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Stubby, Totally Stubby, and Not So Stubby Areas in Multi-Area OSPF

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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 area. During our deeper dive into OSPF, we learnt more about the information packets OSPF routers send to one another so each router can form proper routes. These packets 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 diagnose the type of the area. For example, LSA type 7 packets will show up in *Not so Stubby* areas, but not in *Stubby* nor *Totally Stubby* areas. We also configured EIGRP to advertise external routes into the OSPF network.

Background Information

Routing

Routing is a significant process in networking as it allows hosts on different IP networks to connect to each other. *Open Shortest Path First* (OSPF) is a routing protocol simplifying the process of creating routes by using algorithms to figure out the directions automatically. OSPF excels in interior networks, which are smaller in scale, but would crash in large networks with hundreds of routes. In networking, routes are ultimately just *directions* for packets.

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, set in stone and unchangeable. The map can’t be altered unless it is manually redrawn. If you were to follow the map, you might find some of the routes to be outdated.

It would be nice if routes were adaptable, if they could update based on the fastest paths available. This is the difference between *static routing* and *routing protocols*. Routing protocols update their routing directions automatically based on information sent from neighbors. This is the magic of routing protocols: automatic updates and directions – like google maps – for packets. Routes are stored in a database on the router, known as a *routing table*.

Routing tables

Like a signpost at a fork in the road, routers contain directions for different destinations. These directions are stored in RAM memory on the router, which means that they are temporary; RAM memory can be accessed much faster than hard drives or SSDs but is not saved after the device shuts down. Let’s look at an example of a packet arriving at a router.

A packet arrives at a router. This router has three interfaces: north, south, and east. The packet arrived on the east interface, so it either must turn north or south, assuming one of these paths lead to the destination. Luckily, there are directions in the router: *10.0.0.0/24* out interface *north*; *172.16.0.0/24* out interface *south*. The packet has a destination address of *10.0.0.3*, which matches up with the *north* interface. The router sends the packet out the north interface. Routes are either generated statically, by the admin, or automatically by routing protocols such as OSPF, BGP, etc.

Here is an example of a routing table:

|  |
| --- |
| 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 |

Ignoring the letters on the left (the origin of the route), we can see a range of addresses and the corresponding interface leading towards them. For example, *10.10.10.0/30* addresses direct out the *Serial0/1/1* interface. “Via *ip*”, is also commonly seen as a direction, indicating that a packet should be sent to the specified neighboring router. Sometimes there is a combination of directions: both *interface* and *neighboring ips*.

OSPF

Since we’ve defined routing and routing tables, 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. Every router running OSPF will communicate with neighbor OSPF routers to relay statuses and updates about new routes and preferred paths. By sharing information to neighbor OSPF routers, information can spread through an OSPF network regardless of hop counts between routers. The packets OSPF broadcasts to relay information are known as *Link-State Advertisements* (LSAs).

* Type 1: *Router LSA*
  + Generated by every router.
  + Contains information about the router and lists links to other routers or networks *in the same area*.
  + Appears in a local area only and will be dropped by *Area Border Routers* (ABR).
  + The link state ID is the router ID of the router who originated the LSA packet.
* Type 2: *Network LSA*
  + Only generated by the Designated Router (DR) in a broadcast network type.  
    *For example, if four routers are connected to the same switch, this system becomes a broadcast network. In a broadcast network, one router will be designated to handle most of the updates between the other routers, conserving bandwidth.*
  + Contains *the subnet of the broadcast segment*.
  + Appears in a local area only and will be dropped by *Area Border Routers*.
  + The link state ID is the IP address of the DR.
* Type 3: *Summary LSA*
  + Generated by an *Area Border Router*.
  + Informs *external areas* about networks in a *local area*.
  + Forwarded by *Area Border Routers*.
  + The link state ID is the network address of the advertising ABR.
* Type 4: *ASBR Summary LSA*
  + Generated by an *Area Border Router* in an area containing an *Autonomous System Border Router* (ASBR).  
    *ASBRs are routers that bridge different routing protocols.*
  + Advertisesroutes to the *Autonomous System Border Router* in the area.
  + Flooded in all areas except the area containing the ASBR.
  + The link state is the ASBR’s router ID.
* Type 5: *ASBR External LSA*
  + Generated by an *Autonomous System Border Router.*
  + Advertises external routes connected to the ASBR.
  + Flooded through all areas.
  + The link state ID is the external network number.
* Type 6: *Group Membership LSA* 
  + Designed for *Multicast OSPF* (MOSPF) but is no longer supported by Cisco.
  + MOSPF is deprecated as of OSPFv3 and is not widely used.
* Type 7: *Not so Stubby Area LSA*
  + Generated for external routes that enter a *Not So Stubby Area* (NSSA).  
    *NSSAs block externally distributed routes to save bandwidth.*
  + LSA type 5 packets are blocked or translated to LSA type 7 packets when entering an NSSA. Once the packets exit an *Area Border Router* in the NSSA, they are retranslated back to type 5 LSA packets.

Cost and OSPFv3

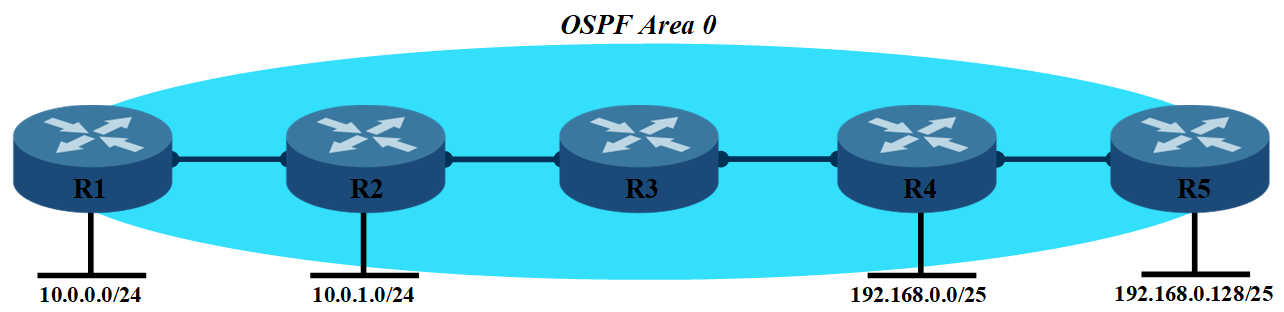
OSPF configured routers rely on *cost* to commute the shortest path through a network. While you can set the cost manually, OSPF will automatically determine the cost value per interface based on a *reference bandwidth* – usually the bandwidth of the fastest interface in your network – and *interface bandwidth***,** the bandwidth of the interface being assessed.

There are two OSPF protocols that can be configured on a router: OSPFv2 and OSPFv3, the main difference being *OSPFv2* routes *IPv4* and *OSPFv3* routes *IPv6*. OSPFv3 has nine *Link-State Advertisements*. LSAs are used to communicate different states and information of an OSPF router, such as a neighbor’s local topology, to build the *routing table*. Although there are other routing protocols such as EIGRP, OSPF is massively adopted in large enterprise networks because of its many benefits: route redundancy, the ability to run on most routers, classless routing, and loop-free topologies.

Multi-area OSPF

OSPF routers communicate to each other using LSA packets, but this communication comes at a cost: bandwidth. When OSPF runs across a large network, LSA packets consume more bandwidth, as there are more routers that send updates. If the network has low-bandwidth interfaces, LSA traffic could hinder the performance. But what if we could limit the amount of LSA traffic on a network?

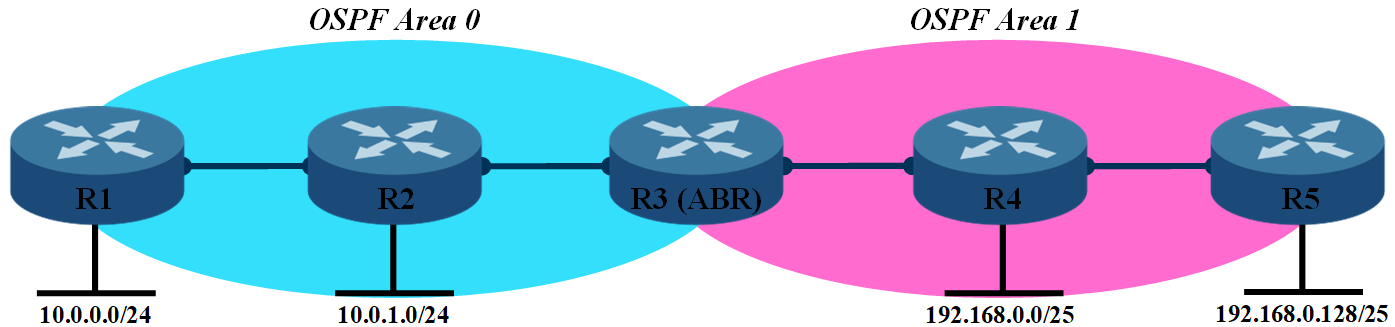
*Multi-area OSPF* is the process of dividing routers into multiple groups, known as *areas*, to reduce the size of LSA packets that need to be sent. Routes need to be specific and abundant for each network advertised within a local area. However, routers in a local area only need a broad definition of networks in external areas. Therefore, LSA packets across areas transmit summarizations by compressing multiple lines of routes into a single subnet. Let’s compare a single-area OSPF network to a multi-area OSPF network.



In this topology, each router needs a specific route for every network in the area. LSA packets would be abundant in this area for each network OSPF is advertising. There would be no summarizations. A routing table on R2 may look something like the following:

* *10.0.0.0/24 out interface GigabitEthernet0*
* *192.168.0.0/25 out interface GigabitEthernet1*
* *192.168.0.128/25 out interface GigabitEthernet1*

Now let’s divide this network into two areas.

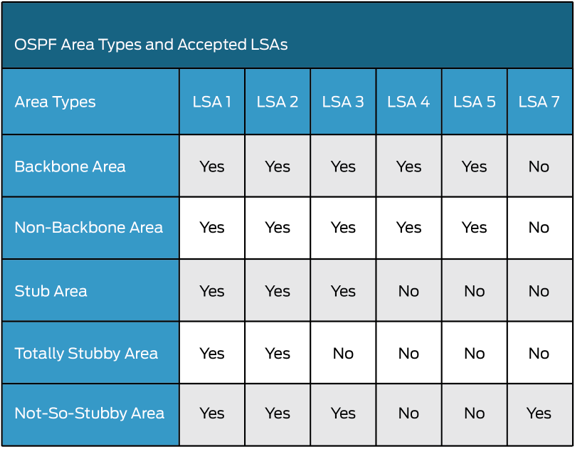


Now that there are multiple areas, we can summarize networks for each area. Instead of routers four and five having routes to the *10.0.0.0/24* and *10.0.1.0/24* networks, they can share a singular, summarized route, *10.0.0.0/23*, that points towards the ASBR. When a packet enters the destination area, more precise routes will direct it to the destined network. An LSA packet to *area 0* from *area 1* might be distributing the following network, *192.168.0.0/24*, only consisting of one prefix. Compared to LSAs containing all the specific routes, *route summarization* helps reduce LSA packet sizes. Now, the routing table on R2 may look something like the following:

* *10.0.0.0/24 out interface GigabitEthernet0*
* *192.168.0.0/24 out interface GigabitEthernet1*

Specialized Areas

While multi-area OSPF may appear to be the most optimal bandwidth conservation option, we can push OSPF further. *Specialized Areas* are additional OSPF configurations that *block* certain LSA types to further limit the amount of LSA traffic. However, specialized areas are circumstantial, requiring specific topologies to properly function. There are three specialized area types that I will cover in this paper: *Stubby*, *Totally Stubby*, and *Not So Stubby* areas.



LSA types found per area

Totally Stubby Area

*Totally Stubby Areas* block the most LSA traffic by dropping all LSA packets except types 1 and 2, conserving the most bandwidth of all the specialized areas. A Totally Stubby area must contain only one *Area Border Router* so all external area traffic can flood out of a default gateway. There are no external routes because there is only one destination for a packet: out the ABR. All external area routes can be replaced by a singular default route. Totally Stubby areas cannot contain an ASBR; this is important because ASBRs generate LSA type 4 and 5 traffic, which are not permitted in the area. While Totally Stubby areas conserve the most bandwidth, they are also very situational.

Stub/Stubby Area

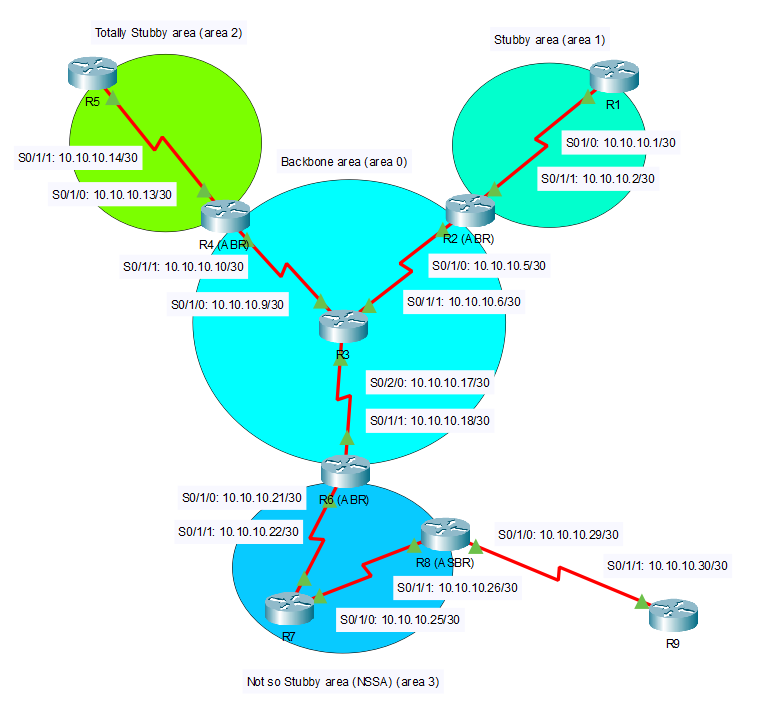
*Stubby Areas* have all the properties of Totally Stubby areas with a slight change in their topologies: they contain more than one *Area Border Router*. This change does come at a cost: LSA type 3 – *summary* – traffic is permitted throughout the area. By allowing more than one ABR in the area, ensuing uncertainty to where external area routes are directed, the area can no longer replace all external area routes with a singular default route. A Stubby area may need external area routes out some of the ABRs, but there will likely be an ABR that routes to the internet. In this case, the Stubby area will have a default route, much like a Totally Stubby area. Stubby areas are used since they retain smaller databases by excluding external network routes, though they do permit summary LSA traffic.

Not so Stubby Area

*Not so Stubby areas* (NSSA) are designed for topologies that include *Autonomous System Border Routers*. ASBRs are routers that run multiple routing protocols, bridging the routing protocols using *redistribution*. Like Stubby and Totally Stubby areas, NSSAs block external routes. But if ASBRs redistribute external routes, then how can NSSAs *block* those external routes?

NSSAs *translate* external routing information into type 7 LSA packets to camouflage external routes that ASBRs produce. Routers in the NSSA ignore type 7 LSA packets and forward them out of the area. Once the type 7 LSAs exit an *Area Border Router* of the Not so Stubby area, they are translated to type 5 LSAs, containing external routes.

Network Diagram



Summary

In this lab, I set up four specialized OSPF areas: a *Stubby*, *Totally Stubby*, *Not so Stubby*, and a *Backbone* area. Attached to the Not so Stubby area was an external EIGRP network to produce type 5 LSA traffic.

I started off by creating a basic topology of my network. It contained four areas, each designed to support a particular specialized OSPF area. Referencing the topology, I created an IP scheme composed of many small [/30] subnets to link the serial interfaces between neighboring routers. I configured the IP addresses in my network and activated the interfaces with a *no shutdown* command.

With the router interfaces set up, I began configuring my first area, the *backbone* area. I configured OSPFv2 like OSPFv3: advertising the networks in *interface-configuration* mode, which should have been all I needed to configure for routers in the backbone area. However, configuring OSPFv2 in such a way – omitting *network* statements – would later cause me many problems.

I configured the stubby area, using the *area [area number] stub* command; I configured the totally stubby area, using the *area [area number] stub no-summary* command; and I configured the not so stubby area, using the *area [area number] nssa* command on each router in the areas. Once my OSPF network was implemented, I needed to configure a small EIGRP network that connected to my NSSA. This was my first time configuring EIGRP, so I was glad to find similarities it had with OSPF configuration.

Lab Commands

|  |  |
| --- | --- |
| **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

// OSPF

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

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

*Generally, OSPF process ids should be the same, though OSPF should still form adjacencies with different process ids. Each OSPF process retains a different routing table; depending on the configuration, process ID could determine what routes are redistributed. A router can run multiple OSPF processes but will contain a separate OSPF database per process.*

Router(config-router)# **router-id** **[*router* *id*]**

* Uniquely determines an OSPF router within a domain

*Router ids are automatically determined by the highest loopback interface if they are not manually defined. Router ids can play a part in DR/BDR elections.*

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

* Advertises the specified subnet to neighbor OSPF routers

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

* Limits LSA traffic based on a specialized area definition

*This command is typed in router configuration mode. Use the following to define specialized areas:*

* *Totally Stubby area | stub no-summary*
* *Stubby area | stub*
* *Totally Not so Stubby area | nssa no-summary*
* *Not so Stubby area | nssa*

// EIGRP

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

* Enables EIGRP of a particular instance 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*]**

* Advertises the specified subnet to neighbor routers

*Other EIGRP routers will gain knowledge of this network and form routes to it.*

// Show Commands

Router# **show [*ipv4/ipv6*] ospf database**

* Displays the routing database

Router# **show [*ipv4/ipv6*] ospf neighbor**

* Displays information about adjacent routers configured with OSPF

Router# **show [*ipv4/ipv6*] ospf interface**

* Displays information about each interface configured with OSPF

// Redistribution

Router(config-router)# **redistribute [*routing protocol*] [*protocol instance*]** <*metric*<*value*>> *subnets*

* Redistributes routes from a routing protocol into another local routing protocol

*The routing protocol defined will be distributed in the local router that the user is in. There are many different additional options when redistributing routes, but I’ve found the metric and subnets to be the most useful. Each routing protocol has a different metric, so when redistributing be sure to use the right one. Subnets usually refers to redistributing classless networks.*

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

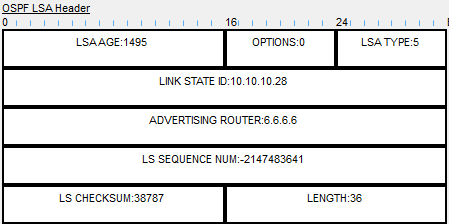
Type escape sequence to abort.

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

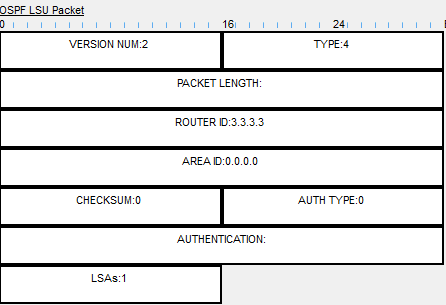
Success rate is 100 percent (5/5), round-trip min/avg/max = 31/34/40 ms

Specialized Area Packets

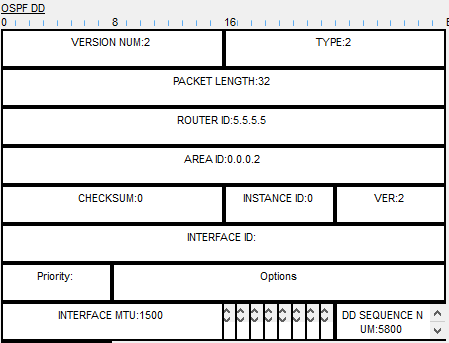
*LSA type 5 being broadcasted into area 0 by Router 6*



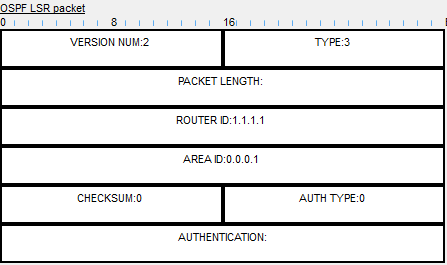
*LSA type 4 being advertised by Router 3*



*LSA type 2 being sent in area 2*



*LSA type 3 being sent in area 1*

****

Problems

Stubby Mismatch

After doing the initial configuration for a *Stubby* area in area 1, I encountered an OSPF adjacency error between R1 and R2: *“Hello from 10.10.10.2 with mismatched Stub/Transit area option bit”*. Adjacency debugging was on, and the log was filling with this message. Typically, when something is mismatched in networking, the admin did not configure the same command on both devices. Some researching in google helped me prove this theory: both adjacent interfaces needed to have the *area 1 stub* command for the relationship to be stubby. I only configured the command on R1, so I added it in R2.

Configuring a Not so Stubby Area

While configuring the *Not so Stubby* area, I ran into my second problem: I did not know the command to configure a NSSA. Luckily, there are many resources online, so I quickly came across a document containing a command that looked promising, *area [area number] nssa*, with various additional arguments. However, packet tracer didn’t support the same additional 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 [area number] stub* *no-summary* command. The extra *“no-summary”* portion determined whether I wanted to exclude summary LSAs, added for totally stubby areas. I decided to omit the *“no-summary”* since it is likely used for a *totally not so stubby area*.

Proper OSPFv2 Configuration

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 advertised its area summary. In other words, the stub, totally stubby, and backbone areas all had routes to the NSSA but the NSSA had no routes back. 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.

Finally, I decided to question the obscure way that I configured OSPFv2. To recap, there are two ways of advertising OSPFv2 subnetworks: using *network statements* in *router-configuration* mode or configuring the area in *interface-configuration* mode. For example, the command *10.10.10.0 0.0.0.255 area 0* in *router-configuration* mode and the command *ip ospf 10 area 0* on the *10.10.10.0/24* interface in *interface-configuration* mode both accomplish the same goal: advertising the *10.10.10.0/24* network. I configured OSPFv2 using the *interface-configuration* command but had not tried implementing the *network* statements. I wiped all OSPF configurations on each interface and replaced them with network statements. This may have been a bug in packet tracer, but I will personally be using network statements from this point fourth as I deem them more reliable.

Eigrp to Ospf Redistribution

The fourth problem I encountered was working out how to properly distribute EIGRP external routes into my OSPF network. The basic *redistribute* statement was not working. This meant I needed more than just a basic redistribute statement – I needed to come up with optional parameters that would satisfy OSPF. I tried many redistribution statements involving EIGRP metrics, but eventually noticed the following message that would pop up each time: *only classful networks will be redistributed*. My networks were subnetted, so they were *classless*. Now I narrowed down problem. I required a configuration that would redistribute *classless* networks.

After some searching, I found an additional argument that allowed classless addresses to be redistributed. 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.

Ospf to Eigrp Redistribution

The fifth problem was the inverse of my last problem. This time, OSPF routes would not distribute into the EIGRP network. The base command, *redistribute ospf 10*, did not appear to redistribute my process 10 OSPF network. Perhaps this command only worked on classful networks. Thanks to my previous problem, I gained the insight that redistributing classless networks is slightly different to redistributing classful networks.

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 with a unique metric: *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.

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, but it was nice to get some troubleshooting experience. Specialized areas might be a little overkill for a network with only ten routers, but the concepts are important to know for progressing further with OSPF. If I could give one piece of advice for configuring OSPFv2, it would be to use *network* statements rather than *interface-configuration* statements.