8:acad:6::2: time=1ms

Reply from 2001:db8:acad:6::2: time=1ms

Ping statistics for 2001:db8:acad:6::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 5ms, Average = 2ms

C:\Users\user>ping 2001:db8:acad:7::1

Pinging 2001:db8:acad:7::1 with 32 bytes of data:

Reply from 2001:db8:acad:7::1: time=1ms

Reply from 2001:db8:acad:7::1: time=1ms

Reply from 2001:db8:acad:7::1: time=1ms

Reply from 2001:db8:acad:7::1: time=1ms

Ping statistics for 2001:db8:acad:7::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:7::2

Pinging 2001:db8:acad:7::2 with 32 bytes of data:

Reply from 2001:db8:acad:7::2: time=4ms

Reply from 2001:db8:acad:7::2: time=1ms

Reply from 2001:db8:acad:7::2: time=1ms

Reply from 2001:db8:acad:7::2: time=1ms

Ping statistics for 2001:db8:acad:7::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 4ms, Average = 1ms

***Ip routes:***

IPv4

---------------

R1:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

C 10.1.1.0/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.2/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.5/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.8/30 [110/2] via 10.1.1.6, 00:14:41, GigabitEthernet0/0/0

O IA 10.1.1.12/30 [110/3] via 10.1.1.6, 00:14:16, GigabitEthernet0/0/0

O IA 10.1.1.16/30 [110/4] via 10.1.1.6, 00:11:36, GigabitEthernet0/0/0

O IA 10.1.1.20/30 [110/5] via 10.1.1.6, 00:09:03, GigabitEthernet0/0/0

O IA 10.1.1.24/30 [110/6] via 10.1.1.6, 00:08:18, GigabitEthernet0/0/0

R2:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

O 10.1.1.0/30 [110/2] via 10.1.1.5, 00:17:48, GigabitEthernet0/0/1

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.6/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.8/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.9/32 is directly connected, GigabitEthernet0/0/0

O IA 10.1.1.12/30 [110/2] via 10.1.1.10, 00:15:28, GigabitEthernet0/0/0

O IA 10.1.1.16/30 [110/3] via 10.1.1.10, 00:12:48, GigabitEthernet0/0/0

O IA 10.1.1.20/30 [110/4] via 10.1.1.10, 00:10:15, GigabitEthernet0/0/0

O IA 10.1.1.24/30 [110/5] via 10.1.1.10, 00:09:30, GigabitEthernet0/0/0

R3:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

O 10.1.1.0/30 [110/3] via 10.1.1.9, 00:16:45, GigabitEthernet0/0/1

O 10.1.1.4/30 [110/2] via 10.1.1.9, 00:16:45, GigabitEthernet0/0/1

C 10.1.1.8/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.10/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.12/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.13/32 is directly connected, GigabitEthernet0/0/0

O IA 10.1.1.16/30 [110/2] via 10.1.1.14, 00:13:55, GigabitEthernet0/0/0

O IA 10.1.1.20/30 [110/3] via 10.1.1.14, 00:11:22, GigabitEthernet0/0/0

O IA 10.1.1.24/30 [110/4] via 10.1.1.14, 00:10:37, GigabitEthernet0/0/0

R4:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

O IA 10.1.1.0/30 [110/4] via 10.1.1.13, 00:16:57, GigabitEthernet0/0/1

O IA 10.1.1.4/30 [110/3] via 10.1.1.13, 00:16:57, GigabitEthernet0/0/1

O IA 10.1.1.8/30 [110/2] via 10.1.1.13, 00:16:57, GigabitEthernet0/0/1

C 10.1.1.12/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.14/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.16/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.17/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.20/30 [110/2] via 10.1.1.18, 00:13:29, GigabitEthernet0/0/0

O 10.1.1.24/30 [110/3] via 10.1.1.18, 00:13:29, GigabitEthernet0/0/0

R5:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

O IA 10.1.1.0/30 [110/5] via 10.1.1.17, 00:17:09, GigabitEthernet0/0/1

O IA 10.1.1.4/30 [110/4] via 10.1.1.17, 00:17:09, GigabitEthernet0/0/1

O IA 10.1.1.8/30 [110/3] via 10.1.1.17, 00:17:09, GigabitEthernet0/0/1

O IA 10.1.1.12/30 [110/2] via 10.1.1.17, 00:17:09, GigabitEthernet0/0/1

C 10.1.1.16/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.18/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.20/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.21/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.24/30 [110/2] via 10.1.1.22, 00:14:31, GigabitEthernet0/0/0

R6:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

O IA 10.1.1.0/30 [110/6] via 10.1.1.21, 00:15:44, GigabitEthernet0/0/1

O IA 10.1.1.4/30 [110/5] via 10.1.1.21, 00:15:44, GigabitEthernet0/0/1

O IA 10.1.1.8/30 [110/4] via 10.1.1.21, 00:15:44, GigabitEthernet0/0/1

O IA 10.1.1.12/30 [110/3] via 10.1.1.21, 00:15:44, GigabitEthernet0/0/1

O 10.1.1.16/30 [110/2] via 10.1.1.21, 00:15:44, GigabitEthernet0/0/1

C 10.1.1.20/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.22/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.24/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.25/32 is directly connected, GigabitEthernet0/0/0

IPv6

--------------

R1:

C 2001:DB8:ACAD:1::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:1::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:2::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:2::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:3::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:4::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:5::/64 [110/4]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:6::/64 [110/5]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:7::/64 [110/6]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R2:

O 2001:DB8:ACAD:1::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:2::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:2::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:3::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:3::1/128 [0/0]

via GigabitEthernet0/0/0, receive

OI 2001:DB8:ACAD:4::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:5::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:6::/64 [110/4]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:7::/64 [110/5]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R3:

O 2001:DB8:ACAD:1::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:ACAD:2::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:3::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:3::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:4::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:4::1/128 [0/0]

via GigabitEthernet0/0/0, receive

OI 2001:DB8:ACAD:5::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:6::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:7::/64 [110/4]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R4:

OI 2001:DB8:ACAD:1::/64 [110/4]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:2::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:3::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:4::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:4::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:5::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:5::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:6::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

O 2001:DB8:ACAD:7::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R5:

OI 2001:DB8:ACAD:1::/64 [110/5]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:2::/64 [110/4]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:3::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:4::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:5::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:5::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:6::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:6::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:7::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R6:

OI 2001:DB8:ACAD:1::/64 [110/6]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:2::/64 [110/5]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:3::/64 [110/4]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:4::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:ACAD:5::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:6::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:6::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:7::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:7::1/128 [0/0]

via GigabitEthernet0/0/0, receive

L FF00::/8 [0/0]

via Null0, receive

***Router 1 Config:***

hostname r1

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214421CF

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

ip address 10.1.1.5 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:2::1/64

ipv6 ospf 10 area 1

interface GigabitEthernet0/0/1

ip address 10.1.1.2 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address 2001:DB8:ACAD:1::2/64

ipv6 ospf 10 area 1

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router ospf 10

router-id 1.1.1.1

network 10.1.1.0 0.0.0.3 area 1

network 10.1.1.4 0.0.0.3 area 1

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ip route 0.0.0.0 0.0.0.0 GigabitEthernet0/0/0

ipv6 router ospf 10

router-id 1.1.1.1

control-plane

line con 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 2 Config:***

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO211216BL

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

ip address 10.1.1.9 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:3::1/64

ipv6 ospf 10 area 1

interface GigabitEthernet0/0/1

ip address 10.1.1.6 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:2::2/64

ipv6 ospf 10 area 1

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router ospf 10

router-id 2.2.2.2

network 10.1.1.4 0.0.0.3 area 1

network 10.1.1.8 0.0.0.3 area 1

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 2.2.2.2

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 3 Config:***

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

ipv6 unicast-routing

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420G7

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface GigabitEthernet0/0/0

ip address 10.1.1.13 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:4::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

ip address 10.1.1.10 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:3::2/64

ipv6 ospf 10 area 1

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

router-id 3.3.3.3

network 10.1.1.8 0.0.0.3 area 0

network 10.1.1.12 0.0.0.3 area 1

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 3.3.3.3

control-plane

line con 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

***Router 4 Config:***

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

ipv6 unicast-routing

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21442B21

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface GigabitEthernet0/0/0

ip address 10.1.1.17 255.255.255.252

ip ospf 10 area 2

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:5::1/64

ipv6 ospf 10 area 2

interface GigabitEthernet0/0/1

ip address 10.1.1.14 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:4::2/64

ipv6 ospf 10 area 0

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

router-id 4.4.4.4

network 10.1.1.12 0.0.0.3 area 0

network 10.1.1.16 0.0.0.3 area 2

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 4.4.4.4

control-plane

line con 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

***Router 5 Config:***

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

login on-success log

subscriber templating

ipv6 unicast-routing

multilink bundle-name authenticated

crypto pki trustpoint TP-self-signed-2270144787

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-2270144787

revocation-check none

rsakeypair TP-self-signed-2270144787

crypto pki certificate chain TP-self-signed-2270144787

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

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

69666963 6174652D 32323730 31343437 3837301E 170D3232 30393134 31373030

30345A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 32373031

34343738 37308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 0100AD37 2C831684 9C5FCA8D D4881B1F 60442411 2A5BFE41 0E81FF19

7BD588FD 65181375 5773AEFA 4B22659E 378C23C6 85E962FC 908FDC43 14A29AB2

F1CD2719 0A541976 9E74AE51 1B2064C8 83D46B00 D29ED427 DEAA4FDD F97FD3E2

84A57367 7E69AEFA 3E41F022 600CA211 887E6C71 5A0A6184 2DE0904A 557887E8

488A66D4 91CD5992 C408FDA0 C791A87C AA3BC27E C09CA618 2A433988 64F1601D

5443D021 F8030CA2 E4C4D7BF 54D2B808 E17466C0 FEEB5F7E 163D34E9 3CCC1B11

3D431E43 45801671 C8182A71 21A7436F BEB10128 24600E9A 2822218C 08A9A852

38F849D5 61D9101F 83FF596A 67C41938 976CF5D0 4669A2F1 6C990656 E7BBC52E

F00E3251 466B0203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 14E3ED39 291D0D78 2523924E 40A4970F 3E5EB403

EF301D06 03551D0E 04160414 E3ED3929 1D0D7825 23924E40 A4970F3E 5EB403EF

300D0609 2A864886 F70D0101 05050003 82010100 6F0F53E3 61F6BABB 7F1BE097

73E588FD 3237381C 1D0BA707 93F1E96F DCFEA5D6 77AE4E58 41B54537 AB8556D3

CAC41029 AB2000E7 20F5A0FF 67071B31 81FB2D4F 22C38FB9 E6D26506 F09F4384

8D21B149 D0DD064F 02293ED3 E82981DF 45730B57 A31E4DFE D0CB322C 640D8022

4459C080 E81D004B 589DF043 AD7A1786 C64EF69C B7D27A35 5784C9E2 D4772CA5

EE985C24 2A7C9E82 50086DBB 5B18E45A 54527023 5B576E04 2382BA7E 57AE690B

EA659045 6156E48B D2219C2C AF4F5DE4 8ECC5B6B 170CB1A6 3717B128 F342F279

9A6B425C 19542113 2CEE22AA CA3173C5 185BEE9E 0F24BA30 6646C7AB 63BB8357

CC6FA1FF 1EBDEA11 4B5AF3B6 718B202A 95D45A60

quit

license udi pid ISR4321/K9 sn FLM24060912

no license smart enable

diagnostic bootup level minimal

spanning-tree extend system-id

redundancy

mode none

interface GigabitEthernet0/0/0

ip address 10.1.1.21 255.255.255.252

ip ospf 10 area 2

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:6::1/64

ipv6 ospf 10 area 2

interface GigabitEthernet0/0/1

ip address 10.1.1.18 255.255.255.252

ip ospf 10 area 2

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:5::2/64

ipv6 ospf 10 area 2

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

router ospf 10

router-id 5.5.5.5

network 10.1.1.16 0.0.0.3 area 2

network 10.1.1.20 0.0.0.3 area 2

ip forward-protocol nd

ip http server

ip http authentication local

ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 5.5.5.5

control-plane

line con 0

logging synchronous

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 6 Config:***

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

login on-success log

subscriber templating

ipv6 unicast-routing

multilink bundle-name authenticated

crypto pki trustpoint TP-self-signed-4144679456

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-4144679456

revocation-check none

rsakeypair TP-self-signed-4144679456

crypto pki trustpoint TP-self-signed-2270144787

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-2270144787

revocation-check none

rsakeypair TP-self-signed-2270144787

crypto pki certificate chain TP-self-signed-4144679456

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

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

69666963 6174652D 34313434 36373934 3536301E 170D3232 30393134 31363439

33395A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D34 31343436

37393435 36308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 0100CCFC 6E2220E1 93956DC6 5E773AC2 B25126DF 1F533987 4770D4F2

5C5D887D 4DA1B02C 48269BD0 2BC4ACB2 BDD05959 BCFC4A73 E7ACBC82 1674B948

13B98F92 206F03EA 0D2E10A4 3E0966B9 EC926C9C 009BFB1F C2498968 10341BFB

43F71DFF EB883A17 C5A95169 94C59844 4D1B02FF 2C5FA356 97ECB734 95484613

0C06A29C 7F59B35A B4091FDC 0E00BEB7 64EAEC35 AEAF101E 85D01754 DA0D689A

17F726CF 849731E7 5F7C9A3E 05C4B072 FC6FB2AE 6B5668FD D34B1481 6F375EE7

21EF65DA E1F6C5CF 9DA4C34B 982A35EE 9F0D5F14 4B919A47 6EF46DAA D1A8D3AA

087B04DD 506BF7B8 5F73D919 D6C66F64 BB499BF4 F41EBB97 1C33F37A C9BA2B14

C8F3AD25 3ECB0203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 1419AC83 C50741EF 51D6578F 04A6FE55 55441C58

95301D06 03551D0E 04160414 19AC83C5 0741EF51 D6578F04 A6FE5555 441C5895

300D0609 2A864886 F70D0101 05050003 82010100 AD8E5DE2 BFBD529C E4F704A4

6D069DF9 C8A98356 FF2543FF 89D4D880 60ED8465 B80C0FE9 FF241FA8 4B3A73CB

00DD845B D9D0BE2C 1AF573DC CE192909 9092A588 86E15D9A 298FCB42 F34B1EB7

9D9BF334 A4CE35A7 C686B8BD 16AA2402 091D1ABD 7B52A79D A5D26C56 2F6CE52A

8CA49442 3343C6E9 BB5FF37F B16C3766 6F53DA5C 43F18FD2 2FCBE250 60F977AF

4E4B2137 A883AAC5 66A3B921 A4AE105B 043C06C2 9C81F0D2 A027B78E 0FC1FF9A

24021FF6 2E2A5F3F 7EA676CE 935CF95B C3BA4AF1 AB1B1B21 F2205D8F 37514CBB

AD893919 56167B92 C0DE9DCF B313E9CD 8656F62E 09C6A9A9 07559E28 07DE9933

3359BDA3 5854FFC1 5FE4F6D1 A7E4C49B 2BDE0A98

quit

crypto pki certificate chain TP-self-signed-2270144787

license udi pid ISR4321/K9 sn FLM2408005M

no license smart enable

diagnostic bootup level minimal

spanning-tree extend system-id

redundancy

mode none

interface GigabitEthernet0/0/0

ip address 10.1.1.25 255.255.255.252

ip ospf 10 area 2

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:7::1/64

ipv6 ospf 10 area 2

interface GigabitEthernet0/0/1

ip address 10.1.1.22 255.255.255.252

ip ospf 10 area 2

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:6::2/64

ipv6 ospf 10 area 2

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

router ospf 10

router-id 6.6.6.6

network 10.1.1.20 0.0.0.3 area 2

network 10.1.1.24 0.0.0.3 area 2

ip forward-protocol nd

ip http server

ip http authentication local

ip http secure-server

ip tftp source-interface GigabitEthernet0

ip route 0.0.0.0 0.0.0.0 GigabitEthernet0/0/1

ipv6 router ospf 10

router-id 6.6.6.6

control-plane

line con 0

logging synchronous

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

Problems

Due to having previous experience in configuring single area OSPF the lab went rather smoothly for the most part. The major difference was planning out areas and implementing the area command. We encountered a problem when there weren’t any adjacencies being formed for OSPFv3 between routers 4 and 5. We found out that the problem was due to configuring link local addresses on the wrong interfaces. When the link-local addresses were fixed, the connection was formed. The other problems that we encountered was that the host could ping across the network with IPv4 but were unable to ping across the network with IPv6. Originally, we tried setting passive interfaces and checked over our configuration’s multiple times, but we couldn’t find any errors. This was solved by shutting down the failing interface and restarting it and it fixed the problem.

Conclusion

In this lab, we created a OSPF and OSPFv3 network with 6 routers with interfaces between routers 3 and 4 in area 0 and the interfaces between routers 1 to 3 in area 1 and the interfaces between routers 4 to 6 in area 2. Pings were sent across the network from PCs to confirm functionality. Things that originally went wrong were misconfigurations of link-local addresses for OSPFv3 and a stubborn interface that we had to restart. We learned that the reason why OSPFv3 does not require network statements is due to the existence of link local addresses which share crucial information between routers for OSPFv3. I learned how to set up OSPF and OSPFv3 while planning and exploring with different OSPF areas. In the end, we were successful in configuring OSPF and functionality was confirmed through successful pings throughout the network.



**Implementing BGP (6 routers)***Derek Liu*

Purpose

The purpose of this lab was the explore the functions of BGP and how to set it up. More specifically, learning how BGP can connecting two different routing protocols (EIGRP and OSPF) and allow them to share information and create both Ipv4 and Ipv6 routes.

Background Information

EIGRP is a routing protocol that was not implemented before in previous laps. EIGRP, also known as enhanced interior gateway routing protocol, is a routing protocol like OSPF as it allows rapid convergence of network topologies. It allows for scalability in a network. Routes in EIGRP are calculated using hop count and DUAL (diffusing update algorithm). The major difference between EIGRP and OSPF is that EIGRP is Cisco proprietary and EIGRP converges faster.

BGP or border gateway protocol is also a routing protocol that supports both Ipv4 and ipv6. However, it manages how packets get routed from network to network through the exchanging of routing and reachability information among edge routers. For example, as used in this lab, exchanging packets between OSPF and EIGRP. BGP allows for redundancy by guaranteeing routers can adapt to failures: if one path goes down, another path can be located. The difference between BGP and OSPF is that OSPF is used in internal networks while BGP is used for larger networks since it is the most scalable out of all the routing protocols. It can carry routes for multicast, Ipv6, VPNs, and a variety of other data. It uses a TCP connection on port number 179 to exchange update information.

The origin of this protocol came from a sketch on three napkins in 1989 and is still sometimes known as the three-napkin protocol. It was first applied as part of the internet in 1994.

BGP plays a very important role on the internet. For example, when Instagram went down for six hours on October 4th 2021, it was due to no working BGP routes into social media sites.

Different types of BGP networks can be formed. One of them is EBGP or external BGP which forms BGP connections between external peers (peers in a different autonomous system than the local system). There is also IBGP or internal BGP which forms BGP connections between internal peers.

Lab Summary

Using six Cisco 4321 routers connected linearly, we connected them using gigabit ethernet cables with ports g0/0/0 and g0/0/1. The g0/0/0 port of router 1 was connected to an end device (PC1) and the g0/0/1 port of router 6 was connected another end device (PC2). Using previously acquired skills of configuring OSPF, we configured OSPF and OSPFv3 on routers 1-3 in the backbone area 0. Routers 4-6 were configured with EIGRP for both Ipv4 and Ipv6. We then configured BGP on the network between router 3 and 4. We had OSPF and OSPFv3 redistribute information to BGP and vice versa on router 4. We then had EIGRP and EIGRP for ipv6 redistribute information to BGP and vice versa on router 3. Connection was tested through examining both ipv4 and ipv6 routes on the routers and pings were sent across the network from the two end devices.

Lab Commands

**BGP Commands**:

R3:

router bgp 100

router-id 3.3.3.3

no bgp default ipv4-unicast

neighbor 10.1.1.14 remote-as 200

neighbor 2001:db8:acad:4::2 remote-as 200

address-family ipv4

redistribute ospf 10

network 10.1.1.12

neighbor 10.1.1.14 activate

address-family ipv6

redistribute ospf 10

network 2001:db8:acad:4::/64

neighbor 2001:db8:acad:4::2 activate

R4:

router bgp 200

router-id 4.4.4.4

no bgp default ipv4-unicast

neighbor 10.1.1.13 remote-as 100

neighbor 2001:db8:acad:4::1 remote-as 100

address-family ipv4

network 10.1.1.12

neighbor 10.1.1.13 activate

redistribute eigrp 10

address-family ipv6

network 2001:db8:acad:4::/64

neighbor 2001:db8:acad:4::1 activate

redistribute eigrp 10

**EIGRP Commands**:

en

config t

hostname r5

router eigrp 10

network 10.1.1.18 0.0.0.3

network 10.1.1.21 0.0.0.3

ipv6 unicast-routing

ipv6 router eigrp 10

int g0/0/0

ip address 10.1.1.21 255.255.255.252

no shut

ipv6 address 2001:db8:acad:6::1/64

ipv6 address fe80::1 link-local

ipv6 eigrp 10

ipv6 enable

int g0/0/1

ip address 10.1.1.18 255.255.255.252

no shut

ipv6 address 2001:db8:acad:5::2/64

ipv6 address fe80::2 link-local

ipv6 eigrp 10

ipv6 enable

**OSPF Commands**:

en

config t

hostname r1

router ospf 10

router-id 1.1.1.1

network 10.1.1.0 0.0.0.3 area 1

network 10.1.1.4 0.0.0.3 area 1

ipv6 unicast-routing

ipv6 router ospf 10

router-id 1.1.1.1

int g0/0/0

ip address 10.1.1.5 255.255.255.252

ip ospf 10 area 1

no shut

ipv6 address 2001:db8:acad:2::1/64

ipv6 address fe80::1 link-local

ipv6 ospf 10 area 1

int g0/0/1

ip address 10.1.1.2 255.255.255.252

ip ospf 10 area 1

no shut

ipv6 address 2001:db8:acad:1::2/64

ipv6 address fe80::2 link-local

ipv6 ospf 10 area 1

Network Diagrams with IP

A diagram of a network

Description automatically generated with low confidence

Configurations

***Pings (ipv4):***

C:\Users\user>ping 10.1.1.2

Pinging 10.1.1.2 with 32 bytes of data:

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Ping statistics for 10.1.1.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.5

Pinging 10.1.1.5 with 32 bytes of data:

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Ping statistics for 10.1.1.5:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.6

Pinging 10.1.1.6 with 32 bytes of data:

Reply from 10.1.1.6: bytes=32 time=1ms TTL=254

Reply from 10.1.1.6: bytes=32 time<1ms TTL=254

Reply from 10.1.1.6: bytes=32 time<1ms TTL=254

Reply from 10.1.1.6: bytes=32 time<1ms TTL=254

Ping statistics for 10.1.1.6:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.9

Pinging 10.1.1.9 with 32 bytes of data:

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Ping statistics for 10.1.1.9:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.10

Pinging 10.1.1.10 with 32 bytes of data:

Reply from 10.1.1.10: bytes=32 time=1ms TTL=253

Reply from 10.1.1.10: bytes=32 time<1ms TTL=253

Reply from 10.1.1.10: bytes=32 time<1ms TTL=253

Reply from 10.1.1.10: bytes=32 time<1ms TTL=253

Ping statistics for 10.1.1.10:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.13

Pinging 10.1.1.13 with 32 bytes of data:

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Ping statistics for 10.1.1.13:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.14

Pinging 10.1.1.14 with 32 bytes of data:

Reply from 10.1.1.14: bytes=32 time=1ms TTL=252

Reply from 10.1.1.14: bytes=32 time<1ms TTL=252

Reply from 10.1.1.14: bytes=32 time<1ms TTL=252

Reply from 10.1.1.14: bytes=32 time<1ms TTL=252

Ping statistics for 10.1.1.14:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.17

Pinging 10.1.1.17 with 32 bytes of data:

Reply from 10.1.1.17: bytes=32 time=1ms TTL=252

Reply from 10.1.1.17: bytes=32 time<1ms TTL=252

Reply from 10.1.1.17: bytes=32 time<1ms TTL=252

Reply from 10.1.1.17: bytes=32 time<1ms TTL=252

Ping statistics for 10.1.1.17:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.18

Pinging 10.1.1.18 with 32 bytes of data:

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Ping statistics for 10.1.1.18:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 10.1.1.21

Pinging 10.1.1.21 with 32 bytes of data:

Reply from 10.1.1.21: bytes=32 time=1ms TTL=251

Reply from 10.1.1.21: bytes=32 time=1ms TTL=251

Reply from 10.1.1.21: bytes=32 time<1ms TTL=251

Reply from 10.1.1.21: bytes=32 time=1ms TTL=251

Ping statistics for 10.1.1.21:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.22

Pinging 10.1.1.22 with 32 bytes of data:

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Ping statistics for 10.1.1.22:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 10.1.1.25

Pinging 10.1.1.25 with 32 bytes of data:

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Ping statistics for 10.1.1.25:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 10.1.1.26

Pinging 10.1.1.26 with 32 bytes of data:

Reply from 10.1.1.26: bytes=32 time=1ms TTL=122

Reply from 10.1.1.26: bytes=32 time=1ms TTL=122

Reply from 10.1.1.26: bytes=32 time=1ms TTL=122

Reply from 10.1.1.26: bytes=32 time=1ms TTL=122

Ping statistics for 10.1.1.26:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

***Pings (ipv6):***

C:\Users\user>ping 2001:db8:acad:1::2

Pinging 2001:db8:acad:1::2 with 32 bytes of data:

Reply from 2001:db8:acad:1::2: time<1ms

Reply from 2001:db8:acad:1::2: time<1ms

Reply from 2001:db8:acad:1::2: time<1ms

Reply from 2001:db8:acad:1::2: time<1ms

Ping statistics for 2001:db8:acad:1::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:2::1

Pinging 2001:db8:acad:2::1 with 32 bytes of data:

Reply from 2001:db8:acad:2::1: time=2ms

Reply from 2001:db8:acad:2::1: time<1ms

Reply from 2001:db8:acad:2::1: time<1ms

Reply from 2001:db8:acad:2::1: time<1ms

Ping statistics for 2001:db8:acad:2::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 2ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:2::2

Pinging 2001:db8:acad:2::2 with 32 bytes of data:

Reply from 2001:db8:acad:2::2: time=6ms

Reply from 2001:db8:acad:2::2: time<1ms

Reply from 2001:db8:acad:2::2: time<1ms

Reply from 2001:db8:acad:2::2: time<1ms

Ping statistics for 2001:db8:acad:2::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 6ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:3::1

Pinging 2001:db8:acad:3::1 with 32 bytes of data:

Reply from 2001:db8:acad:3::1: time<1ms

Reply from 2001:db8:acad:3::1: time<1ms

Reply from 2001:db8:acad:3::1: time=1ms

Reply from 2001:db8:acad:3::1: time<1ms

Ping statistics for 2001:db8:acad:3::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:3::2

Pinging 2001:db8:acad:3::2 with 32 bytes of data:

Reply from 2001:db8:acad:3::2: time=8ms

Reply from 2001:db8:acad:3::2: time<1ms

Reply from 2001:db8:acad:3::2: time<1ms

Reply from 2001:db8:acad:3::2: time<1ms

Ping statistics for 2001:db8:acad:3::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 8ms, Average = 2ms

C:\Users\user>ping 2001:db8:acad:4::1

Pinging 2001:db8:acad:4::1 with 32 bytes of data:

Reply from 2001:db8:acad:4::1: time<1ms

Reply from 2001:db8:acad:4::1: time=1ms

Reply from 2001:db8:acad:4::1: time<1ms

Reply from 2001:db8:acad:4::1: time<1ms

Ping statistics for 2001:db8:acad:4::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:4::2

Pinging 2001:db8:acad:4::2 with 32 bytes of data:

Reply from 2001:db8:acad:4::2: time=8ms

Reply from 2001:db8:acad:4::2: time=1ms

Reply from 2001:db8:acad:4::2: time=1ms

Reply from 2001:db8:acad:4::2: time=1ms

Ping statistics for 2001:db8:acad:4::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 8ms, Average = 2ms

C:\Users\user>ping 2001:db8:acad:5::1

Pinging 2001:db8:acad:5::1 with 32 bytes of data:

Reply from 2001:db8:acad:5::1: time=1ms

Reply from 2001:db8:acad:5::1: time<1ms

Reply from 2001:db8:acad:5::1: time=1ms

Reply from 2001:db8:acad:5::1: time=1ms

Ping statistics for 2001:db8:acad:5::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:5::2

Pinging 2001:db8:acad:5::2 with 32 bytes of data:

Reply from 2001:db8:acad:5::2: time=8ms

Reply from 2001:db8:acad:5::2: time=1ms

Reply from 2001:db8:acad:5::2: time=1ms

Reply from 2001:db8:acad:5::2: time=1ms

Ping statistics for 2001:db8:acad:5::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 8ms, Average = 2ms

C:\Users\user>ping 2001:db8:acad:6::1

Pinging 2001:db8:acad:6::1 with 32 bytes of data:

Reply from 2001:db8:acad:6::1: time=1ms

Reply from 2001:db8:acad:6::1: time=1ms

Reply from 2001:db8:acad:6::1: time=1ms

Reply from 2001:db8:acad:6::1: time=1ms

Ping statistics for 2001:db8:acad:6::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:6::2

Pinging 2001:db8:acad:6::2 with 32 bytes of data:

Reply from 2001:db8:acad:6::2: time=5ms

Reply from 2001:db8:acad:6::2: time=1ms

Reply from 2001:db8:acad:6::2: time=1ms

Reply from 2001:db8:acad:6::2: time=1ms

Ping statistics for 2001:db8:acad:6::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 5ms, Average = 2ms

C:\Users\user>ping 2001:db8:acad:7::1

Pinging 2001:db8:acad:7::1 with 32 bytes of data:

Reply from 2001:db8:acad:7::1: time=1ms

Reply from 2001:db8:acad:7::1: time=1ms

Reply from 2001:db8:acad:7::1: time=1ms

Reply from 2001:db8:acad:7::1: time=1ms

Ping statistics for 2001:db8:acad:7::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:7::2

Pinging 2001:db8:acad:7::2 with 32 bytes of data:

Reply from 2001:db8:acad:7::2: time=4ms

Reply from 2001:db8:acad:7::2: time=1ms

Reply from 2001:db8:acad:7::2: time=1ms

Reply from 2001:db8:acad:7::2: time=1ms

Ping statistics for 2001:db8:acad:7::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 4ms, Average = 1ms

***Ip routes:***

IPv4

---------------

R1:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

C 10.1.1.0/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.2/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.5/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.8/30 [110/2] via 10.1.1.6, 00:14:41, GigabitEthernet0/0/0

O IA 10.1.1.12/30 [110/3] via 10.1.1.6, 00:14:16, GigabitEthernet0/0/0

O IA 10.1.1.16/30 [110/4] via 10.1.1.6, 00:11:36, GigabitEthernet0/0/0

O IA 10.1.1.20/30 [110/5] via 10.1.1.6, 00:09:03, GigabitEthernet0/0/0

O IA 10.1.1.24/30 [110/6] via 10.1.1.6, 00:08:18, GigabitEthernet0/0/0

R2:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

O 10.1.1.0/30 [110/2] via 10.1.1.5, 00:17:48, GigabitEthernet0/0/1

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.6/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.8/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.9/32 is directly connected, GigabitEthernet0/0/0

O IA 10.1.1.12/30 [110/2] via 10.1.1.10, 00:15:28, GigabitEthernet0/0/0

O IA 10.1.1.16/30 [110/3] via 10.1.1.10, 00:12:48, GigabitEthernet0/0/0

O IA 10.1.1.20/30 [110/4] via 10.1.1.10, 00:10:15, GigabitEthernet0/0/0

O IA 10.1.1.24/30 [110/5] via 10.1.1.10, 00:09:30, GigabitEthernet0/0/0

R3:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

O 10.1.1.0/30 [110/3] via 10.1.1.9, 00:16:45, GigabitEthernet0/0/1

O 10.1.1.4/30 [110/2] via 10.1.1.9, 00:16:45, GigabitEthernet0/0/1

C 10.1.1.8/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.10/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.12/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.13/32 is directly connected, GigabitEthernet0/0/0

O IA 10.1.1.16/30 [110/2] via 10.1.1.14, 00:13:55, GigabitEthernet0/0/0

O IA 10.1.1.20/30 [110/3] via 10.1.1.14, 00:11:22, GigabitEthernet0/0/0

O IA 10.1.1.24/30 [110/4] via 10.1.1.14, 00:10:37, GigabitEthernet0/0/0

R4:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

O IA 10.1.1.0/30 [110/4] via 10.1.1.13, 00:16:57, GigabitEthernet0/0/1

O IA 10.1.1.4/30 [110/3] via 10.1.1.13, 00:16:57, GigabitEthernet0/0/1

O IA 10.1.1.8/30 [110/2] via 10.1.1.13, 00:16:57, GigabitEthernet0/0/1

C 10.1.1.12/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.14/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.16/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.17/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.20/30 [110/2] via 10.1.1.18, 00:13:29, GigabitEthernet0/0/0

O 10.1.1.24/30 [110/3] via 10.1.1.18, 00:13:29, GigabitEthernet0/0/0

R5:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

O IA 10.1.1.0/30 [110/5] via 10.1.1.17, 00:17:09, GigabitEthernet0/0/1

O IA 10.1.1.4/30 [110/4] via 10.1.1.17, 00:17:09, GigabitEthernet0/0/1

O IA 10.1.1.8/30 [110/3] via 10.1.1.17, 00:17:09, GigabitEthernet0/0/1

O IA 10.1.1.12/30 [110/2] via 10.1.1.17, 00:17:09, GigabitEthernet0/0/1

C 10.1.1.16/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.18/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.20/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.21/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.24/30 [110/2] via 10.1.1.22, 00:14:31, GigabitEthernet0/0/0

R6:

10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks

O IA 10.1.1.0/30 [110/6] via 10.1.1.21, 00:15:44, GigabitEthernet0/0/1

O IA 10.1.1.4/30 [110/5] via 10.1.1.21, 00:15:44, GigabitEthernet0/0/1

O IA 10.1.1.8/30 [110/4] via 10.1.1.21, 00:15:44, GigabitEthernet0/0/1

O IA 10.1.1.12/30 [110/3] via 10.1.1.21, 00:15:44, GigabitEthernet0/0/1

O 10.1.1.16/30 [110/2] via 10.1.1.21, 00:15:44, GigabitEthernet0/0/1

C 10.1.1.20/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.22/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.24/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.25/32 is directly connected, GigabitEthernet0/0/0

IPv6

--------------

R1:

C 2001:DB8:ACAD:1::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:1::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:2::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:2::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:3::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:4::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:5::/64 [110/4]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:6::/64 [110/5]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:7::/64 [110/6]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R2:

O 2001:DB8:ACAD:1::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:2::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:2::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:3::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:3::1/128 [0/0]

via GigabitEthernet0/0/0, receive

OI 2001:DB8:ACAD:4::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:5::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:6::/64 [110/4]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:7::/64 [110/5]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R3:

O 2001:DB8:ACAD:1::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:ACAD:2::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:3::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:3::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:4::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:4::1/128 [0/0]

via GigabitEthernet0/0/0, receive

OI 2001:DB8:ACAD:5::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:6::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

OI 2001:DB8:ACAD:7::/64 [110/4]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R4:

OI 2001:DB8:ACAD:1::/64 [110/4]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:2::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:3::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:4::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:4::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:5::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:5::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:6::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

O 2001:DB8:ACAD:7::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R5:

OI 2001:DB8:ACAD:1::/64 [110/5]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:2::/64 [110/4]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:3::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:4::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:5::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:5::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:6::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:6::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:7::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R6:

OI 2001:DB8:ACAD:1::/64 [110/6]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:2::/64 [110/5]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:3::/64 [110/4]

via FE80::1, GigabitEthernet0/0/1

OI 2001:DB8:ACAD:4::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:ACAD:5::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:6::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:6::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:7::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:7::1/128 [0/0]

via GigabitEthernet0/0/0, receive

L FF00::/8 [0/0]

via Null0, receive

***Router 1 Config:***

hostname r1

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214421CF

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.1.1 255.255.255.0

ip ospf 10 area 0

ipv6 address 2001:DB8:1::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 10.1.1.5 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:2::1/64

ipv6 ospf 10 area 1

interface GigabitEthernet0/0/1

ip address 10.1.1.2 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address 2001:DB8:ACAD:1::2/64

ipv6 ospf 10 area 1

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router ospf 10

router-id 1.1.1.1

network 10.1.1.0 0.0.0.3 area 1

network 10.1.1.4 0.0.0.3 area 1

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ip route 0.0.0.0 0.0.0.0 GigabitEthernet0/0/0

ipv6 router ospf 10

router-id 1.1.1.1

control-plane

line con 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 2 Config:***

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO211216BL

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.2.1 255.255.255.0

ip ospf 10 area 0

ipv6 address 2001:DB8:2::1/64

ipv6 ospf 10 area 1

interface GigabitEthernet0/0/0

ip address 10.1.1.9 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:3::1/64

ipv6 ospf 10 area 1

interface GigabitEthernet0/0/1

ip address 10.1.1.6 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:2::2/64

ipv6 ospf 10 area 1

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router ospf 10

router-id 2.2.2.2

network 10.1.1.4 0.0.0.3 area 1

network 10.1.1.8 0.0.0.3 area 1

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 2.2.2.2

control-plane

line con 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 3 Config:***

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

ipv6 unicast-routing

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420G7

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface Loopback0

ip address 192.168.3.1 255.255.255.0

ipv6 address 2001:DB8:3::1/64

ipv6 ospf 10 area 1

interface GigabitEthernet0/0/0

ip address 10.1.1.13 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:4::1/64

ipv6 ospf 10 area 1

interface GigabitEthernet0/0/1

ip address 10.1.1.10 255.255.255.252

ip ospf 10 area 1

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:3::2/64

ipv6 ospf 10 area 1

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

router-id 3.3.3.3

redistribute bgp 100 subnets

network 10.1.1.8 0.0.0.3 area 1

network 10.1.1.12 0.0.0.3 area 1

network 192.168.4.0 0.0.0.255 area 1

router bgp 100

bgp router-id 3.3.3.3

bgp log-neighbor-changes

no bgp default ipv4-unicast

neighbor 10.1.1.14 remote-as 200

neighbor 2001:DB8:ACAD:4::2 remote-as 200

address-family ipv4

network 10.1.1.8

network 10.1.1.12

network 192.168.3.0

redistribute ospf 10

neighbor 10.1.1.14 activate

exit-address-family

address-family ipv6

redistribute ospf 10

network 2001:DB8:3::/64

network 2001:DB8:ACAD:3::/64

network 2001:DB8:ACAD:4::/64

neighbor 2001:DB8:ACAD:4::2 activate

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

redistribute bgp 100 metric 10000

control-plane

line con 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 4 Config:***

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

ipv6 unicast-routing

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21442B21

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface Loopback0

ip address 192.168.4.1 255.255.255.0

ipv6 address 2001:DB8:4::1/64

ipv6 eigrp 10

interface GigabitEthernet0/0/0

ip address 10.1.1.17 255.255.255.252

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:5::1/64

ipv6 eigrp 10

interface GigabitEthernet0/0/1

ip address 10.1.1.14 255.255.255.252

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:4::2/64

ipv6 eigrp 10

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 eigrp 10

network 10.1.1.12 0.0.0.3

network 10.1.1.16 0.0.0.3

network 192.168.4.0

redistribute bgp 200 metric 10000 100 255 1 1500

eigrp router-id 4.4.4.4

router bgp 200

bgp router-id 4.4.4.4

bgp log-neighbor-changes

no bgp default ipv4-unicast

neighbor 10.1.1.13 remote-as 100

neighbor 2001:DB8:ACAD:4::1 remote-as 100

address-family ipv4

network 10.1.1.12

network 10.1.1.16

network 192.168.4.0

redistribute eigrp 10

neighbor 10.1.1.13 activate

exit-address-family

address-family ipv6

redistribute eigrp 10

network 2001:DB8:4::/64

network 2001:DB8:ACAD:4::/64

network 2001:DB8:ACAD:5::/64

neighbor 2001:DB8:ACAD:4::1 activate

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router eigrp 10

eigrp router-id 4.4.4.4

redistribute bgp 200 metric 10000 100 255 1 1500

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 5 Config:***

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

login on-success log

subscriber templating

ipv6 unicast-routing

multilink bundle-name authenticated

crypto pki trustpoint TP-self-signed-2270144787

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-2270144787

revocation-check none

rsakeypair TP-self-signed-2270144787

crypto pki certificate chain TP-self-signed-2270144787

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

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

69666963 6174652D 32323730 31343437 3837301E 170D3232 31303034 31373131

31365A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 32373031

34343738 37308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 010091E8 5CF43324 EA2305CE 23C2325C 83678A2D DE8D1401 51469202

59875EB1 5D8DE3CF 78D89071 548D190D 00EF5934 23590721 336301B4 1D88516A

0CA96593 95015667 8A26676F FC29D2F0 A0C2F8F5 0781577A A1563569 4C943075

0ECC2A3F D30346F5 6EC533EF 310E2F2B 5A8D9B48 969D6BB9 5F294C9D 63003545

39C20BE8 9125EA82 B3D08B5B 142B3057 9861A7BD A6D567B6 5189FCDA 330FB57A

F5D075DF AC71CD04 A13EC59F FE3C7467 1ACA7D98 04307A32 78706A1E 20038921

C1BE87EB A2D2A8CA AE0DFF11 5BF1C70F B9D68407 EB0DF639 ED576D60 3FD7AFAF

A51E5B93 5ACAA2C4 B6EC8888 1EA47A19 81FEDD41 B1488D92 2D151114 D28E7205

17F0A305 B01F0203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 14C7CF9E 415237A9 33310B8C E9409253 39567120

DF301D06 03551D0E 04160414 C7CF9E41 5237A933 310B8CE9 40925339 567120DF

300D0609 2A864886 F70D0101 05050003 82010100 87BE5C4F 6AA01F83 FA617820

AAE4775C FEBCCB11 2CC1E111 50F3D928 23F36BF7 3250F0B4 021A078E 64F7BDEF

42078020 3132A015 F4F7B8BE B8B83A84 ECD21655 09C22E00 0A9901AF 06BDDF71

D8271D7D 8EFB24FA 9F2F319D 9C14F6EB 7E903988 C79C7629 C405A8B5 A23AD369

45E9EEC8 F06C2EF2 B9F7BDEF 3074F3C4 2EC1CE63 C178FCFF 31A93952 A6F01595

31BFBBC7 79E0D03A 2826063A 029335F3 F6927134 18369249 A3811CDE 67490D79

5E978487 DB17F64C EAEAB46B 86ADCB1A 28BFC35D 175AE9E4 F45851E6 CDD19B87

2C44D926 B069E503 FA9E8BF0 7626C530 CD7560EB 60370D7E 57AD4E3D 3114B04C

68933BC5 3709FBE7 D787B776 A78BF200 AB3934D4

quit

license udi pid ISR4321/K9 sn FLM24060912

no license smart enable

diagnostic bootup level minimal

spanning-tree extend system-id

redundancy

mode none

interface Loopback0

ip address 192.168.5.1 255.255.255.0

ipv6 address 2001:DB8:5::1/64

ipv6 eigrp 10

interface GigabitEthernet0/0/0

ip address 10.1.1.21 255.255.255.252

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:6::1/64

ipv6 enable

ipv6 eigrp 10

interface GigabitEthernet0/0/1

ip address 10.1.1.18 255.255.255.252

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:5::2/64

ipv6 enable

ipv6 eigrp 10

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

router eigrp 10

network 10.1.1.16 0.0.0.3

network 10.1.1.20 0.0.0.3

ip forward-protocol nd

ip http server

ip http authentication local

ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router eigrp 10

eigrp router-id 5.5.5.5

control-plane

line con 0

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

***Router 6 Config:***

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

login on-success log

subscriber templating

ipv6 unicast-routing

multilink bundle-name authenticated

crypto pki trustpoint TP-self-signed-4144679456

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-4144679456

revocation-check none

rsakeypair TP-self-signed-4144679456

crypto pki certificate chain TP-self-signed-4144679456

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

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

69666963 6174652D 34313434 36373934 3536301E 170D3232 31303034 31373138

31365A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D34 31343436

37393435 36308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 010087CC 266FCB7F CBF7B4EE 138D3485 B2401F70 519C8EDA B5D1E5EC

D3C8D992 21065BCF 869991E0 795A9990 E7E8D247 1D55DCF8 EF12BE1F F6C8CB1E

17C6FEEE 8E10B242 D2C0E98D 679DC16A 9D5D11C6 9617EA8C 2845DC66 21251470

59442738 719AB69D C0F3311E DF116EB7 C6C223E4 A6C06D3D A822AAB8 91369FC1

679B9582 E8BFC5EE 070945EC 4E6E2D5C C4820706 F40E5C42 A0F02B86 7A471330

516082A5 91C02659 F5591812 1B85EDEF 58693D0E 3D1334D8 AA3010BA 12CBB929

E1D7B9B3 2FD29D3E 15A7F473 42A17035 05FE7F9E CA973314 389BADD9 04910E99

EE3904C5 4B5D4BE0 47D895EE 91B0A71A 77181933 A2F0AECB 740E5100 3414F677

5D86C36F 5C7B0203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 14BEAF09 270773AD 4353C83A 6020F1BC 0A05B90D

5E301D06 03551D0E 04160414 BEAF0927 0773AD43 53C83A60 20F1BC0A 05B90D5E

300D0609 2A864886 F70D0101 05050003 82010100 8142B8C1 5EA90A17 2A9D2B3E

C44BA6C1 F460EB6E 1F465E6E 8F0A8EEB 3DB59EDC 80AEDC55 4C38F05A 6CA34F3B

E9CB5D16 B072846A F56E988F 7535D239 77595A89 C828E3AF AA8BF4E2 A796B46F

9819500F 69A36EC0 579C9FB1 971AB1AA 090EF2A7 B9ECA02B E1E64147 03ADAB1A

256F3FD4 E9D768D7 0FED6A34 4825B486 F874025A 3952BA2D FC251D67 216E38CB

B45C6CCD 7B15BB04 6656DA4E 381FE2F5 1F5467E5 172B3945 D3F40EC0 9F2623AB

BD73FFAC EC51537D CF073BF9 41C32E30 78EFBDB9 FEA8D7D1 5C205F0F F68822B6

5FED0266 1060C191 1427F936 DD2076EC 389828DF 819BB112 FF2F4814 3D208BDF

A38EABA2 87CA8C8E 4000A356 413FCE86 0D7415F9

quit

license udi pid ISR4321/K9 sn FLM2408005M

no license smart enable

diagnostic bootup level minimal

spanning-tree extend system-id

redundancy

mode none

interface Loopback0

ip address 192.168.6.1 255.255.255.0

ipv6 address 2001:DB8:6::1/64

ipv6 eigrp 10

interface GigabitEthernet0/0/0

ip address 10.1.1.25 255.255.255.252

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:7::1/64

ipv6 enable

ipv6 eigrp 10

interface GigabitEthernet0/0/1

ip address 10.1.1.22 255.255.255.252

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:6::2/64

ipv6 enable

ipv6 eigrp 10

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

router eigrp 10

network 10.1.1.20 0.0.0.3

network 10.1.1.24 0.0.0.3

eigrp router-id 6.6.6.6

ip forward-protocol nd

ip http server

ip http authentication local

ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router eigrp 10

eigrp router-id 6.6.6.6

control-plane

line con 0

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

End

Problems

While setting up BGP for Ipv4 went very smoothly, we ran into a lot of problems when configuring BGP for Ipv6. This was because we only configured BGP on the interfaces between routers 3 and 4. This was fixed by configuring OSPF on the g0/0/1 interface of router 3 and EIGRP on the interface g0/0/0 of router 4. Another problem that we had was we realized that BGP has Ipv4 unicast on by default which is another reason why Ipv6 routes weren’t being shared across BGP. This was fixed by using the command “no bgp default ipv4-unicast”. The problem that we had with EIGRP was the use of metrics which wasn’t something that was configured for OSPF. This was fixed by learning how metrics worked and configuring a metric for EIGRP routes.

Conclusion

In this lab, we connected an OSPF and EIGRP network together using BPG for both Ipv4 and Ipv6. Six routers were connected linearly and routers 1 through 3 were configured with OSPF while routers 4 through 6 were configured with EIGRP. BGP was configured on routers 3 and 4 to redistribute OSPF and EIGRP information to BGP and vice versa. The main problem we ran into in this lab was configuring BGP for Ipv6. The functionality of the network was confirmed at the end by checking the IP routes on each router as well as pinging across the network by connecting end devices on separate ends of the network.



**Implementing IBGP (7 routers)***Derek Liu*

Purpose

The purpose of this lab is to continue exploring the functions of BGP, specifically IBGP. IBGP will allow routes not only shared across networks but through networks as well. In this lab, we will be sharing routes between two different EIGRP networks through an OSPF network through IBGP.

Background Information

BGP or border gateway protocol is an inter-autonomous system routing protocol designed for TCP/IP. This protocol is extremely important as it is used extensively throughout the internet to link different networks together. However, when trying to route between the same autonomous system, it had to be a full mesh network in order for it to function. This created scalability problems which IBGP was able to solve.

IBGP as an extension of BGP allowed for routing information to be exchanged within the same autonomous system without the need of creating a full-mesh network. This process is called route-reflection and was designed with simplicity, an easy transition between full-mesh and IBGP, and compatibility in mind. In the context of this lab, there was only one new command that established and IBGP connection. IBGP functions by reflecting all routes from non-client IBGP peers to all client IBGP peers and reflecting all routes from client-IBGP peers to both non-client IBGP peers and client IBGP peers. In this lab, there were multiple routers with route-reflection. In this case, IBGP treats other route-reflector routers like another client IBGP peer. IBGP is configured with redundancy in mind so redundant routes can be configured without breaking the network. The main difference between IBGP and BGP is the use of cluster lists which differentiate between IBGP clients and non-IBGP clients and originator IDs which carry information about the BGP identifier and the originator of the route in the local autonomous system. The main problem with IBGP is the possibility of routing loops.

IBGP should only be used after careful consideration of a network as it will not work with IGP if configured incorrectly.

Lab Summary

In this lab we used seven Cisco 4321 routers connected in a linear fashion with copper straight-through cables. Interfaces g0/0/0 and g0/0/1 were used on the routers. The routers were accessed through a terminal emulator at a workstation with a console cord. The first two routers had interfaces configured with the EIGRP routing protocol to share routes throughout the network. The next three routers were configured with the OSPF routing protocol, and the remaining two configured with another EIGRP network. BGP was set up between the OSPF and EIGRP networks to allow routes to be shared between the different routing protocols. IBGP was configured by setting up internal neighbors in the OSPF network. This allowed for the EIGRP networks on either ends of the OSPF networks to also share routes. Both IPv4 and IPv6 routes were configured in this lab. Connection was tested by examining the routing table on each router and by sending pings across the network.

Lab Commands

New commands: neighbor 10.1.1.18 next-hop-self **the neighbor in both IPv6 and IPv4 will be the interface facing inside the network at the edge of the internal network.**

Network Diagrams with IP

A diagram of a computer network

Description automatically generated with low confidence

Configurations

***Pings (ipv4):***

From PC1

C:\Users\user>ping 10.1.1.1

Pinging 10.1.1.1 with 32 bytes of data:

Reply from 10.1.1.1: bytes=32 time<1ms TTL=128

Reply from 10.1.1.1: bytes=32 time<1ms TTL=128

Reply from 10.1.1.1: bytes=32 time<1ms TTL=128

Reply from 10.1.1.1: bytes=32 time<1ms TTL=128

Ping statistics for 10.1.1.1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.2

Pinging 10.1.1.2 with 32 bytes of data:

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Reply from 10.1.1.2: bytes=32 time<1ms TTL=255

Ping statistics for 10.1.1.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.6

Pinging 10.1.1.6 with 32 bytes of data:

Reply from 10.1.1.6: bytes=32 time<1ms TTL=254

Reply from 10.1.1.6: bytes=32 time<1ms TTL=254

Reply from 10.1.1.6: bytes=32 time<1ms TTL=254

Reply from 10.1.1.6: bytes=32 time<1ms TTL=254

Ping statistics for 10.1.1.6:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.5

Pinging 10.1.1.5 with 32 bytes of data:

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Reply from 10.1.1.5: bytes=32 time<1ms TTL=255

Ping statistics for 10.1.1.5:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.9

Pinging 10.1.1.9 with 32 bytes of data:

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Reply from 10.1.1.9: bytes=32 time<1ms TTL=254

Ping statistics for 10.1.1.9:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.10

Pinging 10.1.1.10 with 32 bytes of data:

Reply from 10.1.1.10: bytes=32 time<1ms TTL=253

Reply from 10.1.1.10: bytes=32 time<1ms TTL=253

Reply from 10.1.1.10: bytes=32 time<1ms TTL=253

Reply from 10.1.1.10: bytes=32 time<1ms TTL=253

Ping statistics for 10.1.1.10:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.13

Pinging 10.1.1.13 with 32 bytes of data:

Reply from 10.1.1.13: bytes=32 time=1ms TTL=253

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Reply from 10.1.1.13: bytes=32 time<1ms TTL=253

Ping statistics for 10.1.1.13:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.14

Pinging 10.1.1.14 with 32 bytes of data:

Reply from 10.1.1.14: bytes=32 time=1ms TTL=252

Reply from 10.1.1.14: bytes=32 time<1ms TTL=252

Reply from 10.1.1.14: bytes=32 time<1ms TTL=252

Reply from 10.1.1.14: bytes=32 time<1ms TTL=252

Ping statistics for 10.1.1.14:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.17

Pinging 10.1.1.17 with 32 bytes of data:

Reply from 10.1.1.17: bytes=32 time=1ms TTL=252

Reply from 10.1.1.17: bytes=32 time<1ms TTL=252

Reply from 10.1.1.17: bytes=32 time<1ms TTL=252

Reply from 10.1.1.17: bytes=32 time<1ms TTL=252

Ping statistics for 10.1.1.17:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.18

Pinging 10.1.1.18 with 32 bytes of data:

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Reply from 10.1.1.18: bytes=32 time<1ms TTL=251

Reply from 10.1.1.18: bytes=32 time=1ms TTL=251

Ping statistics for 10.1.1.18:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.21

Pinging 10.1.1.21 with 32 bytes of data:

Reply from 10.1.1.21: bytes=32 time=1ms TTL=251

Reply from 10.1.1.21: bytes=32 time=1ms TTL=251

Reply from 10.1.1.21: bytes=32 time=1ms TTL=251

Reply from 10.1.1.21: bytes=32 time=1ms TTL=251

Ping statistics for 10.1.1.21:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 10.1.1.22

Pinging 10.1.1.22 with 32 bytes of data:

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Reply from 10.1.1.22: bytes=32 time=1ms TTL=250

Ping statistics for 10.1.1.22:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 10.1.1.25

Pinging 10.1.1.25 with 32 bytes of data:

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Reply from 10.1.1.25: bytes=32 time=1ms TTL=250

Ping statistics for 10.1.1.25:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 10.1.1.26

Pinging 10.1.1.26 with 32 bytes of data:

Reply from 10.1.1.26: bytes=32 time=1ms TTL=249

Reply from 10.1.1.26: bytes=32 time<1ms TTL=249

Reply from 10.1.1.26: bytes=32 time<1ms TTL=249

Reply from 10.1.1.26: bytes=32 time<1ms TTL=249

Ping statistics for 10.1.1.26:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.29

Pinging 10.1.1.29 with 32 bytes of data:

Reply from 10.1.1.29: bytes=32 time=1ms TTL=249

Reply from 10.1.1.29: bytes=32 time<1ms TTL=249

Reply from 10.1.1.29: bytes=32 time<1ms TTL=249

Reply from 10.1.1.29: bytes=32 time<1ms TTL=249

Ping statistics for 10.1.1.29:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.30

Pinging 10.1.1.30 with 32 bytes of data:

Reply from 10.1.1.30: bytes=32 time=1ms TTL=121

Reply from 10.1.1.30: bytes=32 time=1ms TTL=121

Reply from 10.1.1.30: bytes=32 time=1ms TTL=121

Reply from 10.1.1.30: bytes=32 time=1ms TTL=121

Ping statistics for 10.1.1.30:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

***Pings (ipv6):***

From PC1

C:\Users\user>ping 2001:db8:acad:1::1

Pinging 2001:db8:acad:1::1 with 32 bytes of data:

Reply from 2001:db8:acad:1::1: time<1ms

Reply from 2001:db8:acad:1::1: time<1ms

Reply from 2001:db8:acad:1::1: time<1ms

Reply from 2001:db8:acad:1::1: time<1ms

Ping statistics for 2001:db8:acad:1::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:1::2

Pinging 2001:db8:acad:1::2 with 32 bytes of data:

Reply from 2001:db8:acad:1::2: time<1ms

Reply from 2001:db8:acad:1::2: time<1ms

Reply from 2001:db8:acad:1::2: time<1ms

Reply from 2001:db8:acad:1::2: time<1ms

Ping statistics for 2001:db8:acad:1::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:2::1

Pinging 2001:db8:acad:2::1 with 32 bytes of data:

Reply from 2001:db8:acad:2::1: time<1ms

Reply from 2001:db8:acad:2::1: time<1ms

Reply from 2001:db8:acad:2::1: time<1ms

Reply from 2001:db8:acad:2::1: time<1ms

Ping statistics for 2001:db8:acad:2::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:2::2

Pinging 2001:db8:acad:2::2 with 32 bytes of data:

Reply from 2001:db8:acad:2::2: time<1ms

Reply from 2001:db8:acad:2::2: time<1ms

Reply from 2001:db8:acad:2::2: time<1ms

Reply from 2001:db8:acad:2::2: time<1ms

Ping statistics for 2001:db8:acad:2::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:3::1

Pinging 2001:db8:acad:3::1 with 32 bytes of data:

Reply from 2001:db8:acad:3::1: time<1ms

Reply from 2001:db8:acad:3::1: time=1ms

Reply from 2001:db8:acad:3::1: time<1ms

Reply from 2001:db8:acad:3::1: time<1ms

Ping statistics for 2001:db8:acad:3::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:3::2

Pinging 2001:db8:acad:3::2 with 32 bytes of data:

Reply from 2001:db8:acad:3::2: time<1ms

Reply from 2001:db8:acad:3::2: time<1ms

Reply from 2001:db8:acad:3::2: time<1ms

Reply from 2001:db8:acad:3::2: time<1ms

Ping statistics for 2001:db8:acad:3::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:4::1

Pinging 2001:db8:acad:4::1 with 32 bytes of data:

Reply from 2001:db8:acad:4::1: time<1ms

Reply from 2001:db8:acad:4::1: time<1ms

Reply from 2001:db8:acad:4::1: time<1ms

Reply from 2001:db8:acad:4::1: time<1ms

Ping statistics for 2001:db8:acad:4::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:4::2

Pinging 2001:db8:acad:4::2 with 32 bytes of data:

Reply from 2001:db8:acad:4::2: time=1ms

Reply from 2001:db8:acad:4::2: time=1ms

Reply from 2001:db8:acad:4::2: time=1ms

Reply from 2001:db8:acad:4::2: time=1ms

Ping statistics for 2001:db8:acad:4::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:5::1

Pinging 2001:db8:acad:5::1 with 32 bytes of data:

Reply from 2001:db8:acad:5::1: time=1ms

Reply from 2001:db8:acad:5::1: time<1ms

Reply from 2001:db8:acad:5::1: time=1ms

Reply from 2001:db8:acad:5::1: time<1ms

Ping statistics for 2001:db8:acad:5::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 2001:db8:acad:5::2

Pinging 2001:db8:acad:5::2 with 32 bytes of data:

Reply from 2001:db8:acad:5::2: time=1ms

Reply from 2001:db8:acad:5::2: time=1ms

Reply from 2001:db8:acad:5::2: time=1ms

Reply from 2001:db8:acad:5::2: time=1ms

Ping statistics for 2001:db8:acad:5::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:6::1

Pinging 2001:db8:acad:6::1 with 32 bytes of data:

Reply from 2001:db8:acad:6::1: time=1ms

Reply from 2001:db8:acad:6::1: time=1ms

Reply from 2001:db8:acad:6::1: time=1ms

Reply from 2001:db8:acad:6::1: time=1ms

Ping statistics for 2001:db8:acad:6::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:6::2

Pinging 2001:db8:acad:6::2 with 32 bytes of data:

Reply from 2001:db8:acad:6::2: time=1ms

Reply from 2001:db8:acad:6::2: time=1ms

Reply from 2001:db8:acad:6::2: time=1ms

Reply from 2001:db8:acad:6::2: time=1ms

Ping statistics for 2001:db8:acad:6::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:7::1

Pinging 2001:db8:acad:7::1 with 32 bytes of data:

Reply from 2001:db8:acad:7::1: time=1ms

Reply from 2001:db8:acad:7::1: time=1ms

Reply from 2001:db8:acad:7::1: time=1ms

Reply from 2001:db8:acad:7::1: time=1ms

Ping statistics for 2001:db8:acad:7::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:7::2

Pinging 2001:db8:acad:7::2 with 32 bytes of data:

Reply from 2001:db8:acad:7::2: time=1ms

Reply from 2001:db8:acad:7::2: time=1ms

Reply from 2001:db8:acad:7::2: time=1ms

Reply from 2001:db8:acad:7::2: time=1ms

Ping statistics for 2001:db8:acad:7::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:8::1

Pinging 2001:db8:acad:8::1 with 32 bytes of data:

Reply from 2001:db8:acad:8::1: time=1ms

Reply from 2001:db8:acad:8::1: time=1ms

Reply from 2001:db8:acad:8::1: time=1ms

Reply from 2001:db8:acad:8::1: time=1ms

Ping statistics for 2001:db8:acad:8::1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

C:\Users\user>ping 2001:db8:acad:8::2

Pinging 2001:db8:acad:8::2 with 32 bytes of data:

Reply from 2001:db8:acad:8::2: time=5ms

Reply from 2001:db8:acad:8::2: time=1ms

Reply from 2001:db8:acad:8::2: time=1ms

Reply from 2001:db8:acad:8::2: time=1ms

Ping statistics for 2001:db8:acad:8::2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 5ms, Average = 2ms

***Ip routes:***

IPV4 Routes:

-----------

R1:

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

C 10.1.1.0/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.2/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.5/32 is directly connected, GigabitEthernet0/0/0

D 10.1.1.8/30 [90/3072] via 10.1.1.6, 00:53:46, GigabitEthernet0/0/0

D EX 10.1.1.12/30

[170/281856] via 10.1.1.6, 00:52:26, GigabitEthernet0/0/0

D EX 10.1.1.16/30

[170/281856] via 10.1.1.6, 00:51:53, GigabitEthernet0/0/0

D EX 10.1.1.20/30

[170/281856] via 10.1.1.6, 00:50:52, GigabitEthernet0/0/0

D EX 10.1.1.24/30

[170/281856] via 10.1.1.6, 00:25:28, GigabitEthernet0/0/0

D EX 10.1.1.28/30

[170/281856] via 10.1.1.6, 00:25:28, GigabitEthernet0/0/0

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback0

L 192.168.1.1/32 is directly connected, Loopback0

D 192.168.2.0/24 [90/130816] via 10.1.1.6, 00:54:42, GigabitEthernet0/0/0

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

D EX 192.168.3.0/24

[170/281856] via 10.1.1.6, 00:52:26, GigabitEthernet0/0/0

D EX 192.168.3.1/32

[170/281856] via 10.1.1.6, 00:50:21, GigabitEthernet0/0/0

D EX 192.168.4.0/24 [170/281856] via 10.1.1.6, 00:51:23, GigabitEthernet0/0/0

192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks

D EX 192.168.5.0/24

[170/281856] via 10.1.1.6, 00:50:21, GigabitEthernet0/0/0

D EX 192.168.5.1/32

[170/281856] via 10.1.1.6, 00:50:52, GigabitEthernet0/0/0

D EX 192.168.6.0/24 [170/281856] via 10.1.1.6, 00:25:28, GigabitEthernet0/0/0

D EX 192.168.7.0/24 [170/281856] via 10.1.1.6, 00:13:51, GigabitEthernet0/0/0

R2:

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

D 10.1.1.0/30 [90/3072] via 10.1.1.5, 00:53:49, GigabitEthernet0/0/1

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.6/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.8/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.9/32 is directly connected, GigabitEthernet0/0/0

B 10.1.1.12/30 [20/0] via 10.1.1.10, 00:51:36

B 10.1.1.16/30 [20/2] via 10.1.1.10, 00:51:03

B 10.1.1.20/30 [20/3] via 10.1.1.10, 00:50:02

B 10.1.1.24/30 [20/0] via 10.1.1.10, 00:24:38

B 10.1.1.28/30 [20/0] via 10.1.1.10, 00:24:38

D 192.168.1.0/24 [90/130816] via 10.1.1.5, 00:53:49, GigabitEthernet0/0/1

192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.2.0/24 is directly connected, Loopback0

L 192.168.2.1/32 is directly connected, Loopback0

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

B 192.168.3.0/24 [20/0] via 10.1.1.10, 00:51:36

B 192.168.3.1/32 [20/0] via 10.1.1.10, 00:49:31

B 192.168.4.0/24 [20/0] via 10.1.1.10, 00:50:33

192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks

B 192.168.5.0/24 [20/0] via 10.1.1.10, 00:49:31

B 192.168.5.1/32 [20/3] via 10.1.1.10, 00:50:02

B 192.168.6.0/24 [20/0] via 10.1.1.10, 00:24:38

B 192.168.7.0/24 [20/0] via 10.1.1.10, 00:13:01

R3:

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

B 10.1.1.0/30 [20/3072] via 10.1.1.9, 00:50:55

B 10.1.1.4/30 [20/0] via 10.1.1.9, 00:50:55

C 10.1.1.8/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.10/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.12/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.13/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.16/30 [110/2] via 10.1.1.14, 00:49:38, GigabitEthernet0/0/0

O 10.1.1.20/30 [110/3] via 10.1.1.14, 00:24:02, GigabitEthernet0/0/0

O E2 10.1.1.24/30 [110/1] via 10.1.1.14, 00:24:00, GigabitEthernet0/0/0

O E2 10.1.1.28/30 [110/1] via 10.1.1.14, 00:24:00, GigabitEthernet0/0/0

B 192.168.1.0/24 [20/130816] via 10.1.1.9, 00:50:55

B 192.168.2.0/24 [20/0] via 10.1.1.9, 00:50:55

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.3.0/24 is directly connected, Loopback0

L 192.168.3.1/32 is directly connected, Loopback0

O E2 192.168.4.0/24 [110/1] via 10.1.1.14, 00:50:41, GigabitEthernet0/0/0

192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks

B 192.168.5.0/24 [200/0] via 10.1.1.18, 00:49:13

O 192.168.5.1/32 [110/3] via 10.1.1.14, 00:49:38, GigabitEthernet0/0/0

O E2 192.168.6.0/24 [110/1] via 10.1.1.14, 00:24:00, GigabitEthernet0/0/0

O E2 192.168.7.0/24 [110/1] via 10.1.1.14, 00:12:20, GigabitEthernet0/0/0

R4:

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

O E2 10.1.1.0/30 [110/1] via 10.1.1.13, 00:46:57, GigabitEthernet0/0/1

O E2 10.1.1.4/30 [110/1] via 10.1.1.13, 00:46:57, GigabitEthernet0/0/1

O 10.1.1.8/30 [110/2] via 10.1.1.13, 00:46:57, GigabitEthernet0/0/1

C 10.1.1.12/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.14/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.16/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.17/32 is directly connected, GigabitEthernet0/0/0

O 10.1.1.20/30 [110/2] via 10.1.1.18, 00:20:18, GigabitEthernet0/0/0

O E2 10.1.1.24/30 [110/1] via 10.1.1.18, 00:20:16, GigabitEthernet0/0/0

O E2 10.1.1.28/30 [110/1] via 10.1.1.18, 00:20:16, GigabitEthernet0/0/0

O E2 192.168.1.0/24 [110/1] via 10.1.1.13, 00:46:57, GigabitEthernet0/0/1

O E2 192.168.2.0/24 [110/1] via 10.1.1.13, 00:46:57, GigabitEthernet0/0/1

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

B 192.168.3.0/24 [200/0] via 10.1.1.13, 00:46:34

O 192.168.3.1/32 [110/2] via 10.1.1.13, 00:46:57, GigabitEthernet0/0/1

192.168.4.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.4.0/24 is directly connected, Loopback0

L 192.168.4.1/32 is directly connected, Loopback0

192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks

B 192.168.5.0/24 [200/0] via 10.1.1.18, 00:45:29

O 192.168.5.1/32 [110/2] via 10.1.1.18, 00:45:54, GigabitEthernet0/0/0

O E2 192.168.6.0/24 [110/1] via 10.1.1.18, 00:20:16, GigabitEthernet0/0/0

O E2 192.168.7.0/24 [110/1] via 10.1.1.18, 00:08:35, GigabitEthernet0/0/0

R5:

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

O E2 10.1.1.0/30 [110/1] via 10.1.1.17, 00:45:18, GigabitEthernet0/0/1

O E2 10.1.1.4/30 [110/1] via 10.1.1.17, 00:45:18, GigabitEthernet0/0/1

O 10.1.1.8/30 [110/3] via 10.1.1.17, 00:45:18, GigabitEthernet0/0/1

O 10.1.1.12/30 [110/2] via 10.1.1.17, 00:45:18, GigabitEthernet0/0/1

C 10.1.1.16/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.18/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.20/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.21/32 is directly connected, GigabitEthernet0/0/0

B 10.1.1.24/30 [20/0] via 10.1.1.22, 00:19:36

B 10.1.1.28/30 [20/3072] via 10.1.1.22, 00:19:36

O E2 192.168.1.0/24 [110/1] via 10.1.1.17, 00:45:18, GigabitEthernet0/0/1

O E2 192.168.2.0/24 [110/1] via 10.1.1.17, 00:45:18, GigabitEthernet0/0/1

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

B 192.168.3.0/24 [200/0] via 10.1.1.13, 00:44:49

O 192.168.3.1/32 [110/3] via 10.1.1.17, 00:45:18, GigabitEthernet0/0/1

O E2 192.168.4.0/24 [110/1] via 10.1.1.17, 00:45:18, GigabitEthernet0/0/1

192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.5.0/24 is directly connected, Loopback0

L 192.168.5.1/32 is directly connected, Loopback0

B 192.168.6.0/24 [20/0] via 10.1.1.22, 00:19:36

B 192.168.7.0/24 [20/130816] via 10.1.1.22, 00:07:55

R6:

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

B 10.1.1.0/30 [20/0] via 10.1.1.21, 00:18:53

B 10.1.1.4/30 [20/0] via 10.1.1.21, 00:18:53

B 10.1.1.8/30 [20/3] via 10.1.1.21, 00:18:53

B 10.1.1.12/30 [20/2] via 10.1.1.21, 00:18:53

B 10.1.1.16/30 [20/0] via 10.1.1.21, 00:18:53

C 10.1.1.20/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.22/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.24/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.25/32 is directly connected, GigabitEthernet0/0/0

D 10.1.1.28/30 [90/3072] via 10.1.1.26, 00:18:54, GigabitEthernet0/0/0

B 192.168.1.0/24 [20/0] via 10.1.1.21, 00:18:53

B 192.168.2.0/24 [20/0] via 10.1.1.21, 00:18:53

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

B 192.168.3.0/24 [20/0] via 10.1.1.21, 00:18:53

B 192.168.3.1/32 [20/3] via 10.1.1.21, 00:18:53

B 192.168.4.0/24 [20/0] via 10.1.1.21, 00:18:53

192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks

B 192.168.5.0/24 [20/0] via 10.1.1.21, 00:18:53

B 192.168.5.1/32 [20/0] via 10.1.1.21, 00:18:53

192.168.6.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.6.0/24 is directly connected, Loopback0

L 192.168.6.1/32 is directly connected, Loopback0

D 192.168.7.0/24 [90/130816] via 10.1.1.26, 00:07:12, GigabitEthernet0/0/0

R7:

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

D EX 10.1.1.0/30

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

D EX 10.1.1.4/30

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

D EX 10.1.1.8/30

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

D EX 10.1.1.12/30

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

D EX 10.1.1.16/30

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

D 10.1.1.20/30 [90/3072] via 10.1.1.25, 00:15:53, GigabitEthernet0/0/1

C 10.1.1.24/30 is directly connected, GigabitEthernet0/0/1

L 10.1.1.26/32 is directly connected, GigabitEthernet0/0/1

C 10.1.1.28/30 is directly connected, GigabitEthernet0/0/0

L 10.1.1.29/32 is directly connected, GigabitEthernet0/0/0

D EX 192.168.1.0/24

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

D EX 192.168.2.0/24

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

D EX 192.168.3.0/24

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

D EX 192.168.3.1/32

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

D EX 192.168.4.0/24

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks

D EX 192.168.5.0/24

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

D EX 192.168.5.1/32

[170/281856] via 10.1.1.25, 00:15:49, GigabitEthernet0/0/1

D 192.168.6.0/24 [90/130816] via 10.1.1.25, 00:15:53, GigabitEthernet0/0/1

192.168.7.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.7.0/24 is directly connected, Loopback0

L 192.168.7.1/32 is directly connected, Loopback0

IPV6 Routes:

-----------

R1:

C 2001:DB8:1::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:1::1/128 [0/0]

via Loopback0, receive

D 2001:DB8:2::/64 [90/130816]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:3::/64 [170/281856]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:3::1/128 [170/281856]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:4::1/128 [170/281856]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:5::/64 [170/281856]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:5::1/128 [170/281856]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:6::/64 [170/281856]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:7::/64 [170/281856]

via FE80::2, GigabitEthernet0/0/0

C 2001:DB8:ACAD:1::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:1::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:2::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:2::1/128 [0/0]

via GigabitEthernet0/0/0, receive

D 2001:DB8:ACAD:3::/64 [90/3072]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:ACAD:4::/64 [170/281856]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:ACAD:5::/64 [170/281856]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:ACAD:6::/64 [170/281856]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:ACAD:7::/64 [170/281856]

via FE80::2, GigabitEthernet0/0/0

EX 2001:DB8:ACAD:8::/64 [170/281856]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R2:

D 2001:DB8:1::/64 [90/130816]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:2::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:2::1/128 [0/0]

via Loopback0, receive

B 2001:DB8:3::/64 [20/0]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:3::1/128 [20/0]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:4::1/128 [20/1]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:5::/64 [20/0]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:5::1/128 [20/2]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:6::/64 [20/0]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:7::/64 [20/0]

via FE80::2, GigabitEthernet0/0/0

D 2001:DB8:ACAD:1::/64 [90/3072]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:2::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:2::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:3::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:3::1/128 [0/0]

via GigabitEthernet0/0/0, receive

B 2001:DB8:ACAD:4::/64 [20/0]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:ACAD:5::/64 [20/2]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:ACAD:6::/64 [20/3]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:ACAD:7::/64 [20/0]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:ACAD:8::/64 [20/0]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R3:

B 2001:DB8:1::/64 [20/130816]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:2::/64 [20/0]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:3::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:3::1/128 [0/0]

via Loopback0, receive

O 2001:DB8:4::1/128 [110/1]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:5::/64 [200/0]

via 2001:DB8:ACAD:5::2

O 2001:DB8:5::1/128 [110/2]

via FE80::2, GigabitEthernet0/0/0

OE2 2001:DB8:6::/64 [110/10000]

via FE80::2, GigabitEthernet0/0/0

OE2 2001:DB8:7::/64 [110/10000]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:ACAD:1::/64 [20/3072]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:ACAD:2::/64 [20/0]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:3::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:3::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:4::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:4::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:5::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

O 2001:DB8:ACAD:6::/64 [110/3]

via FE80::2, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:7::/64 [110/10000]

via FE80::2, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:8::/64 [110/10000]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R4:

OE2 2001:DB8:1::/64 [110/10000]

via FE80::1, GigabitEthernet0/0/1

OE2 2001:DB8:2::/64 [110/10000]

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:3::1/128 [110/1]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:4::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:4::1/128 [0/0]

via Loopback0, receive

O 2001:DB8:5::1/128 [110/1]

via FE80::2, GigabitEthernet0/0/0

OE2 2001:DB8:6::/64 [110/10000]

via FE80::2, GigabitEthernet0/0/0

OE2 2001:DB8:7::/64 [110/10000]

via FE80::2, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:1::/64 [110/10000]

via FE80::1, GigabitEthernet0/0/1

OE2 2001:DB8:ACAD:2::/64 [110/10000]

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:ACAD:3::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:4::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:4::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:5::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:5::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:6::/64 [110/2]

via FE80::2, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:7::/64 [110/10000]

via FE80::2, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:8::/64 [110/10000]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R5

OE2 2001:DB8:1::/64 [110/10000]

via FE80::1, GigabitEthernet0/0/1

OE2 2001:DB8:2::/64 [110/10000]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:3::/64 [200/0]

via 2001:DB8:ACAD:4::1

O 2001:DB8:3::1/128 [110/2]

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:4::1/128 [110/1]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:5::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:5::1/128 [0/0]

via Loopback0, receive

B 2001:DB8:6::/64 [20/0]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:7::/64 [20/130816]

via FE80::2, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:1::/64 [110/10000]

via FE80::1, GigabitEthernet0/0/1

OE2 2001:DB8:ACAD:2::/64 [110/10000]

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:ACAD:3::/64 [110/3]

via FE80::1, GigabitEthernet0/0/1

O 2001:DB8:ACAD:4::/64 [110/2]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:5::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:5::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:6::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:6::1/128 [0/0]

via GigabitEthernet0/0/0, receive

B 2001:DB8:ACAD:7::/64 [20/0]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:ACAD:8::/64 [20/3072]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R6:

B 2001:DB8:1::/64 [20/0]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:2::/64 [20/0]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:3::/64 [20/0]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:3::1/128 [20/2]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:4::1/128 [20/1]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:5::/64 [20/0]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:5::1/128 [20/0]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:6::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:6::1/128 [0/0]

via Loopback0, receive

D 2001:DB8:7::/64 [90/130816]

via FE80::2, GigabitEthernet0/0/0

B 2001:DB8:ACAD:1::/64 [20/0]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:ACAD:2::/64 [20/0]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:ACAD:3::/64 [20/3]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:ACAD:4::/64 [20/2]

via FE80::1, GigabitEthernet0/0/1

B 2001:DB8:ACAD:5::/64 [20/0]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:6::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:6::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:7::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:7::1/128 [0/0]

via GigabitEthernet0/0/0, receive

D 2001:DB8:ACAD:8::/64 [90/3072]

via FE80::2, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

R7:

EX 2001:DB8:1::/64 [170/281856]

via FE80::1, GigabitEthernet0/0/1

EX 2001:DB8:2::/64 [170/281856]

via FE80::1, GigabitEthernet0/0/1

EX 2001:DB8:3::/64 [170/281856]

via FE80::1, GigabitEthernet0/0/1

EX 2001:DB8:3::1/128 [170/281856]

via FE80::1, GigabitEthernet0/0/1

EX 2001:DB8:4::1/128 [170/281856]

via FE80::1, GigabitEthernet0/0/1

EX 2001:DB8:5::/64 [170/281856]

via FE80::1, GigabitEthernet0/0/1

EX 2001:DB8:5::1/128 [170/281856]

via FE80::1, GigabitEthernet0/0/1

D 2001:DB8:6::/64 [90/130816]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:7::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:7::1/128 [0/0]

via Loopback0, receive

EX 2001:DB8:ACAD:1::/64 [170/281856]

via FE80::1, GigabitEthernet0/0/1

EX 2001:DB8:ACAD:2::/64 [170/281856]

via FE80::1, GigabitEthernet0/0/1

EX 2001:DB8:ACAD:3::/64 [170/281856]

via FE80::1, GigabitEthernet0/0/1

EX 2001:DB8:ACAD:4::/64 [170/281856]

via FE80::1, GigabitEthernet0/0/1

EX 2001:DB8:ACAD:5::/64 [170/281856]

via FE80::1, GigabitEthernet0/0/1

D 2001:DB8:ACAD:6::/64 [90/3072]

via FE80::1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:7::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:7::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:8::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:8::1/128 [0/0]

via GigabitEthernet0/0/0, receive

L FF00::/8 [0/0]

via Null0, receive

***Router 1 Config:***

hostname r1

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

login on-success log

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

crypto pki trustpoint TP-self-signed-4144679456

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-4144679456

revocation-check none

rsakeypair TP-self-signed-4144679456

crypto pki certificate chain TP-self-signed-4144679456

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

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

69666963 6174652D 34313434 36373934 3536301E 170D3232 31303034 31373138

31365A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D34 31343436

37393435 36308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 010087CC 266FCB7F CBF7B4EE 138D3485 B2401F70 519C8EDA B5D1E5EC

D3C8D992 21065BCF 869991E0 795A9990 E7E8D247 1D55DCF8 EF12BE1F F6C8CB1E

17C6FEEE 8E10B242 D2C0E98D 679DC16A 9D5D11C6 9617EA8C 2845DC66 21251470

59442738 719AB69D C0F3311E DF116EB7 C6C223E4 A6C06D3D A822AAB8 91369FC1

679B9582 E8BFC5EE 070945EC 4E6E2D5C C4820706 F40E5C42 A0F02B86 7A471330

516082A5 91C02659 F5591812 1B85EDEF 58693D0E 3D1334D8 AA3010BA 12CBB929

E1D7B9B3 2FD29D3E 15A7F473 42A17035 05FE7F9E CA973314 389BADD9 04910E99

EE3904C5 4B5D4BE0 47D895EE 91B0A71A 77181933 A2F0AECB 740E5100 3414F677

5D86C36F 5C7B0203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 14BEAF09 270773AD 4353C83A 6020F1BC 0A05B90D

5E301D06 03551D0E 04160414 BEAF0927 0773AD43 53C83A60 20F1BC0A 05B90D5E

300D0609 2A864886 F70D0101 05050003 82010100 8142B8C1 5EA90A17 2A9D2B3E

C44BA6C1 F460EB6E 1F465E6E 8F0A8EEB 3DB59EDC 80AEDC55 4C38F05A 6CA34F3B

E9CB5D16 B072846A F56E988F 7535D239 77595A89 C828E3AF AA8BF4E2 A796B46F

9819500F 69A36EC0 579C9FB1 971AB1AA 090EF2A7 B9ECA02B E1E64147 03ADAB1A

256F3FD4 E9D768D7 0FED6A34 4825B486 F874025A 3952BA2D FC251D67 216E38CB

B45C6CCD 7B15BB04 6656DA4E 381FE2F5 1F5467E5 172B3945 D3F40EC0 9F2623AB

BD73FFAC EC51537D CF073BF9 41C32E30 78EFBDB9 FEA8D7D1 5C205F0F F68822B6

5FED0266 1060C191 1427F936 DD2076EC 389828DF 819BB112 FF2F4814 3D208BDF

A38EABA2 87CA8C8E 4000A356 413FCE86 0D7415F9

quit

license udi pid ISR4321/K9 sn FDO214421CF

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.1.1 255.255.255.0

ipv6 address 2001:DB8:1::1/64

ipv6 eigrp 10

interface GigabitEthernet0/0/0

ip address 10.1.1.5 255.255.255.252

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:2::1/64

ipv6 enable

ipv6 eigrp 10

interface GigabitEthernet0/0/1

ip address 10.1.1.2 255.255.255.252

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:1::2/64

ipv6 enable

ipv6 eigrp 10

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router eigrp 10

network 10.1.1.0 0.0.0.3

network 10.1.1.4 0.0.0.3

network 192.168.1.0

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router eigrp 10

eigrp router-id 1.1.1.1

redistribute bgp 100 metric 10000 100 255 1 1500

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

***Router 2 Config:***

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO211216BL

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.2.1 255.255.255.0

ipv6 address 2001:DB8:2::1/64

ipv6 eigrp 10

interface GigabitEthernet0/0/0

ip address 10.1.1.9 255.255.255.252

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:3::1/64

ipv6 enable

ipv6 eigrp 10

interface GigabitEthernet0/0/1

ip address 10.1.1.6 255.255.255.252

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:2::2/64

ipv6 enable

ipv6 eigrp 10

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router eigrp 10

network 10.1.1.4 0.0.0.3

network 10.1.1.8 0.0.0.3

network 192.168.2.0

redistribute bgp 100 metric 10000 100 255 1 1500

eigrp router-id 2.2.2.2

router bgp 100

bgp router-id 2.2.2.2

bgp log-neighbor-changes

no bgp default ipv4-unicast

neighbor 10.1.1.10 remote-as 200

neighbor 2001:DB8:ACAD:3::2 remote-as 200

address-family ipv4

network 10.1.1.8

redistribute eigrp 10

neighbor 10.1.1.10 activate

exit-address-family

address-family ipv6

redistribute eigrp 10

network 2001:DB8:2::/64

network 2001:DB8:ACAD:2::/64

network 2001:DB8:ACAD:3::/64

neighbor 2001:DB8:ACAD:3::2 activate

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router eigrp 10

eigrp router-id 2.2.2.2

redistribute bgp 100 metric 10000 100 255 1 1500

control-plane

line con 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

***Router 3 Config:***

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

ipv6 unicast-routing

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420G7

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface Loopback0

ip address 192.168.3.1 255.255.255.0

ipv6 address 2001:DB8:3::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 10.1.1.13 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:4::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

ip address 10.1.1.10 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:3::2/64

ipv6 ospf 10 area 0

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

router-id 3.3.3.3

redistribute bgp 200 subnets

network 10.1.1.8 0.0.0.3 area 0

network 10.1.1.12 0.0.0.3 area 0

network 192.168.3.0 0.0.0.255 area 0

router bgp 200

bgp router-id 3.3.3.3

bgp log-neighbor-changes

no bgp default ipv4-unicast

neighbor 10.1.1.9 remote-as 100

neighbor 10.1.1.14 remote-as 200

neighbor 10.1.1.18 remote-as 200

neighbor 2001:DB8:ACAD:3::1 remote-as 100

neighbor 2001:DB8:ACAD:4::2 remote-as 200

neighbor 2001:DB8:ACAD:5::2 remote-as 200

address-family ipv4

network 10.1.1.8

network 10.1.1.12

network 192.168.3.0

redistribute ospf 10

neighbor 10.1.1.9 activate

neighbor 10.1.1.14 activate

neighbor 10.1.1.18 activate

neighbor 10.1.1.18 next-hop-self

exit-address-family

address-family ipv6

redistribute ospf 10

network 2001:DB8:3::/64

network 2001:DB8:ACAD:3::/64

network 2001:DB8:ACAD:4::/64

neighbor 2001:DB8:ACAD:3::1 activate

neighbor 2001:DB8:ACAD:4::2 activate

neighbor 2001:DB8:ACAD:5::2 activate

neighbor 2001:DB8:ACAD:5::2 next-hop-self

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 3.3.3.3

redistribute bgp 200 metric 10000

control-plane

line con 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

***Router 4 Config:***

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

ipv6 unicast-routing

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21442B21

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface Loopback0

ip address 192.168.4.1 255.255.255.0

ipv6 address 2001:DB8:4::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 10.1.1.17 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:5::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

ip address 10.1.1.14 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:4::2/64

ipv6 ospf 10 area 0

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

router-id 4.4.4.4

redistribute bgp 200 subnets

network 10.1.1.12 0.0.0.3 area 0

network 10.1.1.16 0.0.0.3 area 0

network 192.167.4.0 0.0.0.255 area 0

router bgp 200

bgp router-id 4.4.4.4

bgp log-neighbor-changes

no bgp default ipv4-unicast

neighbor 10.1.1.13 remote-as 200

neighbor 10.1.1.18 remote-as 200

address-family ipv4

network 10.1.1.12

network 10.1.1.16

network 192.168.4.0

redistribute ospf 10

neighbor 10.1.1.13 activate

neighbor 10.1.1.18 activate

exit-address-family

address-family ipv6

redistribute ospf 10

network 2001:DB8:4::/64

network 2001:DB8:ACAD:4::/64

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 4.4.4.4

redistribute bgp 200

control-plane

line con 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

***Router 5 Config:***

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

login on-success log

subscriber templating

ipv6 unicast-routing

multilink bundle-name authenticated

crypto pki trustpoint TP-self-signed-2270144787

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-2270144787

revocation-check none

rsakeypair TP-self-signed-2270144787

crypto pki certificate chain TP-self-signed-2270144787

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

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

69666963 6174652D 32323730 31343437 3837301E 170D3232 31313130 31373536

33385A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 32373031

34343738 37308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 01009829 E8C41F14 3A435358 2EAF2403 F077FF8A 55B7704F D3FE6970

1A2B6DC2 6F7FD1EB 1272C2B9 23E4B566 A85523B2 123D3BB4 0B8A1F95 496513A8

1DC6DEFD 7FD5D901 BC33E489 93B284F3 A0FA6B17 42D9B937 4E03A89D E9F29F0B

FBBC8B8A FBC83A05 2230706C 215BC545 E0238D1C 6333B807 5ED988B5 EB74C37F

434B2C94 0080EB88 23CD5763 62EAC216 799BB46F 2DB3F2AE F587C111 355C50A8

42146174 4FF2ED16 C7B0ECF6 CB6744B1 C1E8040D 838F429E 99A118CD 45E37E38

9B73CF19 8CECA946 A16DFC4A 6AABBD10 AAC2E56D E47096E5 0DC8C6EC 87F29C17

F0259793 799AA50B 6819FC6E 4FD3D536 F843CFAA 1F820D6D B0BCEB90 25CC7BDD

875C97F9 AB850203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 14A39AAE 64FB66E8 F207BDF0 18E58A84 30ED1E30

ED301D06 03551D0E 04160414 A39AAE64 FB66E8F2 07BDF018 E58A8430 ED1E30ED

300D0609 2A864886 F70D0101 05050003 82010100 8501D8F3 B031975E 5BD18983

61010A83 18A7E5B0 5220D982 13D258B4 461EBE6B 2F456965 BA1979EB 4531EA38

2E7F4C2E 51C58E19 CD165867 F8D6B0A8 287A77DA CD188998 9835004A F6F1392D

9A08A9C2 5C1BB142 313B9F2C 58A9A412 C7677D19 14CC3ED2 281503A2 50BEC58A

771582A6 887B47A0 D2B24C62 12A3963C 98777629 DE74CAC3 6340F260 A9136452

387E5E05 230AA544 11BA09E4 6EDC7F18 56381F2A B1B3E7A6 5A3433DE 2FD3B402

8534FD8A 90092515 F02B7A6C A126CC56 0666CB71 031A89F9 2850658D 1EE7D845

B7BCD784 765602BF C62EDEA9 E9EBBEE0 AA2175E8 DF639665 6C778D5B 560CED32

C084F7C2 E9F95A58 4294991F 0CBFBCD4 25C7F8A5

quit

license udi pid ISR4321/K9 sn FLM24060912

no license smart enable

diagnostic bootup level minimal

spanning-tree extend system-id

redundancy

mode none

interface Loopback0

ip address 192.168.5.1 255.255.255.0

ipv6 address 2001:DB8:5::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 10.1.1.21 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:6::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

ip address 10.1.1.18 255.255.255.252

ip ospf 10 area 0

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:5::2/64

ipv6 ospf 10 area 0

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

router ospf 10

router-id 5.5.5.5

redistribute bgp 200 subnets

network 10.1.1.16 0.0.0.3 area 0

network 10.1.1.20 0.0.0.3 area 0

network 192.168.5.0 0.0.0.255 area 0

router bgp 200

bgp router-id 5.5.5.5

bgp log-neighbor-changes

no bgp default ipv4-unicast

neighbor 10.1.1.13 remote-as 200

neighbor 10.1.1.17 remote-as 200

neighbor 10.1.1.22 remote-as 300

neighbor 2001:DB8:ACAD:4::1 remote-as 200

neighbor 2001:DB8:ACAD:5::1 remote-as 200

neighbor 2001:DB8:ACAD:6::2 remote-as 300

address-family ipv4

network 10.1.1.20

network 192.168.5.0

redistribute ospf 10

neighbor 10.1.1.13 activate

neighbor 10.1.1.13 next-hop-self

neighbor 10.1.1.17 activate

neighbor 10.1.1.22 activate

exit-address-family

address-family ipv6

redistribute ospf 10

network 2001:DB8:5::/64

network 2001:DB8:ACAD:5::/64

network 2001:DB8:ACAD:6::/64

network 2001:DB8:ACAD:7::/64

neighbor 2001:DB8:ACAD:4::1 activate

neighbor 2001:DB8:ACAD:4::1 next-hop-self

neighbor 2001:DB8:ACAD:5::1 activate

neighbor 2001:DB8:ACAD:6::2 activate

exit-address-family

ip forward-protocol nd

ip http server

ip http authentication local

ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

router-id 5.5.5.5

redistribute bgp 200 metric 10000

control-plane

line con 0

logging synchronous

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

***Router 6 Config:***

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

login on-success log

subscriber templating

ipv6 unicast-routing

multilink bundle-name authenticated

crypto pki trustpoint TP-self-signed-4144679456

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-4144679456

revocation-check none

rsakeypair TP-self-signed-4144679456

crypto pki certificate chain TP-self-signed-4144679456

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

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

69666963 6174652D 34313434 36373934 3536301E 170D3232 31313130 31383032

30325A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D34 31343436

37393435 36308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 0100A832 52F38549 AF78B1EA 14008DFF FD2B06BD 20E6DC0C BC69D311

CC0C194A D93F5091 96DCCFD8 CA5CAB4D 8A4989E6 704EE787 E83C861D D3DB3730

559CF5F6 BCBACB2D D6E517B2 6A3A184E 3855F2D6 414C4DE0 5BCFE617 F919C9A6

7CD084F4 063CB550 C8ED1C13 2BD463EA B7DFCE95 4FA8F535 E6A66174 1B5B1613

5CFA7CED BF096D9A 86413C66 D9CEDA10 7D555EDD 65295778 23CE80BC D744C731

F4243908 A3571967 878C3DB2 3AAB6022 80C22135 5C69CE0D 0A4BD734 A24B706C

DA3CF0BB 173152FD 414F3607 828E784E E4065B8A CE5A6339 DDF8A286 960EFB80

9777DBB6 A777E03E FBB6E87E 3EE4B847 D5E60D3E AB9C65EB 9C81A1EA BB728B89

8CE838B5 E5C10203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 14A22D2F 62ABEE6C DA395BD3 9E6403AD 3DD8FE07

A0301D06 03551D0E 04160414 A22D2F62 ABEE6CDA 395BD39E 6403AD3D D8FE07A0

300D0609 2A864886 F70D0101 05050003 82010100 79E72647 85466836 51558896

3420C465 9D9D2857 42A72769 64D93E17 2E94E6ED 189C8E94 38D12550 64330C8D

006CB795 2BA9CABE 81CCCCC2 EEC09611 279B1447 3FEC547E 9118AFE3 327BB074

6414C44F 8BA5B3D5 4D9CF15A 193A6BCA CD228016 EE57B5CB FE15C7F4 A5EC6C55

728C8B43 217210CC 0FE58CDA 535A2006 B635EE97 E3E885BF 3CEF158A C358E6A4

A807A1FA A426F07A 8CF82F1D A52DCAE2 55B48744 BDDE2940 01ED1FFC 3CD0E1D2

6EC18C45 2927CADD 5967C7A8 EBA9FEF7 94C0D6E3 3C09014D 9E84560E 46659300

414A6A7A 83CBC86D 7ACEBCC9 85287BF9 FB4DD5C3 9FAC3B9F 9734277C E2DCB9D8

09E60172 78C26404 F2263B5D 3A4D3F81 10CE8C65

quit

license udi pid ISR4321/K9 sn FLM2408005M

no license smart enable

diagnostic bootup level minimal

spanning-tree extend system-id

redundancy

mode none

interface Loopback0

ip address 192.168.6.1 255.255.255.0

ipv6 address 2001:DB8:6::1/64

ipv6 enable

ipv6 eigrp 20

interface GigabitEthernet0/0/0

ip address 10.1.1.25 255.255.255.252

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:7::1/64

ipv6 enable

ipv6 eigrp 20

interface GigabitEthernet0/0/1

ip address 10.1.1.22 255.255.255.252

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:6::2/64

ipv6 enable

ipv6 eigrp 20

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

router eigrp 20

network 10.1.1.20 0.0.0.3

network 10.1.1.24 0.0.0.3

network 10.1.1.28 0.0.0.3

network 192.168.6.0

redistribute bgp 300 metric 10000 100 255 1 1500

eigrp router-id 6.6.6.6

router bgp 300

bgp router-id 6.6.6.6

bgp log-neighbor-changes

no bgp default ipv4-unicast

neighbor 10.1.1.21 remote-as 200

neighbor 2001:DB8:ACAD:6::1 remote-as 200

address-family ipv4

network 10.1.1.20

redistribute eigrp 20

neighbor 10.1.1.21 activate

exit-address-family

address-family ipv6

redistribute eigrp 20

network 2001:DB8:6::/64

network 2001:DB8:ACAD:6::/64

network 2001:DB8:ACAD:7::/64

neighbor 2001:DB8:ACAD:6::1 activate

exit-address-family

ip forward-protocol nd

no ip http server

ip http authentication local

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router eigrp 20

eigrp router-id 6.6.6.6

redistribute bgp 300 metric 10000 100 255 1 1500

control-plane

line con 0

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

***Router 7 Config:***

hostname r7

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

login on-success log

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

crypto pki trustpoint TP-self-signed-187689846

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-187689846

revocation-check none

rsakeypair TP-self-signed-187689846

crypto pki certificate chain TP-self-signed-187689846

certificate self-signed 01

3082032E 30820216 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

30312E30 2C060355 04031325 494F532D 53656C66 2D536967 6E65642D 43657274

69666963 6174652D 31383736 38393834 36301E17 0D323231 31303331 38303233

365A170D 33303031 30313030 30303030 5A303031 2E302C06 03550403 1325494F

532D5365 6C662D53 69676E65 642D4365 72746966 69636174 652D3138 37363839

38343630 82012230 0D06092A 864886F7 0D010101 05000382 010F0030 82010A02

82010100 BF6070C6 927A845F 5894218F 7CCB640D FA6B7780 F0005270 135E9D62

88939C7A B6579E7E 0BA8E197 5C639A72 44ACFF57 DE42AA8B 63FD62CC A1723ED1

518D9A8E 5CFA19A2 48E1BB86 7EA2F966 68F5021E FD2A9FFB 8DF3DC8E 04011B5A

A4DA788D A4A616CB DEF37103 6B0B9925 94E851D6 E5C220B0 EBFC20AE 9EEA2360

AAE9ABEE E558ADFB 829868A9 7C70E354 FB9DAEE5 BF2F942E BF6306A8 0E691189

B00FF095 60EB3671 09F9EE6E A1A1C394 F2D0188A 070C3D34 8C310598 5AB10508

2BCC6504 D97F10E4 5EF18340 34B0F75B 10CD02E1 851F9AB9 085C94E7 F09969F3

D66115A2 74612E4A 522010B5 CE41E9EF 1F268695 8AEF2B13 0C80995F F06C4717

BCC71E91 02030100 01A35330 51300F06 03551D13 0101FF04 05300301 01FF301F

0603551D 23041830 1680144F F7019371 95BDC04C FE229FE7 027E514B 04BE8830

1D060355 1D0E0416 04144FF7 01937195 BDC04CFE 229FE702 7E514B04 BE88300D

06092A86 4886F70D 01010505 00038201 010091FF BA855D0C 6D4BBCF3 B5786F90

6C2AF12B A9B8718F 92C61351 78123DD8 D997CA01 27A9E8C9 BC099E99 0218E9C7

CF81E531 D0529D91 7992562D 4127F2CD AA10EF3B 4C04D6D7 8011656E 34869E34

A65972A4 6619D717 386ECD00 D2943A71 60F28C41 07F34E95 389F27EB DBDA9E49

D66CDC6C 3BEFEDD4 F7E8F9EB 987B2932 DC72AE1D BCEE0869 845D1FB3 71008F6E

8BCEB0B8 F6361836 723C92F7 1F96E26F 979FB2B6 66863DD2 54C16BC7 FEEEE2E3

53A3E649 65DC9703 2AF2694B 57DC506F 723C6A30 2511D827 C2AF458C 14666E90

78A2CB78 D3494080 2D41245C CC58B9DD 5634C67F 067C4557 2F8EA3F7 E0F5A52B

89226F82 E70195A9 8D64910C 5D13DBD1 7387

quit

license udi pid ISR4321/K9 sn FDO214421BU

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.7.1 255.255.255.0

ipv6 address 2001:DB8:7::1/64

ipv6 enable

ipv6 eigrp 20

interface GigabitEthernet0/0/0

ip address 10.1.1.29 255.255.255.252

negotiation auto

ipv6 address FE80::1 link-local

ipv6 address 2001:DB8:ACAD:8::1/64

ipv6 enable

ipv6 eigrp 20

interface GigabitEthernet0/0/1

ip address 10.1.1.26 255.255.255.252

negotiation auto

ipv6 address FE80::2 link-local

ipv6 address 2001:DB8:ACAD:7::2/64

ipv6 enable

ipv6 eigrp 20

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface Service-Engine0/2/0

no ip address

shutdown

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router eigrp 20

network 10.1.1.20 0.0.0.3

network 10.1.1.24 0.0.0.3

network 10.1.1.28 0.0.0.3

network 192.168.7.0

eigrp router-id 7.7.7.7

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router eigrp 20

eigrp router-id 7.7.7.7

redistribute bgp 300 metric 10000 100 255 1 1500

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

Problems

When setting up OSPF and EIGRP for IPv4 and IPv6, no problems arose. When setting up BGP connections between the OSPF and EIGRP for IPv6, EIGRP routes were not being redistributed into BGP. This was caused by two different IPv6 address being put on the interface that linked EIGRP to BGP. After removing the incorrect address, BPG worked throughout the network. After a lot of trial and error and research of implementing IBGP (e.g. trying to set neighbors as router-IDs), we were able to successfully configure IBGP connections with IPv4. The reason why IPv6 wasn’t working was due to missing IPv6 network statements in the BGP configurations. After the networks statements were added, IBGP was functional.

Conclusion

In this lab, we IBGP to allow connections between two different EIGRP networks through an OSPF network. Seven Cisco 4321 routers were connected in a linear fashion and the routers were configured using the PuTTy terminal emulator. The main problem that we ran into while completing this lab was the obscurity of the usage of IBGP so there were few resources to work with when gathering information on how the protocol works and how it should be configured. In the end, we succeeded in distributing IPv4 and IPv6 routes throughout the network through the usage of OSPF, EIGRP, BGP, and IBGP.



**VoIP and FXO Configuration with CME**

*Derek Liu*

Purpose

Other than data, networks also can also route voice. This is possible through voice over IP or VoIP. Voice samples can be transmitted over the internet rather than standard copper phone lines. However, rather than just configuring VoIP, we also explored possible ways for VoIP phones to access analog lines and make calls through there.

Background Information

Voice over IP or VoIP is a technology that allows phone calls to be made over the internet. VoIP converts voice into digital signals and sends them over the internet. These signals are then interpreted and converted back to voice. This is a very call-effective method of calling as it doesn’t require the setup of copper phone lines since the internet is used as the medium for transferring the data. While we were only using VoIP in a LAN environment, calls can be made across a WAN through h.323 standards. H.323 defines the signaling and control messages and is commonly used in conjunction with SIP or SCCP and MGCP.

In this lab, we used SCCP as seen through the firmware being pushed to the phones through TFTP (firmware starts with P00). SCCP stands for skinny call control protocol and is Cisco proprietary. It is used for signaling and control of voice and video calls between Cisco IP phones. IT is often used in conjunction with with RTP and RTCP to transmit both audio and voice over IP networks. SCCP can be used with either CUCM or CUCME. The main difference between SIP and SCCP is that SCCP is Cisco proprietary.

In this lab, VoIP was made possible through Cisco unified communication manager express or CUCME. The CUCME is a software-based IP private branch exchange (PBX) system that runs on Cisco routers. This is convenient for small to medium sized businesses as they won’t need to have a dedicated server in order to run CUCM.

The phones in this lab didn’t need to be configured beyond just plugging it into a PoE switch. This is due to TFTP which allows for configuration files to be sent through UDP to the phones. TFTP is often used in network environments where it is necessary to transfer files to or from devices that do not have the resources or capabilities to support more complex file transfer protocols. It is also commonly used to transfer configuration files and software images to and from Cisco devices.

VoIP was originally developed around 1995 by a company called VocalTec. This voice technology is relatively new and is slowly being incorporated into our networks as an alternative to traditional phone services. Currently, it is being used in a lot of popular services such as Skype, WhatsApp, Google Hangouts, and Discord.

Lab Summary

In this lab, we established a LAN connection between two Cisco VoIP phones, meaning they were able to call each other with VoIP. One of the 7940 model and the other of the 7960 model. This was done by using Cisco unified communication manager express or CUCME/CME. One Cisco 2811 router with FXO voice cards was used to run CME and transfer calls from VoIP to analog. A PoE switch was used to provide power to the VoIP phones and create routes to the internet. Two computers were connected to the phones and configured with DHCP and were able to access the internet. This lab was considered successful when the computers were able to access the internet, the Cisco phones were able to contact each other through VoIP, and the Cisco phone was able to make a call to a cell phone. This last requirement was tested by making a call to a local pizza delivery place and ordering a pizza.

Lab Commands

**(Bolded comments are not part of the commands used and are just comments)**

**Switch Commands**

vlan 20

name VOICE **name vlan. We have a vlan 10 for data but realized it wasn’t necessary.**

interface FastEthernet0/1

switchport trunk encapsulation dot1q **trunk connection for router on a stick**

switchport trunk native vlan 50 **assigns native vlan as 50**

switchport mode trunk

interface FastEthernet0/2

switchport mode access

switchport voice vlan 20 **assign voice vlan**

spanning-tree portfast **not necessary for this lab**

**Router Commands**

ip dhcp excluded-address 192.168.20.1 192.168.20.5 **excludes dhcp addresses that can be assigned**

ip dhcp pool VOICE20 **name dhcp pool**

network 192.168.20.0 255.255.255.0

default-router 192.168.20.1

option 150 ip 192.168.20.1 **Cisco proprietary command for Cisco IP Phones**

interface FastEthernet0/0

ip address dhcp **interface requests dhcp address**

interface FastEthernet0/0.20 **activates sub interface**

encapsulation dot1Q 20

ip address 192.168.20.1 255.255.255.0

tftp-server P00308000500.sbn **sends files that the Cisco phones require**

tftp-server P00308000500.loads

tftp-server flash:P00308000500.bin alias P00308000500

tftp-server flash:P00308000500.sb2

voice-port 1/0/0 **the port number for our FXO port**

ring number 3 **number of rings before FXO port answers call**

connection plar opx 1010

caller-id enable **transfers the caller’s telephone number to the called**

dial-peer voice 83 pots **creates a dial-peer. The number doesn’t matter**

destination-pattern 91[2-9]..[2-9]...... **destination pattern to forward calls. 9 to call out. 1 for US country code. [2-9] to prevent accidental dialing of 911. Dots represent digits of the 10 digit phone number.**

port 1/0/0 **fxo port number**

forward-digits all **forwards digits to the called**

telephony-service **enables telephony service**

max-ephones 2 **max of 2 ephones in our network**

max-dn 2 **max of 2 directory numbers in our network**

ip source-address 192.167.20.1 port 2000 **source address for SCCP messages**

auto assign 1 to 2 **automatically assign dn numbers to the two phones**

system message ad astra per aspera

ephone-dn 1

number 1010 **assign a number to ephone**

ephone 1

mac-address 001D.A219.FA62 **configure mac-address for ephone**

type 7940 **model of the phone**

button 1:2

Network Diagram

Diagram

Description automatically generated

Process

Start by creating a network like the one shown in the Network Diagram section. In this case we used a Cisco 2811 Router to run CUCME and PoE switch in order to provide power to the IP phones.

The computers behind the IP phones should be able to receive an IP address at this point when set as a DHCP client. First, ensure that the router has CUCME in its flash. This can be confirmed with a show flash: command. In our case, we didn’t have CME files in our router. After establishing a connection between the computer, installing a TFTP server, we copied a CME tar file into the router with the command copy tftp://10.0.0.2/ flash: (file-name). The tar file was then extracted with archive tar /extract (file name) flash: and CME files could be found the flash.

Something that could not be accurately modeled in the Network Diagram section was the FXO port connection. The in the 2811 router, there were FXO port voice interface cards. These were connected with an RJ11 jack to an analog line.

Configurations

***Router Configuration:***

hostname Router

boot-start-marker

boot-end-marker

logging message-counter syslog

no aaa new-model

memory-size iomem 10

no network-clock-participate slot 1

dot11 syslog

ip source-route

no ip cef

ip dhcp excluded-address 192.168.20.1 192.168.20.5

ip dhcp pool VOICE20

network 192.168.20.0 255.255.255.0

default-router 192.168.20.1

option 150 ip 192.168.20.1

no ipv6 cef

multilink bundle-name authenticated

voice-card 0

no dspfarm

voice-card 1

no dspfarm

vtp domain cisco

vtp mode transparent

archive

log config

hidekeys

vlan 20

interface FastEthernet0/0

ip address dhcp

duplex auto

speed auto

no shutdown

interface FastEthernet0/0.20

encapsulation dot1Q 20

ip address 192.168.20.1 255.255.255.0

interface FastEthernet0/0.50

encapsulation dot1Q 50 native

interface FastEthernet0/1

no ip address

shutdown

duplex auto

speed auto

interface FastEthernet0/0/0

interface FastEthernet0/0/1

interface FastEthernet0/0/2

interface FastEthernet0/0/3

interface Serial0/1/0

no ip address

shutdown

interface Serial0/2/0

no ip address

shutdown

clock rate 2000000

interface Serial0/2/1

no ip address

shutdown

clock rate 2000000

interface Serial0/3/0

no ip address

shutdown

clock rate 2000000

interface Serial0/3/1

no ip address

shutdown

clock rate 2000000

interface Vlan1

no ip address

shutdown

ip forward-protocol nd

no ip http server

no ip http secure-server

ip flow-export version 9

tftp-server P00308000500.sbn

tftp-server P00308000500.loads

tftp-server flash:P00308000500.bin alias P00308000500

tftp-server flash:P00308000500.sb2

control-plane

voice-port 1/0/0

ring number 3

connection plar opx 1010

caller-id enable

voice-port 1/0/1

voice-port 1/0/2

voice-port 1/0/3

voice-port 1/1/0

voice-port 1/1/1

dial-peer voice 82 pots

destination-pattern 9[2-9]..[2-9]......

port 1/0/0

forward-digits 10

dial-peer voice 83 pots

destination-pattern 91[2-9]..[2-9]......

port 1/0/0

forward-digits all

dial-peer voice 81 pots

destination-pattern 9[469]11

port 1/0/0

forward-digits 3

telephony-service

max-ephones 2

max-dn 2

ip source-address 192.167.20.1 port 2000

auto assign 1 to 2

system message ad astra per aspera

max-conferences 8 gain -6

transfer-system full-consult

create cnf-files version-stamp Jan 01 2002 00:00:00

ephone-dn 1

number 1010

ephone-dn 2

number 1020

ephone 1

device-security-mode none

mac-address 001D.A219.FA62

type 7940

button 1:2

ephone 2

device-security-mode none

mac-address 0015.2B47.6685

type 7960

button 1:1

line con 0

line aux 0

line vty 0 4

login

scheduler allocate 20000 1000

end

***Switch Configuration:***

hostname Switch

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

vtp domain CCNP

vtp mode transparent

authentication mac-move permit

ip subnet-zero

spanning-tree mode pvst

spanning-tree etherchannel guard misconfig

spanning-tree extend system-id

vlan internal allocation policy ascending

vlan 10

name DATA

vlan 20

name VOICE

vlan 50

name NATIVE

vlan 99

name MANAGEMENT

interface FastEthernet0/1

switchport trunk encapsulation dot1q

switchport trunk native vlan 50

switchport mode trunk

interface FastEthernet0/2

switchport mode access

switchport voice vlan 20

spanning-tree portfast

interface FastEthernet0/3

switchport mode access

switchport voice vlan 20

spanning-tree portfast

interface FastEthernet0/4

interface FastEthernet0/5

interface FastEthernet0/6

interface FastEthernet0/7

interface FastEthernet0/8

interface FastEthernet0/9

interface FastEthernet0/10

interface FastEthernet0/11

interface FastEthernet0/12

interface FastEthernet0/13

interface FastEthernet0/14

interface FastEthernet0/15

interface FastEthernet0/16

interface FastEthernet0/17

interface FastEthernet0/18

interface FastEthernet0/19

interface FastEthernet0/20

interface FastEthernet0/21

interface FastEthernet0/22

interface FastEthernet0/23

interface FastEthernet0/24

interface GigabitEthernet0/1

interface GigabitEthernet0/2

interface Vlan1

no ip address

shutdown

ip classless

ip http server

ip sla enable reaction-alerts

line con 0

line vty 0 4

login

line vty 5 15

login

end

Problems

Going into the lab with more ideas of what we wanted rather than how to do it, we ran into a multitude of problems along the way. The first problem we ran into was we were unsure of where to start or what to configure. Our initial guess was to edit settings directly on the phones. This was proven to be ineffective as there was no way to save the changes made on the phones. We turned to configuring the router and the switches instead. The topology of the network was figured out through research online and finding information on how to establish a connection between the IP phones in a LAN with DHCP and router on a stick. The IP phones were able to receive a number and the computers were able to access the internet. While the phones were able to call each other, they displayed an error of “file not found.” After configuring the LAN, we believed that we were close to finishing the lab as the only thing left to configure was a connection to the analog line. However, that is where most of the problems arose.

We had a working analog line which we had tested with an analog phone. We also knew that there were voice ports – both FXS and FXO -- on the router which could be seen on running configuration. After identifying that we needed to connect the analog line to the FXO port, the original approach was the directly try to configure FXO voice port as if it were an ethernet port. This did not work.

After more research, it was realized that our flash didn’t contain appropriate files for CME even though telephony services were allowed to be set up on the router. We obtained a tar file containing the respective files and extracted them. The necessary files were then pushed to the phones through downloading a TFTP service on the computer.

After CME was successfully installed on the router, the phones were still unable to call through the analog line, each time displaying a message of “unknown call.” Due to the lack of guides on the specific goal we were pursuing, we spent a lot of time trying commands. Progress was made when configuring a dial-peer with a destination pattern of 9……….. and assigning it to the FXO voice port as it not longer showed an error of “unknown call.” We were then able to use a forward-digits 7 command and a call was established and connected but no voice could be heard (only beeps). Trying different numbers actually established calls with people who answered, however their number wasn’t the number we had typed into the phone and dialed (e.g. dial in number for pizza hut and we are connected with an art teacher). At this point we continued to work the with forward-digits command. The forward-digits all command was then configured, and it allowed a connection with the correct number.

Conclusion

While there were a lot of problems, we encountered in the lab especially when configuring a connection between VoIP and analog, we were successfully able to create a LAN VoIP connection, connect the computers to the internet, and make a call with a VoIP phone through an analog line. This was made possible through an FXO voice port and CUCME. We learned not only how to use a telephone, but also about the growing influence of VoIP and its usage in many of the voice services we engage with today.



**Implementing VRF (3 routers)***Derek Liu*

Purpose

While VRF isn’t a protocol that is used very often, it can be useful when separate routing tables need to be configured for a network. In this lab we explored the functions and applications of VRF.

Background Information

VRF or virtual routing and forwarding is used to create multiple routing tables within the same router. Traffic is encapsulated and sent across the network through sub-interfaces. VRF is not used very commonly but it can be used in the scenario where a service provider with multiple customers need to share the same network infrastructure. BRF can create and maintain separate routing domains so traffic. VRF segregates traffic and allows the network to remain flexible and scalable. VRF can also be used to provide VPN services with its ability to isolate traffic and routing tables.

Cisco offers an alternative to VRF called VRF Lite which is essentially VRF on a smaller scale. VRF Lite is used in networks where there is no MPLS or MPLS was not necessary. MPLS or multiprotocol label switching is important because it enables the creation of multiple independent routing domains. MPLS provides the necessary infrastructure to achieve this level of segregation and isolation. In MPLS networks, each router assigns labels to the network packets. The level is then used to identify the path the packet should take which means that the router doesn’t need to examine the packet header. This helps with reducing delays and inefficiencies.

VRF Lite is often used in small enterprise networks where it is necessary to isolate traffic for security, but MPLS may not be necessary.

In this lab we configured VRF rather than VRF Lite. The difference can be spotted in the syntax of the configuration where VRF uses the command “ip vrf {name}” while VRF Lite would use the configuration syntax of “vrf definition {name}.”

Lab Summary

In this lab, we connected three routers together and connected two end devices to both ends of the network. The end devices were connected with a layer two device (switch). We used OSPF as a routing protocol to automatically create routing tables. VRF was used to separate routing domains with sub-interfaces. Functionality of the network was tested with pinging across the network. Separation of traffic and routing domains was confirmed with pings as well. Pings were sent to a device that could normally be reached when VRF was configured but when removed from a specific VRF’s routing table, it could no longer be pinged.

Lab Commands

**Configuration for router 1: (bolded comments are not part of the commands used and are just comments)**

ip vrf OSPF10 **create new VRF instance and specifies name**

ip vrf OSPF20

interface GigabitEthernet0/0/0

no ip address **no IP address on interface**

negotiation auto

no shutdown

interface GigabitEthernet0/0/0.10

encapsulation dot1Q 10 **configure sub-interface**

ip vrf forwarding OSPF10 **associate interface with specified VRF**

ip address 10.1.1.1 255.255.255.252

interface GigabitEthernet0/0/0.20

encapsulation dot1Q 20

ip vrf forwarding OSPF20

ip address 10.1.1.1 255.255.255.252 **The IP address can be the same or overlap.**

interface GigabitEthernet0/0/1

no ip address

negotiation auto

no shutdown

interface GigabitEthernet0/0/1.10

encapsulation dot1Q 10

ip vrf forwarding OSPF10

ip address 10.0.0.2 255.255.255.252

interface GigabitEthernet0/0/1.20

encapsulation dot1Q 20

ip vrf forwarding OSPF20

ip address 10.0.0.6 255.255.255.252

router ospf 10 vrf OSPF10 **configure OSPF with process ID of 10 applied to OSPF10 VRF**

router-id 1.1.1.10

network 10.0.0.0 0.0.0.3 area 0

network 10.1.1.0 0.0.0.3 area 0

router ospf 20 vrf OSPF20

router-id 1.1.1.20

network 10.0.0.4 0.0.0.3 area 0

network 10.1.1.0 0.0.0.3 area 0

Network Diagrams with IP

Diagram

Description automatically generated

Configurations

***Pings:***

From PC0(1)

C:\Users\user>ping 10.0.0.2

Pinging 10.0.0.2 with 32 bytes of data:

Reply from 10.0.0.2: bytes=32 time<1ms TTL=255

Reply from 10.0.0.2: bytes=32 time<1ms TTL=255

Reply from 10.0.0.2: bytes=32 time<1ms TTL=255

Reply from 10.0.0.2: bytes=32 time<1ms TTL=255

Ping statistics for 10.0.0.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.1

Pinging 10.1.1.1 with 32 bytes of data:

Reply from 10.1.1.1: bytes=32 time<1ms TTL=255

Reply from 10.1.1.1: bytes=32 time<1ms TTL=255

Reply from 10.1.1.1: bytes=32 time<1ms TTL=255

Reply from 10.1.1.1: bytes=32 time<1ms TTL=255

Ping statistics for 10.1.1.1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.2

Pinging 10.1.1.2 with 32 bytes of data:

Reply from 10.1.1.2: bytes=32 time<1ms TTL=254

Reply from 10.1.1.2: bytes=32 time<1ms TTL=254

Reply from 10.1.1.2: bytes=32 time<1ms TTL=254

Reply from 10.1.1.2: bytes=32 time<1ms TTL=254

Ping statistics for 10.1.1.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.1.1.5

Pinging 10.1.1.5 with 32 bytes of data:

Reply from 10.1.1.5: bytes=32 time<1ms TTL=254

Reply from 10.1.1.5: bytes=32 time<1ms TTL=254

Reply from 10.1.1.5: bytes=32 time=1ms TTL=254

Reply from 10.1.1.5: bytes=32 time<1ms TTL=254

Ping statistics for 10.1.1.5:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.1.1.6

Pinging 10.1.1.6 with 32 bytes of data:

Reply from 10.1.1.6: bytes=32 time<1ms TTL=253

Reply from 10.1.1.6: bytes=32 time<1ms TTL=253

Reply from 10.1.1.6: bytes=32 time=1ms TTL=253

Reply from 10.1.1.6: bytes=32 time<1ms TTL=253

Ping statistics for 10.1.1.6:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.0.1.2

Pinging 10.0.1.2 with 32 bytes of data:

Reply from 10.0.1.2: bytes=32 time<1ms TTL=253

Reply from 10.0.1.2: bytes=32 time<1ms TTL=253

Reply from 10.0.1.2: bytes=32 time<1ms TTL=253

Reply from 10.0.1.2: bytes=32 time<1ms TTL=253

Ping statistics for 10.0.1.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.0.1.1

Pinging 10.0.1.1 with 32 bytes of data:

Reply from 10.0.1.1: bytes=32 time=1ms TTL=125

Reply from 10.0.1.1: bytes=32 time=1ms TTL=125

Reply from 10.0.1.1: bytes=32 time=1ms TTL=125

Reply from 10.0.1.1: bytes=32 time=1ms TTL=125

Ping statistics for 10.0.1.1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 1ms, Maximum = 1ms, Average = 1ms

***Ip routes:***

R1:

Routing Table: OSPF10

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

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

C 10.0.0.0/30 is directly connected, GigabitEthernet0/0/1.10

L 10.0.0.2/32 is directly connected, GigabitEthernet0/0/1.10

O 10.0.1.0/30 [110/3] via 10.1.1.2, 00:02:25, GigabitEthernet0/0/0.10

C 10.1.1.0/30 is directly connected, GigabitEthernet0/0/0.10

L 10.1.1.1/32 is directly connected, GigabitEthernet0/0/0.10

O 10.1.1.4/30 [110/2] via 10.1.1.2, 00:02:35, GigabitEthernet0/0/0.10

Routing Table: OSPF20

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

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

C 10.0.0.4/30 is directly connected, GigabitEthernet0/0/1.20

L 10.0.0.6/32 is directly connected, GigabitEthernet0/0/1.20

O 10.0.1.4/30 [110/3] via 10.1.1.2, 00:03:19, GigabitEthernet0/0/0.20

C 10.1.1.0/30 is directly connected, GigabitEthernet0/0/0.20

L 10.1.1.1/32 is directly connected, GigabitEthernet0/0/0.20

O 10.1.1.4/30 [110/2] via 10.1.1.2, 00:03:29, GigabitEthernet0/0/0.20

R2:

Routing Table: OSPF10

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

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

O 10.0.0.0/30 [110/2] via 10.1.1.1, 00:03:55, GigabitEthernet0/0/1.10

O 10.0.1.0/30 [110/2] via 10.1.1.6, 00:03:23, GigabitEthernet0/0/0.10

C 10.1.1.0/30 is directly connected, GigabitEthernet0/0/1.10

L 10.1.1.2/32 is directly connected, GigabitEthernet0/0/1.10

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/0.10

L 10.1.1.5/32 is directly connected, GigabitEthernet0/0/0.10

Routing Table: OSPF20

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

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

O 10.0.0.4/30 [110/2] via 10.1.1.1, 00:04:09, GigabitEthernet0/0/1.20

O 10.0.1.4/30 [110/2] via 10.1.1.6, 00:03:59, GigabitEthernet0/0/0.20

C 10.1.1.0/30 is directly connected, GigabitEthernet0/0/1.20

L 10.1.1.2/32 is directly connected, GigabitEthernet0/0/1.20

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/0.20

L 10.1.1.5/32 is directly connected, GigabitEthernet0/0/0.20

R3:

Routing Table: OSPF10

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

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

O 10.0.0.0/30 [110/3] via 10.1.1.5, 00:04:09, GigabitEthernet0/0/1.10

C 10.0.1.0/30 is directly connected, GigabitEthernet0/0/0.10

L 10.0.1.2/32 is directly connected, GigabitEthernet0/0/0.10

O 10.1.1.0/30 [110/2] via 10.1.1.5, 00:04:09, GigabitEthernet0/0/1.10

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/1.10

L 10.1.1.6/32 is directly connected, GigabitEthernet0/0/1.10

Routing Table: OSPF20

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

10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks

O 10.0.0.4/30 [110/3] via 10.1.1.5, 00:04:44, GigabitEthernet0/0/1.20

C 10.0.1.4/30 is directly connected, GigabitEthernet0/0/0.20

L 10.0.1.6/32 is directly connected, GigabitEthernet0/0/0.20

O 10.1.1.0/30 [110/2] via 10.1.1.5, 00:04:44, GigabitEthernet0/0/1.20

C 10.1.1.4/30 is directly connected, GigabitEthernet0/0/1.20

L 10.1.1.6/32 is directly connected, GigabitEthernet0/0/1.20

***Router 1 Config:***

hostname R1

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 vrf OSPF10

ip vrf OSPF20

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21491LXV

license accept end user agreement

license boot level securityk9

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

no ip address

negotiation auto

no shutdown

interface GigabitEthernet0/0/0.10

encapsulation dot1Q 10

ip vrf forwarding OSPF10

ip address 10.1.1.1 255.255.255.252

interface GigabitEthernet0/0/0.20

encapsulation dot1Q 20

ip vrf forwarding OSPF20

ip address 10.1.1.1 255.255.255.252

interface GigabitEthernet0/0/1

no ip address

negotiation auto

no shutdown

interface GigabitEthernet0/0/1.10

encapsulation dot1Q 10

ip vrf forwarding OSPF10

ip address 10.0.0.2 255.255.255.252

interface GigabitEthernet0/0/1.20

encapsulation dot1Q 20

ip vrf forwarding OSPF20

ip address 10.0.0.6 255.255.255.252

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 vrf OSPF10

router-id 1.1.1.10

network 10.0.0.0 0.0.0.3 area 0

network 10.1.1.0 0.0.0.3 area 0

router ospf 20 vrf OSPF20

router-id 1.1.1.20

network 10.0.0.4 0.0.0.3 area 0

network 10.1.1.0 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

***Router 2 Config:***

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 vrf OSPF10

ip vrf OSPF20

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420QQ

license accept end user agreement

license boot level securityk9

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

no ip address

negotiation auto

no shutdown

interface GigabitEthernet0/0/0.10

encapsulation dot1Q 10

ip vrf forwarding OSPF10

ip address 10.1.1.5 255.255.255.252

interface GigabitEthernet0/0/0.20

encapsulation dot1Q 20

ip vrf forwarding OSPF20

ip address 10.1.1.5 255.255.255.252

interface GigabitEthernet0/0/1

no ip address

negotiation auto

no shutdown

interface GigabitEthernet0/0/1.10

encapsulation dot1Q 10

ip vrf forwarding OSPF10

ip address 10.1.1.2 255.255.255.252

interface GigabitEthernet0/0/1.20

encapsulation dot1Q 20

ip vrf forwarding OSPF20

ip address 10.1.1.2 255.255.255.252

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 vrf OSPF10

router-id 2.2.2.10

network 10.1.1.0 0.0.0.3 area 0

network 10.1.1.4 0.0.0.3 area 0

router ospf 20 vrf OSPF20

router-id 2.2.2.20

network 10.1.1.0 0.0.0.3 area 0

network 10.1.1.4 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

***Router 3 Config:***

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

ip vrf OSPF10

ip vrf OSPF20

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420HY

license boot level securityk9

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

vlan 10,20

interface GigabitEthernet0/0/0

no ip address

negotiation auto

no shutdown

interface GigabitEthernet0/0/0.10

encapsulation dot1Q 10

ip vrf forwarding OSPF10

ip address 10.0.1.2 255.255.255.252

interface GigabitEthernet0/0/0.20

encapsulation dot1Q 20

ip vrf forwarding OSPF20

ip address 10.0.1.6 255.255.255.252

interface GigabitEthernet0/0/1

no ip address

negotiation auto

no shutdown

interface GigabitEthernet0/0/1.10

encapsulation dot1Q 10

ip vrf forwarding OSPF10

ip address 10.1.1.6 255.255.255.252

interface GigabitEthernet0/0/1.20

encapsulation dot1Q 20

ip vrf forwarding OSPF20

ip address 10.1.1.6 255.255.255.252

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router ospf 10 vrf OSPF10

router-id 3.3.3.10

network 10.0.1.0 0.0.0.3 area 0

network 10.1.1.4 0.0.0.3 area 0

router ospf 20 vrf OSPF20

router-id 3.3.3.20

network 10.0.1.4 0.0.0.3 area 0

network 10.1.1.4 0.0.0.3 area 0

ip forward-protocol nd

no ip http server

no ip http secure-server

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

***Switch 1 Config:***

hostname S1

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

vtp domain CCNP

vtp mode transparent

vlan internal allocation policy ascending

vlan 10,20,99,707

interface FastEthernet1/0/1

switchport access vlan 10

switchport mode access

interface FastEthernet1/0/2

switchport access vlan 20

switchport mode access

interface FastEthernet1/0/3

switchport trunk encapsulation dot1q

switchport mode trunk

interface FastEthernet1/0/4

interface FastEthernet1/0/5

interface FastEthernet1/0/6

interface FastEthernet1/0/7

interface FastEthernet1/0/8

interface FastEthernet1/0/9

interface FastEthernet1/0/10

interface FastEthernet1/0/11

interface FastEthernet1/0/12

interface FastEthernet1/0/13

interface FastEthernet1/0/14

interface FastEthernet1/0/15

interface FastEthernet1/0/16

interface FastEthernet1/0/17

interface FastEthernet1/0/18

interface FastEthernet1/0/19

interface FastEthernet1/0/20

interface FastEthernet1/0/21

interface FastEthernet1/0/22

interface FastEthernet1/0/23

interface FastEthernet1/0/24

interface GigabitEthernet1/0/1

interface GigabitEthernet1/0/2

interface GigabitEthernet1/1/1

speed auto 1000

interface GigabitEthernet1/1/2

speed auto 1000

interface Vlan1

no ip address

shutdown

interface Vlan20

ip address 10.0.0.5 255.255.255.252

ip http server

ip http secure-server

logging esm config

line con 0

logging synchronous

line vty 0 4

login

line vty 5 15

login

end

***Switch 2 Config:***

hostname S2

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

vtp domain CCNP

vtp mode transparent

spanning-tree mode pvst

spanning-tree extend system-id

vlan internal allocation policy ascending

interface FastEthernet1/0/1

switchport access vlan 20

switchport mode access

interface FastEthernet1/0/2

switchport access vlan 10

switchport mode access

interface FastEthernet1/0/3

switchport trunk encapsulation dot1q

switchport mode trunk

interface FastEthernet1/0/4

interface FastEthernet1/0/5

interface FastEthernet1/0/6

interface FastEthernet1/0/7

interface FastEthernet1/0/8

interface FastEthernet1/0/9

interface FastEthernet1/0/10

interface FastEthernet1/0/11

interface FastEthernet1/0/12

interface FastEthernet1/0/13

interface FastEthernet1/0/14

interface FastEthernet1/0/15

interface FastEthernet1/0/16

interface FastEthernet1/0/17

interface FastEthernet1/0/18

interface FastEthernet1/0/19

interface FastEthernet1/0/20

interface FastEthernet1/0/21

interface FastEthernet1/0/22

interface FastEthernet1/0/23

interface FastEthernet1/0/24

interface GigabitEthernet1/0/1

interface GigabitEthernet1/0/2

interface GigabitEthernet1/1/1

interface GigabitEthernet1/1/2

interface Vlan1

no ip address

interface Vlan20

ip address 10.0.1.5 255.255.255.252

ip http server

ip http secure-server

logging esm config

line con 0

line vty 0 4

login

line vty 5 15

login

end

Problems

There were minimal problems in this lab. The only slight setback we encountered was trying to configure the same IP address on the sub-interfaces. When trying to configure overlapping IP addresses with VRF, it is important to configure VRF first before setting an IP address. We originally tried to configure the IP address first which led to a lot of error messages.

Conclusion

The simple way to think of VRF is as a layer 3 version of VLANs. In this lab, we configured VRF on three Cisco routers. Traffic was isolated with sub-interfaces and encapsulation. Routing tables were established with OSPF and isolated with VRF. Connectivity was established with pings and the separation of routing tables was tested by pinging a device that was part of a different VRF and ensuring that the ping does not go through. The lab was very short and straightforward, so we didn’t run into many problems.



**Implementing GLBP (2 routers)***Derek Liu*

Purpose

This lab was done as a recognition of the importance of redundancy. Protocol such as GLBP are helpful in cases when a route goes down and another route is used it place of it while it is getting fixed.

Background Information

While we only configured routers, typically considered a layer 3 device, GLBP or gateway load balancing protocol is a layer 2 protocol. The protocol helps support redundancy in network and also allows for load balancing. Redundancy is especially important in networks because it provides backup systems and alternative paths for network packets to continue to traverse a network in the case any part of a complex network fails. This means that even if one part of the network fails, end users won’t be significantly affected and can continue to access the network.

Redundancy is achieved by having multiple routers share a single virtual IP address and network packets are distributed evenly among these routers (this can be confirmed with a traceroute). This virtual IP address is used as the default gateway for end devices. In the case of a route failing, the AVG or active virtual gateway continues to provide networking connectivity. If the AVG fails, the router with the second highest priority will be designated the AVG (default is 100 and must be manually changed). However, if multiple routers have the same priority, the router with the IP address of the greatest value will be designated the AVG.

GLBP can be used in conjunction with layer 3 routing protocols such as OSPF, BGP, and EIGRP to provide load balancing across networks.

Other redundancy protocols exist with different capabilities such as hot standby router protocol (HSRP), virtual router redundancy protocol (VRRP), multiple spanning tree protocol (MSTP), link aggregation control protocol (LACP), and equal cost multi-path routing protocol (ECMP).

Lab Summary

In this lab, we set up a small network consisting of two routers, two switches, and two end devices. The goal of the lab was to set up a topology that could support and run GLBP. GLBP functionality was confirmed by sending a continuous ping from pc0 to pc1 and then physically detaching one of the interface connected to the AVG. In the case that GLBP is functioning properly, the pings should request timeout and then reconnect shortly.

Lab Commands

**(bolded comments are not part of the commands used and are just comments)**

glbp 1 ip 10.0.0.254 **set ip address of virtual gateway.**

glbp 1 priority 120 **set priority of the route**

glbp 1 preempt **ensure most capable router is AVG.**

Network Diagrams with IP

Diagram

Description automatically generated

Configurations

***Pings (ipv4):***

C:\Users\user>ping 10.0.0.1

Pinging 10.0.0.1 with 32 bytes of data:

Reply from 10.0.0.1: bytes=32 time<1ms TTL=255

Reply from 10.0.0.1: bytes=32 time<1ms TTL=255

Reply from 10.0.0.1: bytes=32 time<1ms TTL=255

Reply from 10.0.0.1: bytes=32 time<1ms TTL=255

Ping statistics for 10.0.0.1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.0.0.2

Pinging 10.0.0.2 with 32 bytes of data:

Reply from 10.0.0.2: bytes=32 time<1ms TTL=255

Reply from 10.0.0.2: bytes=32 time<1ms TTL=255

Reply from 10.0.0.2: bytes=32 time<1ms TTL=255

Reply from 10.0.0.2: bytes=32 time<1ms TTL=255

Ping statistics for 10.0.0.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.0.0.254

Pinging 10.0.0.254 with 32 bytes of data:

Reply from 10.0.0.254: bytes=32 time<1ms TTL=255

Reply from 10.0.0.254: bytes=32 time<1ms TTL=255

Reply from 10.0.0.254: bytes=32 time<1ms TTL=255

Reply from 10.0.0.254: bytes=32 time<1ms TTL=255

Ping statistics for 10.0.0.254:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.0.1.254

Pinging 10.0.1.254 with 32 bytes of data:

Reply from 10.0.1.254: bytes=32 time<1ms TTL=255

Reply from 10.0.1.254: bytes=32 time<1ms TTL=255

Reply from 10.0.1.254: bytes=32 time<1ms TTL=255

Reply from 10.0.1.254: bytes=32 time=1ms TTL=255

Ping statistics for 10.0.1.254:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\user>ping 10.0.1.1

Pinging 10.0.1.1 with 32 bytes of data:

Reply from 10.0.1.1: bytes=32 time<1ms TTL=255

Reply from 10.0.1.1: bytes=32 time<1ms TTL=255

Reply from 10.0.1.1: bytes=32 time<1ms TTL=255

Reply from 10.0.1.1: bytes=32 time<1ms TTL=255

Ping statistics for 10.0.1.1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.0.1.2

Pinging 10.0.1.2 with 32 bytes of data:

Reply from 10.0.1.2: bytes=32 time<1ms TTL=255

Reply from 10.0.1.2: bytes=32 time<1ms TTL=255

Reply from 10.0.1.2: bytes=32 time<1ms TTL=255

Reply from 10.0.1.2: bytes=32 time<1ms TTL=255

Ping statistics for 10.0.1.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\user>ping 10.0.1.10

Pinging 10.0.1.10 with 32 bytes of data:

Reply from 10.0.1.10: bytes=32 time<1ms TTL=127

Reply from 10.0.1.10: bytes=32 time<1ms TTL=127

Reply from 10.0.1.10: bytes=32 time<1ms TTL=127

Reply from 10.0.1.10: bytes=32 time<1ms TTL=127

Ping statistics for 10.0.1.10:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

***Ip routes:***

GLBP Active:

R1#show glbp active

GigabitEthernet0/0/0 - Group 2

State is Active

1 state change, last state change 00:05:53

Virtual IP address is 10.0.1.254

Hello time 3 sec, hold time 10 sec

Next hello sent in 2.432 secs

Redirect time 600 sec, forwarder time-out 14400 sec

Preemption enabled, min delay 0 sec

Active is local

Standby is 10.0.1.2, priority 120 (expires in 8.000 sec)

Priority 150 (configured)

Weighting 100 (default 100), thresholds: lower 1, upper 100

Load balancing: round-robin

Group members:

00f8.2c7f.7190 (10.0.1.2)

b4a8.b947.8e40 (10.0.1.1) local

There are 2 forwarders (1 active)

Forwarder 1

State is Active

1 state change, last state change 00:05:41

MAC address is 0007.b400.0201 (default)

Owner ID is b4a8.b947.8e40

Redirection enabled

Preemption enabled, min delay 30 sec

Active is local, weighting 100

Arp replies sent: 5

Forwarder 2

State is Listen

MAC address is 0007.b400.0202 (learnt)

Owner ID is 00f8.2c7f.7190

Redirection enabled, 598.016 sec remaining (maximum 600 sec)

Time to live: 14398.016 sec (maximum 14400 sec)

Preemption enabled, min delay 30 sec

Active is 10.0.1.2 (primary), weighting 100 (expires in 9.056 sec)

Arp replies sent: 3

GLBP standby:

R1#show glbp standby

GigabitEthernet0/0/1 - Group 1

State is Standby

1 state change, last state change 00:10:42

Virtual IP address is 10.0.0.254

Hello time 3 sec, hold time 10 sec

Next hello sent in 0.864 secs

Redirect time 600 sec, forwarder time-out 14400 sec

Preemption enabled, min delay 0 sec

Active is 10.0.0.2, priority 120 (expires in 9.088 sec)

Standby is local

Priority 120 (configured)

Weighting 100 (default 100), thresholds: lower 1, upper 100

Load balancing: round-robin

Group members:

00f8.2c7f.7191 (10.0.0.2)

b4a8.b947.8e41 (10.0.0.1) local

There are 2 forwarders (1 active)

Forwarder 1

State is Listen

MAC address is 0007.b400.0101 (learnt)

Owner ID is 00f8.2c7f.7191

Time to live: 14397.728 sec (maximum 14400 sec)

Preemption enabled, min delay 30 sec

Active is 10.0.0.2 (primary), weighting 100 (expires in 9.696 sec)

Forwarder 2

State is Active

1 state change, last state change 00:10:45

MAC address is 0007.b400.0102 (default)

Owner ID is b4a8.b947.8e41

Preemption enabled, min delay 30 sec

Active is local, weighting 100

R1:

10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks

C 10.0.0.0/24 is directly connected, GigabitEthernet0/0/1

L 10.0.0.1/32 is directly connected, GigabitEthernet0/0/1

C 10.0.1.0/24 is directly connected, GigabitEthernet0/0/0

L 10.0.1.1/32 is directly connected, GigabitEthernet0/0/0

R2:

10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks

C 10.0.0.0/24 is directly connected, GigabitEthernet0/0/1

L 10.0.0.2/32 is directly connected, GigabitEthernet0/0/1

C 10.0.1.0/24 is directly connected, GigabitEthernet0/0/0

L 10.0.1.2/32 is directly connected, GigabitEthernet0/0/0

***Router 1 Config:***

hostname R1

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 FDO214421CF

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

ip address 10.0.1.1 255.255.255.0

negotiation auto

glbp 2 ip 10.0.1.254

glbp 2 priority 150

glbp 2 preempt

interface GigabitEthernet0/0/1

ip address 10.0.0.1 255.255.255.0

negotiation auto

glbp 1 ip 10.0.0.254

glbp 1 priority 120

glbp 1 preempt

interface Serial0/1/0

no ip address

!

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

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

***Router 2 Config:***

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

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO211216BL

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

ip address 10.0.1.2 255.255.255.0

negotiation auto

glbp 2 ip 10.0.1.254

glbp 2 priority 120

glbp 2 preempt

interface GigabitEthernet0/0/1

ip address 10.0.0.2 255.255.255.0

negotiation auto

glbp 1 ip 10.0.0.254

glbp 1 priority 120

glbp 1 preempt

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

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

Problems

No problems. Designed the topology, set it up on a rack, and got it working within 20 minutes.

Conclusion

While the lab was short and not very complex, the importance of redundancy, especially when working with network administration, is significant. This lab explores the usage of GLBP, but other redundancy protocol exists and can be implemented based on the context of the topology and network at hand. We didn’t run into any problems in setting up GLBP in this small network since the configurations were very straightforward. I do not believe this takes away from the lab since being able to establish redundancy shouldn’t be complex.



**Implementing MPLS***Derek Liu*

Purpose

The purpose of this lab was to set up an MPLS network and also explore the functions of layer 3 switches.

Background Information

MPLS or multiprotocol label switching was developed alongside multiple organizations including the Internet Engineering Task Force (IETF) and Cisco Systems in the late 1990s. MPLS was developed from the concepts of IP switching and label switching and popularized by Cisco.

MPLS is a protocol that is used to efficiently route packets throughout the network. This is done by using labels to identify paths rather than checking the destination IP address at each hop. These labels are chosen based on requirements of the network and specific forwarding needs. Labels can be assigned manually or with LDP or TDP. When a packet enters a MPLS network, the ingress router assigns a label to the packet. As the packet moves throughout the network, the label can swap or be pushed. When the packet reaches its destination or egress router, the MPLS label is popped from the header, and it continues on with an IP header. For this reason, MPLS is also called IP over IP tunneling.

MPLS can be used in contexts beyond just service provider networks. It can be seen used in VPNs as it isolates traffic through labels but also in enterprise networks, data centers, cloud networks, and SDN networks. MPLS can also be used as a tool to create better QoS.

Both LDP (label distribution protocol) and TDP (tag distribution protocol) are protocols that are used to assign labels to packets travelling through a MPLS network. However, there are differences in terms of their usage and implementation. LDP is more widely used and is an industry standard. It also uses a target session approach when assigning label. Meanwhile, TDP is legacy protocol and a Cisco protectory protocol. TDP also uses a multi-cast approach when assigning labels which means it consumes more network resources and is less secure. Another option is to manually assign labels. This offers more control over the network but also allows for more error, is very time consuming, and isn’t very scalable.

A newer evolution of MPLS is segment routing where the forwarding path is directly encoded into the header rather than relying on distributed protocols such as OSPF.

Lab Summary

In this lab, we set up OSPF on all network devices as the distribution protocol. We treated the three layer 3 switches as the MPLS cloud network and used the “mpls ip” command on its interfaces. Loopbacks were used to simulate end devices and other networks.

At this point, an MPLS network has been set up. However, this is a MPLS network set up with LDP enabled by default. We enabled TDP and learned that it doesn’t really make a significant impact on the small network and works the same as LDP in this context. Note that it is recommended to use LDP over TDP.

We also wanted explore the concept of manually assigning labels to packets. This was done by creating a static label range with the “mpls label range 200 8191 static 16 199” command which identified the range in which labels can be assigned to packets. This command removed all labels in the forwarding table previously defined by TDP and LDP. At this point, we were able to manually assign labels with the “mpls static binding ipv4 (ip address) (subnet) output (next hop) (lablel/implicit-null)” command. By using this command multiple times, we were able to manually create a MPLS forwarding table.

Network functionality was confirmed with pings and the existence of MPLS on the network was confirmed using the command “show mpls forwarding-table.”

Lab Commands

ip routing – *enables IP routing on a layer 3 switch*

no switchport – *to turn a layer interface on a switch to a layer 3 interface*

mpls ip – *enables MPLS*

show mpls forwarding-table – *displays MPLS forwarding table*

mpls label protocol tdp – *switches from LDP to TDP*

mpls label range 200 8191 static 16 199 – *configure static label range for MPLS*

mpls static binding ipv4 192.168.3.2 255.255.255.255 output 10.0.1.2 22 – *configure static MPLS binding for ipv4 traffic*

Network Diagrams with IP

![A picture containing text, diagram, screenshot, line

Description automatically generated]()

Configurations

***Pings***

R-1A#ping 192.168.2.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R-1A#ping 192.168.3.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R-1A#ping 10.0.2.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.2.2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R-1A#ping 10.0.2.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.2.1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/2 ms

R-1A#ping 10.0.0.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/3/6 ms

R-1A#ping 10.0.1.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.1.1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms

R-1A#ping 10.0.1.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.1.2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/3/7 ms

R-1A#ping 10.0.0.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.0.2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/3 ms

R-1A#ping 10.0.1.9

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.1.9, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/2 ms

R-1A#ping 10.0.1.10

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.1.10, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/3/6 ms

R-1A#ping 10.0.0.3

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.0.3, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/5 ms

R-1A#ping 10.0.3.5

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.3.5, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/5 ms

R-1A#ping 10.0.3.6

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.3.6, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R-1A#ping 192.168.3.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R-1A#ping 192.168.2.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.2.2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

***Forwarding Table***

S2#show mpls forwarding-table

Local Outgoing Prefix Bytes Label Outgoing Next Hop

Label Label or Tunnel Id Switched interface

16 Pop Label 10.0.0.3/32 472 Gi1/1/2 10.0.1.10

17 Pop Label 10.0.0.1/32 1180 Gi1/1/1 10.0.1.1

18 Pop Label 10.0.2.0/30 1652 Gi1/1/1 10.0.1.1

19 19 192.168.3.1/32 0 Gi1/1/1 10.0.1.1

20 20 192.168.2.1/32 0 Gi1/1/1 10.0.1.1

21 Pop Label 10.0.3.4/30 3660 Gi1/1/2 10.0.1.10

22 22 192.168.3.2/32 610 Gi1/1/2 10.0.1.10

23 23 192.168.2.2/32 610 Gi1/1/2 10.0.1.10

S1#show mpls forwarding-table

Local Outgoing Prefix Bytes Label Outgoing Next Hop

Label Label or Tunnel Id Switched interface

16 Pop Label 10.0.0.2/32 0 Gi1/1/1 10.0.1.2

17 Pop Label 10.0.1.8/30 0 Gi1/1/1 10.0.1.2

18 22 192.168.3.2/32 0 Gi1/1/1 10.0.1.2

19 No Label 192.168.3.1/32 610 Gi1/1/2 10.0.2.2

20 No Label 192.168.2.1/32 610 Gi1/1/2 10.0.2.2

21 21 10.0.3.4/30 0 Gi1/1/1 10.0.1.2

22 23 192.168.2.2/32 0 Gi1/1/1 10.0.1.2

23 16 10.0.0.3/32 0 Gi1/1/1 10.0.1.2

S3#show mpls forwarding-table

Local Outgoing Prefix Bytes Label Outgoing Next Hop

Label Label or Tunnel Id Switched interface

16 Pop Label 10.0.0.2/32 0 Gi1/1/2 10.0.1.9

17 17 10.0.0.1/32 0 Gi1/1/2 10.0.1.9

18 Pop Label 10.0.1.0/30 0 Gi1/1/2 10.0.1.9

19 18 10.0.2.0/30 0 Gi1/1/2 10.0.1.9

20 19 192.168.3.1/32 0 Gi1/1/2 10.0.1.9

21 20 192.168.2.1/32 0 Gi1/1/2 10.0.1.9

22 No Label 192.168.3.2/32 0 Gi1/1/1 10.0.3.6

23 No Label 192.168.2.2/32 0 Gi1/1/1 10.0.3.6

***Switch 1 Config:***

hostname S1

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

ip routing

vtp domain CCNP

vtp mode transparent

mpls label range 200 8191 static 16 199

crypto pki trustpoint TP-self-signed-661422464

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-661422464

revocation-check none

rsakeypair TP-self-signed-661422464

crypto pki certificate chain TP-self-signed-661422464

certificate self-signed 01

3082023C 308201A5 A0030201 02020101 300D0609 2A864886 F70D0101 04050030

30312E30 2C060355 04031325 494F532D 53656C66 2D536967 6E65642D 43657274

69666963 6174652D 36363134 32323436 34301E17 0D393330 33303130 30303130

315A170D 32303031 30313030 30303030 5A303031 2E302C06 03550403 1325494F

532D5365 6C662D53 69676E65 642D4365 72746966 69636174 652D3636 31343232

34363430 819F300D 06092A86 4886F70D 01010105 0003818D 00308189 02818100

D36BB700 D69149C7 3A90EF4B 3CFD4B27 1BC7990D 107F5E91 07743DED EDA8607A

0264F4CD 1B3D0C59 2C873BAA 31307B83 EE0B2E47 2D63D175 1C9B7AFB 470FCC60

DDD24F11 A5B23F2B A0FEB63A 46959C47 8328B23E 6A21EE3B D4211F0A 0C6BF28E

BCBF5613 101CB3B0 E3EDD552 CCB356B0 E88389C1 AF6F503C 07732BFF FE471A6B

02030100 01A36630 64300F06 03551D13 0101FF04 05300301 01FF3011 0603551D

11040A30 08820653 77697463 68301F06 03551D23 04183016 80144AB7 2EC34C23

DD69C33E 5EAE038F BCA9FAA0 5360301D 0603551D 0E041604 144AB72E C34C23DD

69C33E5E AE038FBC A9FAA053 60300D06 092A8648 86F70D01 01040500 03818100

5576EED9 9F157EBA 7CBD14B6 8ACF18CF 314E39A7 83AF69B1 4311808A 11390773

5EFDEA78 AADC3D28 440497B1 70366890 9639713D 7C06E7CB 1198F3C0 B8FAD80C

77641C99 173036A9 86F29966 1F33494F 08B33E78 71103631 30539AAD 6C0292D7

3F54EFF8 822778EB D030E7D1 E01D60F2 6CE474BC ADD43D58 5D5ADA82 01AC7FB9

quit

spanning-tree mode pvst

spanning-tree extend system-id

vlan internal allocation policy ascending

interface Loopback0

ip address 10.0.0.1 255.255.255.255

ip ospf 1 area 0

interface FastEthernet1/0/1

interface FastEthernet1/0/2

interface FastEthernet1/0/3

interface FastEthernet1/0/4

interface FastEthernet1/0/5

interface FastEthernet1/0/6

interface FastEthernet1/0/7

interface FastEthernet1/0/8

interface FastEthernet1/0/9

interface FastEthernet1/0/10

interface FastEthernet1/0/11

interface FastEthernet1/0/12

interface FastEthernet1/0/13

interface FastEthernet1/0/14

interface FastEthernet1/0/15

interface FastEthernet1/0/16

interface FastEthernet1/0/17

interface FastEthernet1/0/18

interface FastEthernet1/0/19

interface FastEthernet1/0/20

interface FastEthernet1/0/21

interface FastEthernet1/0/22

interface FastEthernet1/0/23

interface FastEthernet1/0/24

interface GigabitEthernet1/0/1

interface GigabitEthernet1/0/2

interface GigabitEthernet1/1/1

no switchport

ip address 10.0.1.1 255.255.255.252

ip ospf 1 area 0

speed auto 1000

mpls ip

interface GigabitEthernet1/1/2

no switchport

ip address 10.0.2.1 255.255.255.252

ip ospf 1 area 0

speed auto 1000

interface Vlan1

no ip address

shutdown

router ospf 1

router-id 1.1.1.1

network 10.0.0.1 0.0.0.0 area 0

network 10.0.1.0 0.0.0.3 area 0

network 10.0.2.0 0.0.0.3 area 0

ip http server

ip http secure-server

logging esm config

mpls static binding ipv4 10.0.0.2 255.255.255.255 output 10.0.1.2 implicit-null

mpls static binding ipv4 10.0.0.3 255.255.255.255 output 10.0.1.2 16

mpls static binding ipv4 10.0.1.8 255.255.255.252 output 10.0.1.2 implicit-null

mpls static binding ipv4 10.0.3.4 255.255.255.252 output 10.0.1.2 21

mpls static binding ipv4 192.168.2.2 255.255.255.255 output 10.0.1.2 23

mpls static binding ipv4 192.168.3.2 255.255.255.255 output 10.0.1.2 22

line con 0

line vty 0 4

login

line vty 5 15

login

end

***Switch 2 Config:***

hostname S2

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

ip routing

vtp mode transparent

mpls label range 200 8191 static 16 199

mpls label protocol tdp

crypto pki trustpoint TP-self-signed-666922496

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-666922496

revocation-check none

rsakeypair TP-self-signed-666922496

crypto pki certificate chain TP-self-signed-666922496

certificate self-signed 01

3082023C 308201A5 A0030201 02020101 300D0609 2A864886 F70D0101 04050030

30312E30 2C060355 04031325 494F532D 53656C66 2D536967 6E65642D 43657274

69666963 6174652D 36363639 32323439 36301E17 0D393330 33303130 30303130

315A170D 32303031 30313030 30303030 5A303031 2E302C06 03550403 1325494F

532D5365 6C662D53 69676E65 642D4365 72746966 69636174 652D3636 36393232

34393630 819F300D 06092A86 4886F70D 01010105 0003818D 00308189 02818100

C527C9FE 5ED533D8 BA046768 EB5A04D5 1C74CB75 9B6DD512 1F7D63CB CDA9BD3B

EC43EC5A 8CBCF64C 77375F3B 07BB67D7 7D8F9B89 5841946B D9BED2C5 10EDB787

77847779 A400CD85 CF84FF59 122582BA 25635745 CD558BE8 AA9E0AFD B0AB4CBF

82874F04 387129E4 254CC909 9ABECEC8 D84D7F32 65EEEA9C A7B0F3D4 E2BAE383

02030100 01A36630 64300F06 03551D13 0101FF04 05300301 01FF3011 0603551D

11040A30 08820653 77697463 68301F06 03551D23 04183016 8014E6BF AA3DAB08

87125262 EBC5FC3E 671F8256 C338301D 0603551D 0E041604 14E6BFAA 3DAB0887

125262EB C5FC3E67 1F8256C3 38300D06 092A8648 86F70D01 01040500 03818100

7DAFF1B3 23D9B987 9D8E4982 7096ABB5 810292E5 CA1494AD D2E761B5 4EF947BC

9A3512A1 281074DC 9EB8BCC0 5CE85317 05CF6553 E93EFDAC BE64F3A8 E10D8020

43216718 BCFA9953 A23CCD0A 1084C35E 8CC98FBD 3FA923A8 0282354A 46B057E2

6A1B2248 7E3AD995 6DFBA57E E1C02E90 30CDBA54 863339F3 2245BBEB EF56E313

quit

spanning-tree mode pvst

spanning-tree extend system-id

vlan internal allocation policy ascending

interface Loopback0

ip address 10.0.0.2 255.255.255.255

ip ospf 1 area 0

interface FastEthernet1/0/1

interface FastEthernet1/0/2

interface FastEthernet1/0/3

interface FastEthernet1/0/4

interface FastEthernet1/0/5

interface FastEthernet1/0/6

interface FastEthernet1/0/7

interface FastEthernet1/0/8

interface FastEthernet1/0/9

interface FastEthernet1/0/10

interface FastEthernet1/0/11

interface FastEthernet1/0/12

interface FastEthernet1/0/13

interface FastEthernet1/0/14

interface FastEthernet1/0/15

interface FastEthernet1/0/16

interface FastEthernet1/0/17

interface FastEthernet1/0/18

interface FastEthernet1/0/19

interface FastEthernet1/0/20

interface FastEthernet1/0/21

interface FastEthernet1/0/22

interface FastEthernet1/0/23

interface FastEthernet1/0/24

interface GigabitEthernet1/0/1

interface GigabitEthernet1/0/2

interface GigabitEthernet1/1/1

no switchport

ip address 10.0.1.2 255.255.255.252

ip ospf 1 area 0

speed auto 1000

mpls ip

interface GigabitEthernet1/1/2

no switchport

ip address 10.0.1.9 255.255.255.252

ip ospf 1 area 0

speed auto 1000

mpls ip

interface Vlan1

no ip address

shutdown

router ospf 1

router-id 2.2.2.2

network 10.0.0.2 0.0.0.0 area 0

network 10.0.1.0 0.0.0.3 area 0

network 10.0.1.8 0.0.0.3 area 0

ip http server

ip http secure-server

ip sla enable reaction-alerts

logging esm config

mpls static binding ipv4 10.0.0.1 255.255.255.255 output 10.0.1.1 implicit-null

mpls static binding ipv4 10.0.0.3 255.255.255.255 output 10.0.1.10 implicit-null

mpls static binding ipv4 10.0.2.0 255.255.255.252 output 10.0.1.1 implicit-null

mpls static binding ipv4 192.168.2.1 255.255.255.255 output 10.0.1.1 20

mpls static binding ipv4 192.168.3.1 255.255.255.255 output 10.0.1.1 19

line con 0

line vty 0 4

login

line vty 5 15

login

end

***Switch 3 Config:***

hostname S3

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

ip routing

vtp domain CCNP

vtp mode transparent

mpls label range 200 8191 static 16 199

mpls label protocol tdp

spanning-tree mode pvst

spanning-tree extend system-id

vlan internal allocation policy ascending

interface Loopback0

ip address 10.0.0.3 255.255.255.255

ip ospf 1 area 0

interface FastEthernet1/0/1

interface FastEthernet1/0/2

interface FastEthernet1/0/3

interface FastEthernet1/0/4

interface FastEthernet1/0/5

interface FastEthernet1/0/6

interface FastEthernet1/0/7

interface FastEthernet1/0/8

interface FastEthernet1/0/9

interface FastEthernet1/0/10

interface FastEthernet1/0/11

interface FastEthernet1/0/12

interface FastEthernet1/0/13

interface FastEthernet1/0/14

interface FastEthernet1/0/15

interface FastEthernet1/0/16

interface FastEthernet1/0/17

interface FastEthernet1/0/18

interface FastEthernet1/0/19

interface FastEthernet1/0/20

interface FastEthernet1/0/21

interface FastEthernet1/0/22

interface FastEthernet1/0/23

interface FastEthernet1/0/24

interface GigabitEthernet1/0/1

interface GigabitEthernet1/0/2

interface GigabitEthernet1/1/1

no switchport

ip address 10.0.3.5 255.255.255.252

ip ospf 1 area 0

speed auto 1000

interface GigabitEthernet1/1/2

no switchport

ip address 10.0.1.10 255.255.255.252

ip ospf 1 area 0

speed auto 1000

mpls ip

interface Vlan1

no ip address

shutdown

router ospf 1

router-id 3.3.3.3

network 10.0.1.8 0.0.0.3 area 0

network 10.0.3.0 0.0.0.0 area 0

network 10.0.3.4 0.0.0.3 area 0

ip http server

ip http secure-server

logging esm config

line con 0

line vty 5 15

end

***Router 1 Config:***

hostname R-1A

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

vtp domain cisco

vtp mode transparent

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 192.168.2.1 255.255.255.255

ip ospf 1 area 0

interface Loopback1

ip address 192.168.3.1 255.255.255.255

ip ospf 1 area 0

interface GigabitEthernet0/0/0

ip address 10.0.2.2 255.255.255.252

ip ospf 1 area 0

negotiation auto

interface GigabitEthernet0/0/1

no ip address

shutdown

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 1

redistribute connected subnets

network 10.0.2.0 0.0.0.3 area 0

network 192.168.2.1 0.0.0.0 area 0

network 192.168.3.1 0.0.0.0 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

***Router 2 Config:***

hostname R-2B

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 192.168.3.2 255.255.255.255

ip ospf 1 area 0

interface Loopback1

ip address 192.168.2.2 255.255.255.255

ip ospf 1 area 0

interface GigabitEthernet0/0/0

ip address 10.0.3.6 255.255.255.252

ip ospf 1 area 0

negotiation auto

interface GigabitEthernet0/0/1

no ip address

shutdown

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 1

network 10.0.3.4 0.0.0.3 area 0

network 192.168.2.2 0.0.0.0 area 0

network 192.168.3.2 0.0.0.0 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

Problems

The main problem that we ran into was trying to assign IP addresses to interfaces on the layer 3 switch. Since we were originally unable to figure out the cause of the problem, we set up OSPF first and enabled IP routing. After that, we figured out that the interfaces needed to be switched from layer 2 to layer 3 with the command “no switchport.” The other problem we ran into was that the command “

mpls static binding ipv4 192.168.3.2 255.255.255.255 22” didn’t work since it was changing the input label. This was fixed by specifying that we were changing the output label.

Conclusion

Overall, MPLS is a very useful and versatile protocol. It is very simple to configure and allows for multiple different options in terms of configuration. To set up an MPLS network with default configurations, the only command that is required is “mpls ip” with a distribution protocol. In this lab, we explored different configurations of MPLS as well as its variety of uses.