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**Multiarea OSPF**

with

Stubby, Totally Stubby and Not so Stubby areas

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Purpose

The purpose of this lab was to use our general knowledge of OSPF to figure out how to set up a stubby, totally stubby, and not so stubby (NSSA) area. During our deeper dive into OSPF, we learnt more about the notifications OSPF routers send to one another, so that each router is aware of its surrounding area. These notifications are known as link-state advertisements (LSAs) and there are roughly seven important types of them. Only certain types of LSA packets will show up in certain areas which can help network engineers determine what kind of area is OSPF is running. For example, LSA type 7 packets will show up in not so stubby areas, but not stub nor totally stubby areas. We also set up EIGRP with the goal of being able to ping anywhere in the network.

Background Information

OSPF (Open Shortest Path First) is a routing protocol used in large enterprise networks due to its redundancy and efficiency. What makes OSPF so redundant is its ability to calculate backup routes if routers go down- in other words, there will always be a path allowing traffic to flow through a network. What makes OSPF so efficient is the time it takes to set up compared to manually configuring static routes.

So, what are my routing options and why should I prefer routing protocols? In networking, there are two options when dealing with traffic on a network; you can configure static routes, or you can set up a routing protocol. I like to think of static routes as absolute directions drawn onto a map, perhaps going through a forest. The directions are set in stone; the directions can’t be altered unless they are manually redrawn. Let’s suppose you are following those directions by carriage through a forest but get stuck because there is a fallen tree or a broken bridge across a river. You are now lost and there is nowhere else to go. In this case, you, the packet, would get dropped. But now you’re in the same situation except this time a magical wizard constantly redraws the map to show new directions when older ones become unusable. Thus, is the magic of routing protocols- basically just google maps for packets. Ironically, both google maps and OSPF use the same algorithm for finding the best path, Dijkstra’s Algorithm.

Since we’ve defined what routing protocols are, I can go into more detail on how OSPF functions. Each router is like a junction for packets; packets usually have multiple roads they can turn down to reach further junctions, ultimately ending at their destination. Each router communicates with their neighboring routers to relay statuses and updates about themselves. If each router passes information about themselves and their neighbors to every other router, eventually all the routers will have complete knowledge of every direction to and from each other. In networking, having a table of directions to each destination is known as a routing table. All routers gain these directions by broadcasting their information to their neighbors. Via this process of broadcasting information, routers can get updates on what routes may or may not be viable to determine the best path from source to destination. These packets OSPF broadcasts to relay such information are known as **link-state advertisements** (LSAs). There are multiple types of LSA packets that each play a role in communication between OSPF routers. There are seven LSA types that I will cover.

**[Type 1: Router LSA]** – The router **announces its presence** in these packet types and lists the links to other routers or networks **in the same area**. Type 1 LSAs appear in their area only and can’t breach area border routers (ABR). The link state ID of type 1 LSAs is the router ID from the router who sent the LSA.

**[Type 2: Network LSA]** – If routers are joined on a multi-access network then the designated router (DR) will generate an LSA type 2 packet containing **the subnet of the broadcast segment**. For example, if four routers are each connected to a switch, this system becomes a broadcast segment. In a broadcast segment, a router will be designated to handle most of the updates between the other routers, saving bandwidth. It is noteworthy to know that this doesn’t occur in point-to-point connections. Type 2 LSAs are **generated by the DR** and appear in **their area only**. The link state ID for type 2 LSAs is the IP interface address of the DR.

**[Type 3: Summary LSA]** – Generated by the area border router (ABR), these LSAs **inform external areas about networks learned from an area**. Since the ABR generates LSA type 3 packets, they can be found within **other areas**. The link state ID for type 3 LSAs is the network address of the advertising router.

**[Type 4: ASBR Summary LSA]** – These LSA types **advertise the presence of an ASBR** (Autonomous System Border Router). Like ABRs, ASBRs have connections to other areas, but their primary purpose is to support external routes from another routing protocol. For example, an ASBR could have an interface in an OSPF area but also another interface running BGP, EIGRP, RIP, ext. Oddly enough, type 4 LSAs **aren’t** **broadcasted** in the area **with the ASBR**, instead they are **flooded to all other areas** with information containing **the routes to the ASBR**. The link state ID for a type 4 LSA is the ASBR router ID.

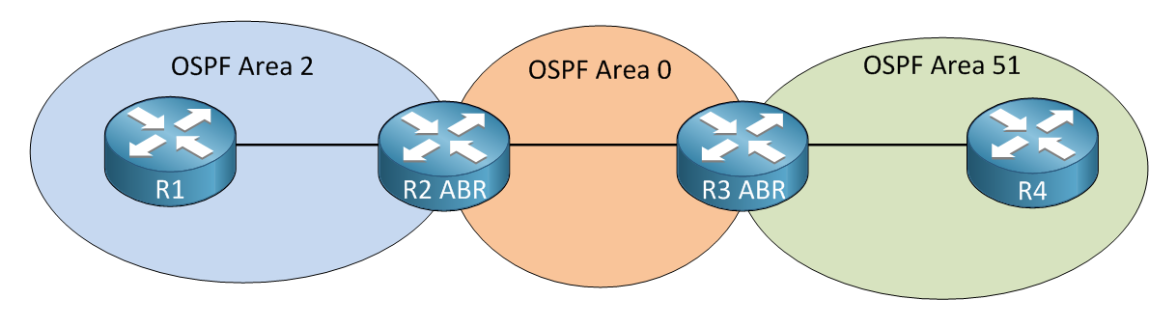
**[Type 5: ASBR External LSA]** – Generated by the ASBR, these LSAs **advertise the external routes connected to the ASBR**. For example, if an ASBR has an interface running BGP, it would advertise those external BGP routes. LSA type 5 packets are **flooded through all areas** once initially generated by an ASBR. The link state ID for a type 5 LSA is the external network number.

**[Type 6: Group Membership LSA]** – These packets were designed for multicast OSPF (MOSPF) but are not supported by CISCO and not widely used. MOSPF is deprecated as of OSPFv3 and isn’t widely used.

**[Type 7: Not so Stubby Area (NSSA) LSA]** – These LSAs are used in not so stubby areas that **block externally distributed routes** to save bandwidth. This means LSA type 5 packets are blocked or translated to LSA type 7 packets whilst in an NSSA since LSA type 5 packets contain external routes. Once the translated LSA type 7 packets pass through the NSSA and reach an ABR, they are passed into the next area and **retranslated** back to type 5 LSA packets.

Multiarea OSPF

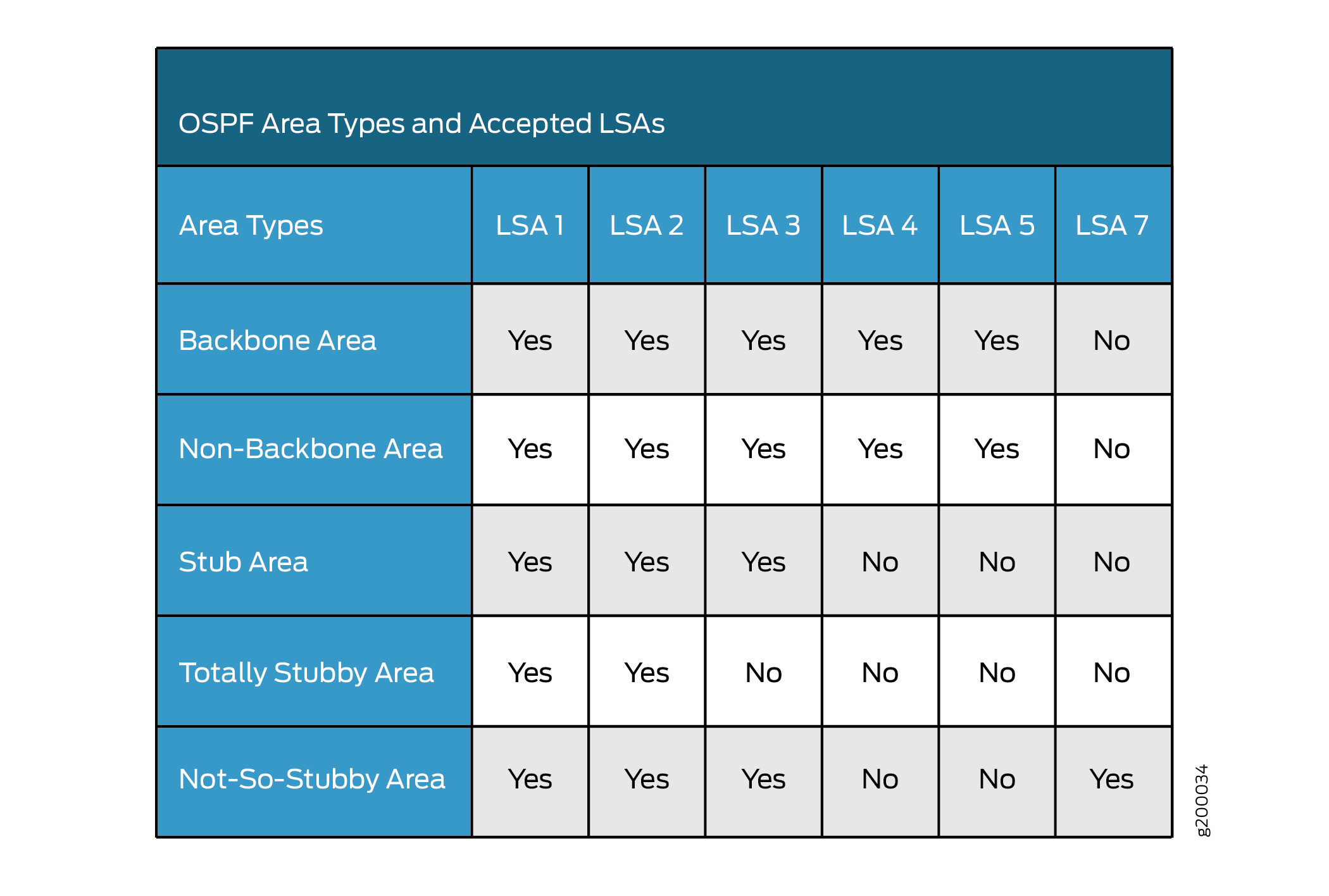
OSPF routers communicate to each other using LSA packets, but this communication comes at a cost: bandwidth. If there was a large network, these LSA packets would begin to congest that network. So how do we limit the amount of LSA traffic on a network? The solution is to use **areas** to section of parts of the network into smaller groups.

Multiarea OSPF is the process of incorporating routers into multiple groups, “areas”, to reduce the size of the local topology (routing table) each router will store. The local topology is reduced due to **route summarization**, a process where multiple routes are combined into a **subnet**. “A router that needs to advertise ten routes needs ten specific lines in its update packet. The more routes you have to advertise, the bigger the packet. The bigger the packet, the more bandwidth the update takes, reducing the bandwidth available to transfer other data. But with route summarization, you can advertise many routes with only one line in an update packet” (Cisco Press). Creating summaries of each area reduces processing power, router memory and overall bandwidth of a network. 

For example, in figure 1, there are three areas. Lets suppose router 1 is looking to send a packet to router 4. Router 1 doesn’t have the exact directions to where router 4 is, but it does have the directions to the subnet router 4 is on: through the interface connected to router 2. Router 2 doesn’t have a route with specific directions to the destination IP (router 4), but, like router 1, it does have the directions to the subnet router 4 is on, leading the packet to router 3. Router 3 is in the same area as router 4 so there’s a route directly to the IP of router 4 instead of just a subnet. The packet reaches router 4.

Specialized Areas

While having multiple areas might seem to solve lots of problems, there might still be bandwidth, processing power, and memory issues. If this occurs, configuring **specialized areas** is a great way to limit LSA traffic even further. There are three specialized area types that I will cover in this paper: stubby, totally stubby, and not so stubby (NSSA) areas.

**[LSA types found per area]**

Totally Stubby Area

A Totally Stubby area was designed to have the least LSA traffic flooding around the area, with only two LSA types utilized: types 1 and 2. It was created to save the most bandwidth by **excluding all external routes** to shorten the routing table. All external routes are replaced by a **default route** since this area type depends on having only **one** exit out of the area. If a router has a packet destined for an IP it doesn’t know, the packet will be flooded out of the area to be dealt with somewhere else. Take, for example, a cul-de-sac: you wouldn’t need directions to get out of somewhere with only one way out.

Totally Stubby areas must only be connected to other areas with **a single ABR**. An ABR, not an ASBR. This is important because ASBRs generate both LSA type 4 and 5 traffic. Therefore, in not being connected to an ASBR, Totally Stubby areas don’t have to deal with either of these LSA types. Ultimately, Totally Stubby areas have the least LSA packet traffic but are the most situational depending on the size of the OSPF network.

Stub/Stubby Area

Stubby areas are like totally stubby areas, only stubby areas bend the rules slightly; these areas can be connected to **more than one ABR**. However, this does mean that LSA type 3 (summary) traffic is flooded throughout the area. Stub areas **still block external routes** like totally stubby areas- something that all three specialized areas have in common. While setting up default routes may be more complicated in this area due to multiple exit points, typically the best place to set default routes up is the ABR leading out towards the internet. Other ABRs in a stub area rely on route summary.

Stub areas are used since they retain smaller databases by excluding external routes, but still flood more LSA traffic than totally stubby areas.

Not so Stubby Area (NSSA)

Not so Stubby areas were designed for areas **containing an ASBR**. Like stub and totally stubby areas, NSSAs block external routes. When you think about it, the point of ASBRs are to advertise external routes, so how can an area containing an ASBR block external routes? NSSAs use type 7 LSA packets to camouflage the external route packets that ASBRs broadcast. Routers in the NSSA ignore these packets while they flood out of the NSSA. Once out of the NSSA, **type 7 LSAs are translated to type 5 LSAs** which contain the external routes of the ASBR.

By being connected to an ASBR and potential ABRs, an NSSA floods four LSA types throughout the area: types 1, 2, 3 and 7. NSSAs are a good choice to configure when dealing with an ASBR.

Lab Summary

In this lab, I set up four specialized OSPF areas: a stubby, totally stubby, not so stubby, and a backbone area. From the ASBR of the NSSA bridged a small EIGRP network which OSPF gained external routes from.

I started off by creating a basic topology of my network. It contained four areas, each designed to support a particular specialized OSPF area. With the topology in mind, I created an IP scheme composed of many small subnets (/30) to be used on the serial interfaces and allocated these IP addresses across the network. Once the IP addresses were set, the interfaces began activating.

I began with the larger backbone area, configuring default OSPF on each router, later branching to the smaller areas. I would activate OSPF using process ID 10 on every router before reconfiguring the specialized areas to their respective area types. However, I configured OSPF in a way that would later cause a large problem. There are two ways of activating OSPFv2 per subnet: using *network statements* in router config mode or *directly in an interface* in interface config mode.

With the central backbone area configured, I circled counterclockwise, configuring the stubby, totally stubby, and not so stubby areas. Configuring these specialized areas was as simple as adding an *area* line to each router in router configuration mode.

Since the OSPF network was basically implemented, the last part I needed to complete was the EIGRP network, a small group of two routers stemming from the NSSA. EIGRP was a routing protocol I had heard of before but never configured, so I was glad to find the similarities it had with OSPF. With EIGRP configured, I had the external routes I needed to truly simulate the NSSA. The network was complete.

Lab commands

|  |  |
| --- | --- |
| **CLI-Command** | A statement necessary for a configuration to work, denoted in bold |
| **[*Argument*]** | An argument necessary for a command to function, denoted in bold italics. |
| *Optional-Statement*  *<Optional Argument>* | An optional argument or statement, not necessary for a command to function, denoted in italics |

Router(config)# **interface [*interface*] [*id*]**

* Enables configuration on a specific interface.

Router(config)# **router ospf [*process id*]**

* Enables the OSPF routing protocol and enters router configuration mode.

It is good practice for the process ID to be the same, however isn’t necessary for OSPF to form adjacencies; process ID is only locally significant. Each OSPF process retains a different routing table, so depending on the configuration, process ID could determine what routes are redistributed. A router can have multiple OSPF processes but will contain a separate OSPF database per process.

Router(config-router)# **network [*network address*] [*wildcard mask*] area [*area number*]**

* Activates OSPFv2 for a specific subnet.

This command is typed after you enter router OSPF configuration mode. Routers in a particular area share a complete topological database and have route summaries of external areas.

Router(config-router)# **area [*area number*] stub** *no-summary*

* Forces the router to act either stubby or totally stubby.

This command is typed in router configuration mode. For link state adjacencies to form, two or more routers in an area must be configured as **stub**. For a totally stubby area, add *no-summary*, so type 3 LSA packets don’t get injected in the area. Routers in a particular area share a complete topological database and have route summaries of external areas.

Router(config-router)# **area [*area number*] nssa** *no-summary*

* Forces the router to act either not so subby or totally not so stubby

This command is typed in router configuration mode. For link state adjacencies to form, two or more routers in an area must be configured as **nssa**. For a totally not so stubby area, add *no-summary*, so type 3 LSA packets don’t get injected in the area. Routers in a particular area share a complete topological database and have route summaries of external areas.

Router(config-router)# **redistribute eigrp [*process id*]** *metric <ospf metric>**subnets*

* Redistributes EIGRP routes into an OSPF network.

This command is typed in router configuration mode. To distribute the EIGRP routes correctly, the EIGRP process ID must match the process EIGRP is running. The *ospf metric* parameter determines the metric number that the distributed routes will have, and the *subnets* enables classless redistribution.

Router(config)# **router eigrp [*instance*]**

* Enables EIGRP of a particular instance on the router and enters router configuration mode.

There can be multiple instances of EIGRP running on a router, however adjacent routers will only communicate if they are using the same instance.

Router(config-router)# **network [*network address*] [*wildcard mask*]**

* Broadcasts specified network to neighbors

This command is typed after you enter router EIGRP configuration mode. Other EIGRP routers will gain knowledge of this network and form routes to it.

Router(config-router)# **redistribute ospf <process id>** *metric <eigrp metrics>*

* Redistributes OSPF routes into an EIGRP network.

The process ID must be set to the same process ID that the OSPF network is running under to be distributed. The routes can optionally get distributed with user defined EIGRP metrics.

Router# **show ipv6 ospf database**

* Displays the routing database.

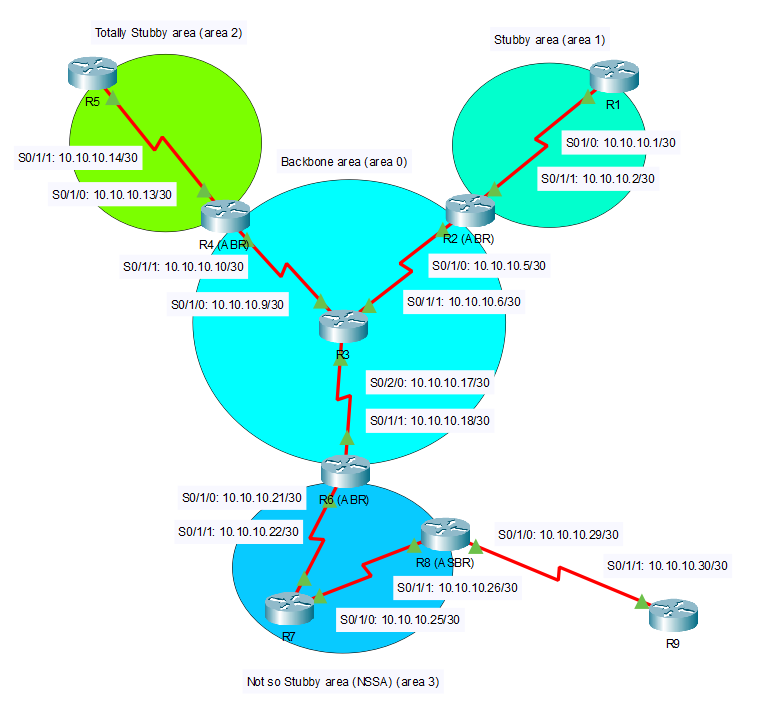
Router# **show ipv6 ospf neighbor**

* Displays information about adjacent routers configured with OSPF.

Router# **show ipv6 ospf interface**

* Displays information about each interface configured with OSPF.

Network Diagram



Configurations

Router 1

**R1#show run**

no service timestamps log datetime msec

no service timestamps debug datetime msec

no service password-encryption

hostname R1

no ip cef

no ipv6 cef

spanning-tree mode pvst

interface GigabitEthernet0/0/0

no ip address

duplex auto

speed auto

shutdown

interface GigabitEthernet0/0/1

no ip address

duplex auto

speed auto

shutdown

interface Serial0/1/0

ip address 10.10.10.1 255.255.255.252

interface Serial0/1/1

no ip address

clock rate 2000000

shutdown

interface GigabitEthernet0/2/0

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/1

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/2

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/3

switchport mode access

switchport nonegotiate

interface Vlan1

no ip address

shutdown

router ospf 10

router-id 1.1.1.1

log-adjacency-changes

area 1 stub

network 10.10.10.0 0.0.0.3 area 1

ip classless

ip flow-export version 9

line con 0

line aux 0

line vty 0 4

login

end

**R1#sh ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is 10.10.10.2 to network 0.0.0.0

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

C 10.10.10.0/30 is directly connected, Serial0/1/0

L 10.10.10.1/32 is directly connected, Serial0/1/0

O IA 10.10.10.4/30 [110/128] via 10.10.10.2, 00:59:41, Serial0/1/0

O IA 10.10.10.8/30 [110/192] via 10.10.10.2, 00:59:21, Serial0/1/0

O IA 10.10.10.12/30 [110/256] via 10.10.10.2, 00:59:21, Serial0/1/0

O IA 10.10.10.16/30 [110/192] via 10.10.10.2, 00:59:21, Serial0/1/0

O IA 10.10.10.20/30 [110/256] via 10.10.10.2, 00:59:21, Serial0/1/0

O IA 10.10.10.24/30 [110/320] via 10.10.10.2, 00:59:21, Serial0/1/0

O\*IA 0.0.0.0/0 [110/65] via 10.10.10.2, 00:59:41, Serial0/1/0

R1#sh ip ospf interface

Serial0/1/0 is up, line protocol is up

Internet address is 10.10.10.1/30, Area 1

Process ID 10, Router ID 1.1.1.1, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:04

Index 1/1, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 2.2.2.2

Suppress hello for 0 neighbor(s)

R1#sh ip ospf database

OSPF Router with ID (1.1.1.1) (Process ID 10)

Router Link States (Area 1)

Link ID ADV Router Age Seq# Checksum Link count

1.1.1.1 1.1.1.1 11 0x8000000c 0x00abc5 2

2.2.2.2 2.2.2.2 13 0x8000000d 0x004c1e 2

Summary Net Link States (Area 1)

Link ID ADV Router Age Seq# Checksum

10.10.10.8 2.2.2.2 1792 0x8000002b 0x003257

10.10.10.16 2.2.2.2 1792 0x8000002c 0x00dfa0

10.10.10.20 2.2.2.2 1792 0x8000002d 0x003803

10.10.10.24 2.2.2.2 1792 0x8000002e 0x009065

10.10.10.12 2.2.2.2 1792 0x8000002f 0x0084bc

10.10.10.4 2.2.2.2 310 0x80000030 0x00cdfa

0.0.0.0 2.2.2.2 310 0x80000031 0x00f62f

R1#sh ip ospf neighbor

Neighbor ID Pri State Dead Time Address Interface

2.2.2.2 0 FULL/ - 00:00:31 10.10.10.2 Serial0/1/0

Router 2

**R2#sh run**

no service timestamps log datetime msec

no service timestamps debug datetime msec

no service password-encryption

hostname R2

no ip cef

no ipv6 cef

spanning-tree mode pvst

interface GigabitEthernet0/0/0

no ip address

duplex auto

speed auto

shutdown

interface GigabitEthernet0/0/1

no ip address

duplex auto

speed auto

shutdown

interface Serial0/1/0

ip address 10.10.10.5 255.255.255.252

interface Serial0/1/1

ip address 10.10.10.2 255.255.255.252

clock rate 2000000

interface GigabitEthernet0/2/0

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/1

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/2

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/3

switchport mode access

switchport nonegotiate

interface Vlan1

no ip address

shutdown

router ospf 10

router-id 2.2.2.2

log-adjacency-changes

area 1 stub

network 10.10.10.0 0.0.0.3 area 1

network 10.10.10.4 0.0.0.3 area 0

ip classless

ip flow-export version 9

line con 0

line aux 0

line vty 0 4

login

end

**R2#sh ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

C 10.10.10.0/30 is directly connected, Serial0/1/1

L 10.10.10.2/32 is directly connected, Serial0/1/1

C 10.10.10.4/30 is directly connected, Serial0/1/0

L 10.10.10.5/32 is directly connected, Serial0/1/0

O 10.10.10.8/30 [110/128] via 10.10.10.6, 01:01:04, Serial0/1/0

O IA 10.10.10.12/30 [110/192] via 10.10.10.6, 01:01:04, Serial0/1/0

O 10.10.10.16/30 [110/128] via 10.10.10.6, 01:01:04, Serial0/1/0

O IA 10.10.10.20/30 [110/192] via 10.10.10.6, 01:01:04, Serial0/1/0

O IA 10.10.10.24/30 [110/256] via 10.10.10.6, 01:01:04, Serial0/1/0

O E2 10.10.10.28/30 [110/100] via 10.10.10.6, 01:01:04, Serial0/1/0

**R2#sh ip ospf interface**

Serial0/1/1 is up, line protocol is up

Internet address is 10.10.10.2/30, Area 1

Process ID 10, Router ID 2.2.2.2, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:00

Index 1/1, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 1.1.1.1

Suppress hello for 0 neighbor(s)

Serial0/1/0 is up, line protocol is up

Internet address is 10.10.10.5/30, Area 0

Process ID 10, Router ID 2.2.2.2, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:00

Index 2/2, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 3.3.3.3

Suppress hello for 0 neighbor(s)

**R2#sh ip ospf database**

OSPF Router with ID (2.2.2.2) (Process ID 10)

Router Link States (Area 0)

Link ID ADV Router Age Seq# Checksum Link count

2.2.2.2 2.2.2.2 105 0x8000000b 0x001746 2

4.4.4.4 4.4.4.4 104 0x8000000b 0x001d27 2

3.3.3.3 3.3.3.3 104 0x80000016 0x00e162 6

6.6.6.6 6.6.6.6 104 0x8000000b 0x00ab76 2

Summary Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

10.10.10.0 2.2.2.2 393 0x80000007 0x0048ad

10.10.10.20 6.6.6.6 404 0x8000088b 0x00e55f

10.10.10.24 6.6.6.6 394 0x8000088e 0x003bc2

10.10.10.12 4.4.4.4 393 0x80000007 0x00934e

Summary ASB Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

6.6.6.6 6.6.6.6 10 0x800008dc 0x00bb2d

Router Link States (Area 1)

Link ID ADV Router Age Seq# Checksum Link count

2.2.2.2 2.2.2.2 105 0x8000000d 0x004c1e 2

1.1.1.1 1.1.1.1 104 0x8000000c 0x00abc5 2

Summary Net Link States (Area 1)

Link ID ADV Router Age Seq# Checksum

10.10.10.4 2.2.2.2 403 0x80000030 0x00cdfa

0.0.0.0 2.2.2.2 403 0x80000031 0x00f62f

10.10.10.8 2.2.2.2 85 0x80000032 0x00245e

10.10.10.16 2.2.2.2 85 0x80000033 0x00d1a7

10.10.10.20 2.2.2.2 85 0x80000034 0x002a0a

10.10.10.24 2.2.2.2 85 0x80000035 0x00816d

10.10.10.12 2.2.2.2 85 0x80000036 0x0076c3

Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

10.10.10.28 6.6.6.6 397 0x80000007 0x009783 0

R2#sh ip ospf neighbor

Neighbor ID Pri State Dead Time Address Interface

3.3.3.3 0 FULL/ - 00:00:38 10.10.10.6 Serial0/1/0

1.1.1.1 0 FULL/ - 00:00:38 10.10.10.1 Serial0/1/1

Router 3

**R3#sh run**

no service timestamps log datetime msec

no service timestamps debug datetime msec

no service password-encryption

hostname R3

no ip cef

no ipv6 cef

spanning-tree mode pvst

interface GigabitEthernet0/0/0

no ip address

duplex auto

speed auto

shutdown

interface GigabitEthernet0/0/1

no ip address

duplex auto

speed auto

shutdown

interface Serial0/1/0

ip address 10.10.10.9 255.255.255.252

interface Serial0/1/1

ip address 10.10.10.6 255.255.255.252

clock rate 2000000

interface Serial0/2/0

ip address 10.10.10.17 255.255.255.252

interface Serial0/2/1

no ip address

clock rate 2000000

shutdown

interface Vlan1

no ip address

shutdown

router ospf 10

router-id 3.3.3.3

log-adjacency-changes

network 10.10.10.4 0.0.0.3 area 0

network 10.10.10.16 0.0.0.3 area 0

network 10.10.10.8 0.0.0.3 area 0

ip classless

ip flow-export version 9

line con 0

line aux 0

line vty 0 4

login

end

**R3#sh ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 11 subnets, 2 masks

O IA 10.10.10.0/30 [110/128] via 10.10.10.5, 01:03:27, Serial0/1/1

C 10.10.10.4/30 is directly connected, Serial0/1/1

L 10.10.10.6/32 is directly connected, Serial0/1/1

C 10.10.10.8/30 is directly connected, Serial0/1/0

L 10.10.10.9/32 is directly connected, Serial0/1/0

O IA 10.10.10.12/30 [110/128] via 10.10.10.10, 01:03:27, Serial0/1/0

C 10.10.10.16/30 is directly connected, Serial0/2/0

L 10.10.10.17/32 is directly connected, Serial0/2/0

O IA 10.10.10.20/30 [110/128] via 10.10.10.18, 01:03:27, Serial0/2/0

O IA 10.10.10.24/30 [110/192] via 10.10.10.18, 01:03:27, Serial0/2/0

O E2 10.10.10.28/30 [110/100] via 10.10.10.18, 01:03:27, Serial0/2/0

**R3#sh ip ospf interface**

Serial0/1/1 is up, line protocol is up

Internet address is 10.10.10.6/30, Area 0

Process ID 10, Router ID 3.3.3.3, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:03

Index 1/1, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 2.2.2.2

Suppress hello for 0 neighbor(s)

Serial0/1/0 is up, line protocol is up

Internet address is 10.10.10.9/30, Area 0

Process ID 10, Router ID 3.3.3.3, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:03

Index 2/2, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 4.4.4.4

Suppress hello for 0 neighbor(s)

Serial0/2/0 is up, line protocol is up

Internet address is 10.10.10.17/30, Area 0

Process ID 10, Router ID 3.3.3.3, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:03

Index 3/3, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 6.6.6.6

Suppress hello for 0 neighbor(s)

R3#sh ip ospf database

OSPF Router with ID (3.3.3.3) (Process ID 10)

Router Link States (Area 0)

Link ID ADV Router Age Seq# Checksum Link count

3.3.3.3 3.3.3.3 230 0x80000016 0x00e162 6

2.2.2.2 2.2.2.2 232 0x8000000b 0x001746 2

4.4.4.4 4.4.4.4 231 0x8000000b 0x001d27 2

6.6.6.6 6.6.6.6 230 0x8000000b 0x00ab76 2

Summary Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

10.10.10.20 6.6.6.6 530 0x8000088b 0x00e55f

10.10.10.24 6.6.6.6 520 0x8000088e 0x003bc2

10.10.10.0 2.2.2.2 519 0x80000007 0x0048ad

10.10.10.12 4.4.4.4 519 0x80000007 0x00934e

Summary ASB Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

6.6.6.6 6.6.6.6 6 0x800008f6 0x008747

Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

10.10.10.28 6.6.6.6 523 0x80000007 0x009783 0

R3#sh ip ospf neighbor

Neighbor ID Pri State Dead Time Address Interface

4.4.4.4 0 FULL/ - 00:00:33 10.10.10.10 Serial0/1/0

2.2.2.2 0 FULL/ - 00:00:33 10.10.10.5 Serial0/1/1

6.6.6.6 0 FULL/ - 00:00:33 10.10.10.18 Serial0/2/0

Router 4

**R4#sh run**

no service timestamps log datetime msec

no service timestamps debug datetime msec

no service password-encryption

hostname R4

no ip cef

no ipv6 cef

spanning-tree mode pvst

interface GigabitEthernet0/0/0

no ip address

duplex auto

speed auto

shutdown

interface GigabitEthernet0/0/1

no ip address

duplex auto

speed auto

shutdown

interface Serial0/1/0

ip address 10.10.10.13 255.255.255.252

interface Serial0/1/1

ip address 10.10.10.10 255.255.255.252

clock rate 2000000

interface GigabitEthernet0/2/0

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/1

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/2

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/3

switchport mode access

switchport nonegotiate

interface Vlan1

no ip address

shutdown

router ospf 10

router-id 4.4.4.4

log-adjacency-changes

area 2 stub no-summary

network 10.10.10.12 0.0.0.3 area 2

network 10.10.10.8 0.0.0.3 area 0

ip classless

ip flow-export version 9

line con 0

line aux 0

line vty 0 4

login

end

**R4#sh ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

O IA 10.10.10.0/30 [110/192] via 10.10.10.9, 01:05:29, Serial0/1/1

O 10.10.10.4/30 [110/128] via 10.10.10.9, 01:05:29, Serial0/1/1

C 10.10.10.8/30 is directly connected, Serial0/1/1

L 10.10.10.10/32 is directly connected, Serial0/1/1

C 10.10.10.12/30 is directly connected, Serial0/1/0

L 10.10.10.13/32 is directly connected, Serial0/1/0

O 10.10.10.16/30 [110/128] via 10.10.10.9, 01:05:29, Serial0/1/1

O IA 10.10.10.20/30 [110/192] via 10.10.10.9, 01:05:29, Serial0/1/1

O IA 10.10.10.24/30 [110/256] via 10.10.10.9, 01:05:29, Serial0/1/1

O E2 10.10.10.28/30 [110/100] via 10.10.10.9, 01:05:29, Serial0/1/1

**R4#sh ip ospf interface**

Serial0/1/0 is up, line protocol is up

Internet address is 10.10.10.13/30, Area 2

Process ID 10, Router ID 4.4.4.4, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:00

Index 1/1, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 5.5.5.5

Suppress hello for 0 neighbor(s)

Serial0/1/1 is up, line protocol is up

Internet address is 10.10.10.10/30, Area 0

Process ID 10, Router ID 4.4.4.4, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:00

Index 2/2, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 3.3.3.3

Suppress hello for 0 neighbor(s)

**R4#sh ip ospf database**

OSPF Router with ID (4.4.4.4) (Process ID 10)

Router Link States (Area 0)

Link ID ADV Router Age Seq# Checksum Link count

4.4.4.4 4.4.4.4 362 0x8000000b 0x001d27 2

2.2.2.2 2.2.2.2 363 0x8000000b 0x001746 2

3.3.3.3 3.3.3.3 362 0x80000016 0x00e162 6

6.6.6.6 6.6.6.6 362 0x8000000b 0x00ab76 2

Summary Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

10.10.10.12 4.4.4.4 651 0x80000007 0x00934e

10.10.10.20 6.6.6.6 662 0x8000088b 0x00e55f

10.10.10.24 6.6.6.6 652 0x8000088e 0x003bc2

10.10.10.0 2.2.2.2 652 0x80000007 0x0048ad

Summary ASB Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

6.6.6.6 6.6.6.6 8 0x80000910 0x005262

Router Link States (Area 2)

Link ID ADV Router Age Seq# Checksum Link count

4.4.4.4 4.4.4.4 363 0x8000000d 0x00df53 2

5.5.5.5 5.5.5.5 363 0x8000000c 0x007eb1 2

Summary Net Link States (Area 2)

Link ID ADV Router Age Seq# Checksum

0.0.0.0 4.4.4.4 660 0x80000007 0x000f39

Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

10.10.10.28 6.6.6.6 655 0x80000007 0x009783 0

**R4#sh ip ospf neighbor**

Neighbor ID Pri State Dead Time Address Interface

3.3.3.3 0 FULL/ - 00:00:32 10.10.10.9 Serial0/1/1

5.5.5.5 0 FULL/ - 00:00:32 10.10.10.14 Serial0/1/0

Router 5

**R5#sh run**

no service timestamps log datetime msec

no service timestamps debug datetime msec

no service password-encryption

hostname R5

no ip cef

no ipv6 cef

spanning-tree mode pvst

interface GigabitEthernet0/0/0

no ip address

duplex auto

speed auto

shutdown

interface GigabitEthernet0/0/1

no ip address

duplex auto

speed auto

shutdown

interface Serial0/1/0

no ip address

clock rate 2000000

shutdown

interface Serial0/1/1

ip address 10.10.10.14 255.255.255.252

clock rate 2000000

interface GigabitEthernet0/2/0

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/1

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/2

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/3

switchport mode access

switchport nonegotiate

interface Vlan1

no ip address

shutdown

router ospf 10

router-id 5.5.5.5

log-adjacency-changes

area 2 stub no-summary

network 10.10.10.12 0.0.0.3 area 2

ip classless

ip flow-export version 9

line con 0

line aux 0

line vty 0 4

login

end

**R5#sh ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is 10.10.10.13 to network 0.0.0.0

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

C 10.10.10.12/30 is directly connected, Serial0/1/1

L 10.10.10.14/32 is directly connected, Serial0/1/1

O\*IA 0.0.0.0/0 [110/65] via 10.10.10.13, 01:07:50, Serial0/1/1

**R5#sh ip ospf interface**

Serial0/1/1 is up, line protocol is up

Internet address is 10.10.10.14/30, Area 2

Process ID 10, Router ID 5.5.5.5, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:06

Index 1/1, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 4.4.4.4

Suppress hello for 0 neighbor(s)

**R5#sh ip ospf database**

OSPF Router with ID (5.5.5.5) (Process ID 10)

Router Link States (Area 2)

Link ID ADV Router Age Seq# Checksum Link count

5.5.5.5 5.5.5.5 486 0x8000000c 0x007eb1 2

4.4.4.4 4.4.4.4 487 0x8000000d 0x00df53 2

Summary Net Link States (Area 2)

Link ID ADV Router Age Seq# Checksum

0.0.0.0 4.4.4.4 784 0x80000007 0x000f39

**R5#sh ip ospf neighbor**

Neighbor ID Pri State Dead Time Address Interface

4.4.4.4 0 FULL/ - 00:00:30 10.10.10.13 Serial0/1/1

Router 6

**R6#sh run**

no service timestamps log datetime msec

no service timestamps debug datetime msec

no service password-encryption

hostname R6

no ip cef

no ipv6 cef

spanning-tree mode pvst

interface GigabitEthernet0/0/0

no ip address

duplex auto

speed auto

shutdown

interface GigabitEthernet0/0/1

no ip address

duplex auto

speed auto

shutdown

interface Serial0/1/0

ip address 10.10.10.21 255.255.255.252

interface Serial0/1/1

ip address 10.10.10.18 255.255.255.252

clock rate 2000000

interface GigabitEthernet0/2/0

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/1

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/2

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/3

switchport mode access

switchport nonegotiate

interface Vlan1

no ip address

shutdown

router ospf 10

router-id 6.6.6.6

log-adjacency-changes

area 3 nssa

network 10.10.10.20 0.0.0.3 area 3

network 10.10.10.16 0.0.0.3 area 0

ip classless

ip flow-export version 9

line con 0

line aux 0

line vty 0 4

login

end

**R6#sh ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

O IA 10.10.10.0/30 [110/192] via 10.10.10.17, 01:09:32, Serial0/1/1

O 10.10.10.4/30 [110/128] via 10.10.10.17, 01:09:32, Serial0/1/1

O 10.10.10.8/30 [110/128] via 10.10.10.17, 01:09:32, Serial0/1/1

O IA 10.10.10.12/30 [110/192] via 10.10.10.17, 01:09:32, Serial0/1/1

C 10.10.10.16/30 is directly connected, Serial0/1/1

L 10.10.10.18/32 is directly connected, Serial0/1/1

C 10.10.10.20/30 is directly connected, Serial0/1/0

L 10.10.10.21/32 is directly connected, Serial0/1/0

O 10.10.10.24/30 [110/128] via 10.10.10.22, 01:09:37, Serial0/1/0

O N2 10.10.10.28/30 [110/100] via 10.10.10.22, 01:09:37, Serial0/1/0

**R6#sh ip ospf interface**

Serial0/1/0 is up, line protocol is up

Internet address is 10.10.10.21/30, Area 3

Process ID 10, Router ID 6.6.6.6, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:01

Index 1/1, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 7.7.7.7

Suppress hello for 0 neighbor(s)

Serial0/1/1 is up, line protocol is up

Internet address is 10.10.10.18/30, Area 0

Process ID 10, Router ID 6.6.6.6, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:01

Index 2/2, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 3.3.3.3

Suppress hello for 0 neighbor(s)

**R6#sh ip ospf database**

OSPF Router with ID (6.6.6.6) (Process ID 10)

Router Link States (Area 0)

Link ID ADV Router Age Seq# Checksum Link count

6.6.6.6 6.6.6.6 591 0x8000000b 0x00ab76 2

2.2.2.2 2.2.2.2 592 0x8000000b 0x001746 2

4.4.4.4 4.4.4.4 592 0x8000000b 0x001d27 2

3.3.3.3 3.3.3.3 591 0x80000016 0x00e162 6

Summary Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

10.10.10.20 6.6.6.6 891 0x8000088b 0x00e55f

10.10.10.24 6.6.6.6 881 0x8000088e 0x003bc2

10.10.10.0 2.2.2.2 881 0x80000007 0x0048ad

10.10.10.12 4.4.4.4 881 0x80000007 0x00934e

Summary ASB Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

6.6.6.6 6.6.6.6 8 0x8000093e 0x00f590

Router Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Link count

6.6.6.6 6.6.6.6 592 0x8000000d 0x00b256 2

8.8.8.8 8.8.8.8 592 0x8000000c 0x00b73a 2

7.7.7.7 7.7.7.7 591 0x80000011 0x004b8e 4

Summary Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

10.10.10.16 6.6.6.6 870 0x80000023 0x00f6c2

10.10.10.4 6.6.6.6 581 0x80000024 0x00ef94

10.10.10.8 6.6.6.6 581 0x80000025 0x00c5b9

10.10.10.0 6.6.6.6 581 0x80000026 0x0096af

10.10.10.12 6.6.6.6 581 0x80000027 0x001c1d

Type-7 AS External Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Tag

10.10.10.28 8.8.8.8 601 0x80000008 0x00a65f 0

Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

10.10.10.28 6.6.6.6 884 0x80000007 0x009783 0

**R6#sh ip ospf neighbor**

Neighbor ID Pri State Dead Time Address Interface

3.3.3.3 0 FULL/ - 00:00:32 10.10.10.17 Serial0/1/1

7.7.7.7 0 FULL/ - 00:00:32 10.10.10.22 Serial0/1/0

Router 7

**R7#sh run**

no service timestamps log datetime msec

no service timestamps debug datetime msec

no service password-encryption

hostname R7

no ip cef

no ipv6 cef

spanning-tree mode pvst

interface GigabitEthernet0/0/0

no ip address

duplex auto

speed auto

shutdown

interface GigabitEthernet0/0/1

no ip address

duplex auto

speed auto

shutdown

interface Serial0/1/0

ip address 10.10.10.25 255.255.255.252

interface Serial0/1/1

ip address 10.10.10.22 255.255.255.252

clock rate 2000000

interface GigabitEthernet0/2/0

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/1

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/2

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/3

switchport mode access

switchport nonegotiate

interface Vlan1

no ip address

shutdown

router ospf 10

router-id 7.7.7.7

log-adjacency-changes

area 3 nssa

network 10.10.10.24 0.0.0.3 area 3

network 10.10.10.20 0.0.0.3 area 3

ip classless

ip flow-export version 9

line con 0

line aux 0

line vty 0 4

login

end

**R7#sh ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

O IA 10.10.10.0/30 [110/256] via 10.10.10.21, 01:11:31, Serial0/1/1

O IA 10.10.10.4/30 [110/192] via 10.10.10.21, 01:11:31, Serial0/1/1

O IA 10.10.10.8/30 [110/192] via 10.10.10.21, 01:11:31, Serial0/1/1

O IA 10.10.10.12/30 [110/256] via 10.10.10.21, 01:11:31, Serial0/1/1

O IA 10.10.10.16/30 [110/128] via 10.10.10.21, 01:11:31, Serial0/1/1

C 10.10.10.20/30 is directly connected, Serial0/1/1

L 10.10.10.22/32 is directly connected, Serial0/1/1

C 10.10.10.24/30 is directly connected, Serial0/1/0

L 10.10.10.25/32 is directly connected, Serial0/1/0

O N2 10.10.10.28/30 [110/100] via 10.10.10.26, 00:15:59, Serial0/1/0

**R7#sh ip ospf interface**

Serial0/1/1 is up, line protocol is up

Internet address is 10.10.10.22/30, Area 3

Process ID 10, Router ID 7.7.7.7, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:04

Index 1/1, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 6.6.6.6

Suppress hello for 0 neighbor(s)

Serial0/1/0 is up, line protocol is up

Internet address is 10.10.10.25/30, Area 3

Process ID 10, Router ID 7.7.7.7, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:04

Index 2/2, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 8.8.8.8

Suppress hello for 0 neighbor(s)

**R7#sh ip ospf database**

OSPF Router with ID (7.7.7.7) (Process ID 10)

Router Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Link count

7.7.7.7 7.7.7.7 711 0x80000011 0x004b8e 4

6.6.6.6 6.6.6.6 713 0x8000000d 0x00b256 2

8.8.8.8 8.8.8.8 713 0x8000000c 0x00b73a 2

Summary Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

10.10.10.16 6.6.6.6 990 0x80000023 0x00f6c2

10.10.10.4 6.6.6.6 701 0x80000024 0x00ef94

10.10.10.8 6.6.6.6 701 0x80000025 0x00c5b9

10.10.10.0 6.6.6.6 701 0x80000026 0x0096af

10.10.10.12 6.6.6.6 701 0x80000027 0x001c1d

Type-7 AS External Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Tag

10.10.10.28 8.8.8.8 722 0x80000008 0x00a65f 0

**R7#sh ip ospf neighbor**

Neighbor ID Pri State Dead Time Address Interface

6.6.6.6 0 FULL/ - 00:00:33 10.10.10.21 Serial0/1/1

8.8.8.8 0 FULL/ - 00:00:33 10.10.10.26 Serial0/1/0

Router 8

**R8#sh run**

no service timestamps log datetime msec

no service timestamps debug datetime msec

no service password-encryption

hostname R8

no ip cef

no ipv6 cef

spanning-tree mode pvst

interface GigabitEthernet0/0/0

no ip address

duplex auto

speed auto

shutdown

interface GigabitEthernet0/0/1

no ip address

duplex auto

speed auto

shutdown

interface Serial0/1/0

ip address 10.10.10.29 255.255.255.252

interface Serial0/1/1

ip address 10.10.10.26 255.255.255.252

clock rate 2000000

interface GigabitEthernet0/2/0

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/1

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/2

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/3

switchport mode access

switchport nonegotiate

interface Vlan1

no ip address

shutdown

router eigrp 1

redistribute ospf 10 metric 1000 33 255 1 1500

network 10.10.10.28 0.0.0.3

auto-summary

router ospf 10

router-id 8.8.8.8

log-adjacency-changes

area 3 nssa

redistribute eigrp 1 metric 100 subnets

redistribute static subnets

redistribute connected

network 10.10.10.24 0.0.0.3 area 3

ip classless

ip flow-export version 9

line con 0

line aux 0

line vty 0 4

login

end

**R8#sh ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 10 subnets, 2 masks

O IA 10.10.10.0/30 [110/320] via 10.10.10.25, 01:13:37, Serial0/1/1

O IA 10.10.10.4/30 [110/256] via 10.10.10.25, 01:13:37, Serial0/1/1

O IA 10.10.10.8/30 [110/256] via 10.10.10.25, 01:13:37, Serial0/1/1

O IA 10.10.10.12/30 [110/320] via 10.10.10.25, 01:13:37, Serial0/1/1

O IA 10.10.10.16/30 [110/192] via 10.10.10.25, 01:13:37, Serial0/1/1

O 10.10.10.20/30 [110/128] via 10.10.10.25, 01:13:47, Serial0/1/1

C 10.10.10.24/30 is directly connected, Serial0/1/1

L 10.10.10.26/32 is directly connected, Serial0/1/1

C 10.10.10.28/30 is directly connected, Serial0/1/0

L 10.10.10.29/32 is directly connected, Serial0/1/0

**R8#sh ip ospf interface**

Serial0/1/1 is up, line protocol is up

Internet address is 10.10.10.26/30, Area 3

Process ID 10, Router ID 8.8.8.8, Network Type POINT-TO-POINT, Cost: 64

Transmit Delay is 1 sec, State POINT-TO-POINT,

Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5

Hello due in 00:00:01

Index 1/1, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 1

Last flood scan time is 0 msec, maximum is 0 msec

Neighbor Count is 1 , Adjacent neighbor count is 1

Adjacent with neighbor 7.7.7.7

Suppress hello for 0 neighbor(s)

**R8#sh ip ospf database**

OSPF Router with ID (8.8.8.8) (Process ID 10)

Router Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Link count

8.8.8.8 8.8.8.8 842 0x8000000c 0x00b73a 2

6.6.6.6 6.6.6.6 843 0x8000000d 0x00b256 2

7.7.7.7 7.7.7.7 841 0x80000011 0x004b8e 4

Summary Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

10.10.10.16 6.6.6.6 1120 0x80000023 0x00f6c2

10.10.10.4 6.6.6.6 831 0x80000024 0x00ef94

10.10.10.8 6.6.6.6 831 0x80000025 0x00c5b9

10.10.10.0 6.6.6.6 831 0x80000026 0x0096af

10.10.10.12 6.6.6.6 831 0x80000027 0x001c1d

Type-7 AS External Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Tag

10.10.10.28 8.8.8.8 851 0x80000008 0x00a65f 0

**R8#sh ip ospf neighbor**

Neighbor ID Pri State Dead Time Address Interface

7.7.7.7 0 FULL/ - 00:00:33 10.10.10.25 Serial0/1/1

**R8#sh ip eigrp interface**

IP-EIGRP interfaces for process 1

Xmit Queue Mean Pacing Time Multicast Pending

Interface Peers Un/Reliable SRTT Un/Reliable Flow Timer Routes

Se0/1/0 1 0/0 1236 0/10 0 0

**R8#sh ip eigrp neighbor**

IP-EIGRP neighbors for process 1

H Address Interface Hold Uptime SRTT RTO Q Seq

(sec) (ms) Cnt Num

0 10.10.10.30 Se0/1/0 12 01:18:01 40 1000 0 42

**R8#sh ip eigrp topology**

IP-EIGRP Topology Table for AS 1/ID(10.10.10.29)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,

r - Reply status

P 10.10.10.0/30, 1 successors, FD is 2568448

via Redistributed (2568448/0)

P 10.10.10.4/30, 1 successors, FD is 2568448

via Redistributed (2568448/0)

P 10.10.10.8/30, 1 successors, FD is 2568448

via Redistributed (2568448/0)

P 10.10.10.12/30, 1 successors, FD is 2568448

via Redistributed (2568448/0)

P 10.10.10.16/30, 1 successors, FD is 2568448

via Redistributed (2568448/0)

P 10.10.10.20/30, 1 successors, FD is 2568448

via Redistributed (2568448/0)

P 10.10.10.24/30, 1 successors, FD is 2568448

via Redistributed (2568448/0)

P 10.10.10.28/30, 1 successors, FD is 2169856

via Connected, Serial0/1/0

Router 9

**R9#sh run**

no service timestamps log datetime msec

no service timestamps debug datetime msec

no service password-encryption

hostname R9

no ip cef

no ipv6 cef

spanning-tree mode pvst

interface GigabitEthernet0/0/0

no ip address

duplex auto

speed auto

shutdown

interface GigabitEthernet0/0/1

no ip address

duplex auto

speed auto

shutdown

interface Serial0/1/0

no ip address

clock rate 2000000

shutdown

interface Serial0/1/1

ip address 10.10.10.30 255.255.255.252

clock rate 2000000

interface GigabitEthernet0/2/0

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/1

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/2

switchport mode access

switchport nonegotiate

interface GigabitEthernet0/2/3

switchport mode access

switchport nonegotiate

interface Vlan1

no ip address

shutdown

router eigrp 1

network 10.10.10.28 0.0.0.3

ip classless

ip flow-export version 9

line con 0

line aux 0

line vty 0 4

login

end

**R9#sh ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is not set

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

D EX 10.10.10.0/30 [170/3080448] via 10.10.10.29, 01:15:29, Serial0/1/1

D EX 10.10.10.4/30 [170/3080448] via 10.10.10.29, 01:15:29, Serial0/1/1

D EX 10.10.10.8/30 [170/3080448] via 10.10.10.29, 01:15:29, Serial0/1/1

D EX 10.10.10.12/30 [170/3080448] via 10.10.10.29, 01:15:29, Serial0/1/1

D EX 10.10.10.16/30 [170/3080448] via 10.10.10.29, 01:15:29, Serial0/1/1

D EX 10.10.10.20/30 [170/3080448] via 10.10.10.29, 01:15:39, Serial0/1/1

D EX 10.10.10.24/30 [170/3080448] via 10.10.10.29, 01:15:54, Serial0/1/1

C 10.10.10.28/30 is directly connected, Serial0/1/1

L 10.10.10.30/32 is directly connected, Serial0/1/1

**R9#sh ip eigrp interfaces**

IP-EIGRP interfaces for process 1

Xmit Queue Mean Pacing Time Multicast Pending

Interface Peers Un/Reliable SRTT Un/Reliable Flow Timer Routes

Se0/1/1 1 0/0 1236 0/10 0 0

**R9#sh ip eigrp neighbors**

IP-EIGRP neighbors for process 1

H Address Interface Hold Uptime SRTT RTO Q Seq

(sec) (ms) Cnt Num

0 10.10.10.29 Se0/1/1 12 01:16:42 40 1000 0 50

**R9#sh ip eigrp topology**

IP-EIGRP Topology Table for AS 1/ID(10.10.10.30)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,

r - Reply status

P 10.10.10.0/30, 1 successors, FD is 3080448

via Rstatic (3080448/2568448)

P 10.10.10.4/30, 1 successors, FD is 3080448

via Rstatic (3080448/2568448)

P 10.10.10.8/30, 1 successors, FD is 3080448

via Rstatic (3080448/2568448)

P 10.10.10.12/30, 1 successors, FD is 3080448

via Rstatic (3080448/2568448)

P 10.10.10.16/30, 1 successors, FD is 3080448

via Rstatic (3080448/2568448)

P 10.10.10.20/30, 1 successors, FD is 3080448

via Rstatic (3080448/2568448)

P 10.10.10.24/30, 1 successors, FD is 3080448

via Rstatic (3080448/2568448)

P 10.10.10.28/30, 1 successors, FD is 2169856

via Connected, Serial0/1/1

Pings

**R1 to R5:**

R1#ping 10.10.10.14

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.10.10.14, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 7/20/25 ms

**R1 to R9:**

R1#ping 10.10.10.30

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.10.10.30, timeout is 2 seconds:

Success rate is 100 percent (5/5), round-trip min/avg/max = 30/35/41 ms

**R5 to R9:**

R5#ping 10.10.10.30

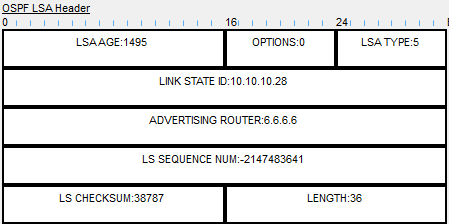
Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.10.10.30, timeout is 2 seconds:

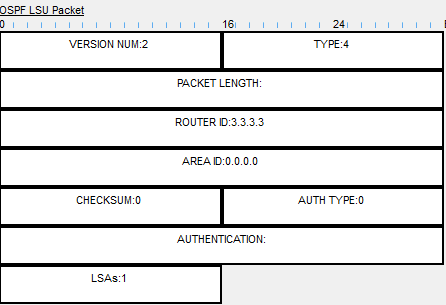
Success rate is 100 percent (5/5), round-trip min/avg/max = 31/34/40 ms

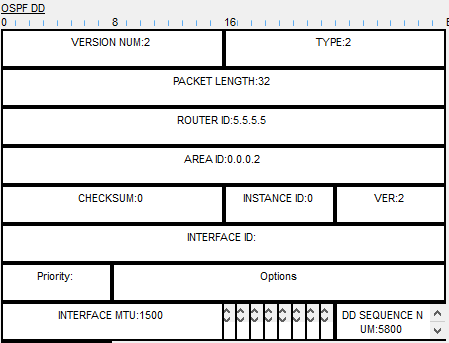
Proof of specialized areas using LSA packets

**LSA type 5 being broadcasted into area 0 by Router 6**

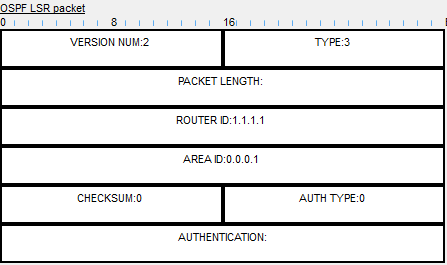


**LSA type 4 being advertised by Router 3**



**LSA type 2 being sent in area 2**

**LSA type 3 being sent in area 1**

****

Problems

The first problem I came across was an OSPF adjacency error between R1 and R2. I had just configured R1 to be a stub area using the **area 1 stub** command but got the error: *Hello from 10.10.10.2 with mismatched Stub/Transit area option bit*. I had turned on adjacency debugging and was repeatedly getting this message. I didn’t think I had to configure R2 with the **area 1 stub** command since it was an ABR. After some researching, I found a source claiming both adjacent interfaces must be configured the same, so I configured the ABR to be stubby. I no longer got the mismatched area error.

Source: <https://lpmazariegos.com/2016/02/10/ospf-stub-areas/>

Whilst configuring the NSSA, I ran into my second problem. I didn’t know how to set up an NSSA. After scouring the internet, I came across a document containing a command that looked promising. The main command was **area [#] nssa** with various optional arguments. However, packet tracer didn’t support these various options the document had. The issue here was figuring out what arguments and parameters I should use. Both the stubby and totally stubby areas had similar configurations statements. The difference was the “no-summary” line of the **area [#] stub** *no-summary* command. The extra “no-summary” portion determined whether I wanted to exclude summary LSAs, employed in totally stubby areas. Therefore, I shouldn’t include the no-summary portion at the end of **area [#] nssa** since that was probably for a totally not so stubby area. While seeming like a menial problem, there was no certainty that this command would work on packet tracer and having to clean up a wrong command could take a chunk of time. Out of safety, I ended up using the base command, **area [#] nssa**.

Source: <https://www.cisco.com/c/m/en_us/techdoc/dc/reference/cli/nxos/commands/ospf/area-nssa-ospf.html>

The toughest problem I encountered occurred after I finished setting up the NSSA. The NSSA received all the routing information from the other areas but never sent its area summary. In other words, the stub, totally stubby, and backbone areas all knew directions to the NSSA but the NSSA didn’t have a clue about the networks in the stub, totally stubby and backbone areas. I rechecked each IP and subnet mask, confirmed all the neighbor adjacencies and restarted every OSPF process. All the IPs were correct, the adjacencies were formed, and the interfaces were up. Every router should have been configured correctly in their respective area and they had the same process ID.

I decided to outsource and learnt my problem could have something to do with the way I configured OSPFv2. As I mentioned earlier in the summary, there are two ways of activating OSPFv2 per subnet: using *network statements* in router config mode or *directly in an interface* in interface config mode. For example, if I wanted OSPF to broadcast the routes for my 10.10.10.0/24 network, the command **network 10.10.10.0 0.0.0.255 area 0** under a process 10 OSPF router should function the same as the command **ip ospf 10 area 0** on the interface of the network. I configured OSPFv2 using the latter method. The solution that arose used the former method. So, I wiped all OSPF configurations on each interface and replaced them with network statements. This fixed the problem. Whether or not this was an issue solely with packet tracer, I gathered that network statements are much more reliable.

Source: Peers

The fourth problem I encountered was working out how to properly distribute EIGRP external routes into my OSPF network. I tried lots of different **redistribute** statements, but they all ended up failing. This meant I needed more than just a basic redistribute statement- there were going to be optional parameters I had to figure out. With each new redistribute statement, I usually got the message: *only classful networks will be redistributed*. My networks were subnetted, they were classless. So now I had locked on to the problem: I required a configuration that would redistribute classless networks.

After some searching, I found an argument that allowed classless addresses to be redistributed: **subnets**. My ever-growing command, **redistribute eigrp [*instance*] metric [#]**, solely needed the **subnets** argument appended to the end. After applying the changes then refreshing the OSPF process, the EIGRP routes began to distribute.

Source: <https://www.ciscopress.com/articles/article.asp?p=27573&amp;seqNum=3>

The fifth problem was the reverse of my last problem. This time, OSPF routes wouldn’t distribute into the EIGRP network. The base command, **redistribute ospf 10**, didn’t appear to redistribute my process 10 OSPF network. Perhaps this command only works on classful networks. The problem I had previously was kindred enough to where I could make that assumption.

After refreshing the OSPF process ID a couple times for good measure, I decided to ask my peers. I was linked to a website that yielded a similar command: **redistribute ospf 10** *metric 1000 33 255 1 1500*. Perhaps the metric somehow specified that these routes were classless. Whatever the issue was, redistributing OSPF with this specific metric solved the problem.

Source: Peers & <https://www.networkstraining.com/redistribution-between-cisco-eigrp-ospf/>

Conclusion

I set up stub, totally stubby, not so stubby and backbone areas using OSPFv2. This lab was riddled with more problems than my other ones which only added to its spice. While setting up all these specialized areas might be a little overkill for a network with roughly ten routers, I believe it is good to know for progressing further with OSPF. Understanding the concepts is as important as being able to configure the network which is why I spent a decent amount of time researching them before I dove into the configurations. If I could give one piece of advice for configuring OSPFv2, it would be to use network statements.