Purpose

For this lab, we had to setup stubby, totally stubby, and not-so-stubby areas within OSPF. We needed four OSPF areas and one network for EIGRP. The purpose of this lab was to teach us about the different types of stubby areas and how they could benefit us and potential work environments. Along with this, we also learned how to use the Wireshark application to track OSPF packets and to identify the different types of stub areas within these packets.

Background Information

Within OSPF, there are LSAs, or Link-state advertisements. OSPF is a routing protocol for IP (Internet Protocol) networks which determines a path across the network by calculating the shortest route to the destination. OSPF is used to link multiple routers together into areas by registering each router as a neighbor. LSAs, or link-state advertisements, are the basic communication within OSPF. It helps communicate a router’s topology to all other routers within the same OSPF area. This is very useful and generally used in big networks with lots of routers and spread between multiple buildings. When a network is this big, they use multi-area OSPF and stub areas to make everything work efficiently. Multi-area OSPF is used to divide up large networks, because it is a way of limiting the amount of neighbors in an area. In multi-area OPSF, there must be a backbone area, area 0, and at least one other area with a number other than 0. The backbone area is the center of the areas and connects all of them together. When OSPF networks start to get large, the LSDB (Link-State Data Base) starts to fill up with a lot of unnecessary LSAs from other networks. This is when stub areas are put into effect. In order to fully understand stub areas, I first need to go through the first seven types of link-state advertisements. These directly correlate with stub areas, so it is essential to understand them.

The first type of LSA is LSA type 1. These LSAs are used within a single area. Each router in a single area will flood all the routers in the area with a type 1 LSA. Type 1 LSAs are sent to describe their own interfaces, but they also carry information about their neighbors to the adjacent routers. Basically, an LSA type 1 is the blueprint of the router, containing essential information that the other routers need in order for them to connect with one another.

The next LSA type is LSA type 2. This type of LSA is generated by the DR in the area. The DR (Designated Router) is the router that has all the LSAs sent to. Because large LANs have higher traffic, having all the routers receive outside LSAs could be a problem, so the DR is there to alleviate this issue and accept the LSAs itself. Type 2 LSAs are only sent out by the DR, and are just informative ones, as they contain information about the attached routers and about the network segment. Just like LSA type 1, these types stay only within a single area and are flooded to all routers in the area.

The next type of LSA is LSA type 3. This LSA type is generated by the ABR. The ABR is the area border router, and it sits on the border between two different OSPF areas. The ABR is used to establish connections between the backbone area and the OSPF areas, and it is a member of both areas through different interfaces. The LSA type 3 is used to send information from an area to all other areas that have been setup. It summarizes the information for scalability and sends it to all the routers within an area. Generally, all routers setup within multi-area OSPF should have an LSA type 3 in their database. These are shown in the routing table as “O IA”.

The next type of LSA is LSA type 4. This LSA type is created by the ASBR. The ASBR is the Autonomous System Border Router. The ASBR is the router that can run multiple protocols and is served as the gateway to routers which are not part of the OSPF domain. This router is able to use a process known as redistribution to import and translate different protocol routes into OSPF. The type 4 LSAs are sent by the ASBR in order to let all routers know where this router is. Once the router is identified as an ASBR, it creates the type 4 summary LSA and floods it into area 0, and from there it is flooded into all the areas.

The next type of LSA is LSA type 5. This LSA is also created by the ASBR. While LSA type 4 simply let’s all the routers know which one is the ASBR, LSA type 5 is used to represent any external routes from another Autonomous System (or routing protocol) that is done through redistribution. These LSAs are flooded through the backbone area and into all of the areas similarly to type 4 LSAs. Type 5 LSAs also contain information about the metric and cost of a route and are shown in the routing table as “O E1” or “O E2”.

The next type of LSA, and the least important one, is LSA type 6. These are multicast LSAs, which aren’t even used anymore. Cisco doesn’t support these LSAs anymore because a better alternative was created. Even though, it is important to know about them.

The next type of LSA leads directly into stubby areas, and it is LSA type 7. This LSA type is only found when using NSSAs, or Not So Stubby Areas. In order for these types of LSAs to travel to other areas, they must go into the ABR of the area, and from there they are converted into type 5 LSAs which are flooded across the network. These LSAs exist because LSA type 5s are not allowed into an NSSA, so instead they take in these LSA type 7’s which are allowed to travel through the area. When shown in the routing table, they are show as “N1” or “N2”.

Now, I will talk about stub areas and the different kinds of it. There are three different kinds of stub areas. These are stub areas, not so stubby areas (NSSA), and totally stubby areas. The purpose of stub areas is to reduce the size of the link state database, because when you have very large networks, these databases grow very large and it is not good. What stub areas do is they do not allow certain LSA types into them and it helps reduce the database. These external routes are instead replaced with a default summary route.

Ordinary stub areas allow within them LSA types 1, 2, and 3. Normally, these areas would have LSA types of 4 and 5 in order to propagate external routes, but instead these routes are summarized as a default route within an LSA type 3. This ensures that the routers in the stub area can route traffic to external destinations without maintaining all the external routes individually. In order to configure a stub area, you would need to use the command “area x stub”.

The next type of stub area is called a totally stubby area. Similarly to stub areas, totally stubby areas do not receive LSA types 4 or 5 from their ABRs. However, they also do not receive type 3 LSAs from other routers, and they instead rely on a single default route which is injected into the ABR. In order to setup a totally stubby area, you need to use the command “area x stub no-summary”.

A potential problem with these two stub areas is that they cannot contain an ASBR. In order to fix this problem, the concept of not so stubby areas was invented by cisco. Not so stubby areas, or NSSAs, use type 7 LSAs primarily instead of type 5 LSAs. These type 7 LSAs allow an ASBR to advertise external links to an ABR, which will then convert these LSAs into type 5 LSAs after leaving the area. NSSAs can actually function as either a stub area or a totally stubby area. For a stub NSSA, type 3 LSAs will pass in and out of the area. Unlike a regular stub area, the ABR will not inject a default route into the NSSA unless it is specifically told to do so. For a totally stubby NSSA, the ABR will inject a default route into the area without any further configuration. In order to configure a stub NSSA, you need to use the command “area x nssa”. If you want to configure a totally stubby NSSA, you need to use the command “area x nssa no-summary”. A useful way to identify stubby areas is by using a program called Wireshark, which captures packets on a network and allows you to read them. If you want to identify if there are stubby areas on a network, you need to search through Wireshark and see if you can find an area without LSA type 4 or LSA type 5s, or if you see any LSA type 7s. Areas that have LSA type 7s can be identified as not-so-stubby areas, and areas only with LSA types 1, 2, and 3 are stubby or totally-stubby areas. If you see any of these clues, you can determine if a network has stubby areas or not.

Overall, stubby areas, not so stubby areas, and totally stubby areas are a very useful tool for shortening the size of your network, so it isn’t too large. By filtering out certain LSA types to prevent their databases from growing large, stub areas can shorten the size of the network and make it much easier to manage for IT specialists.

Lab Summary

In this lab, we setup stubby, totally stubby, and not-so-stubby areas within OSPF and an EIGRP network on the outside. We setup a backbone Area 0 to connect to the other areas, and a stubby area as Area 1, a totally stubby area as Area 2, and a not-so-stubby area as Area 3. We setup up seven routers in total and two PCs on the ends of the areas. Each router and PC was individually setup with an IPv4 and IPv6 address, and OSPF and OSPFv3. Routers 4 and 5, however, were setup with EIGRP and EIGRPv3 and redistributed. After we setup all the routers, we tested it by pinging across and were able to ping from the PCs to the other PC, and to all other routers. After this, we opened up Wireshark and found type 3 summary LSAs with default routes for the totally stubby area and type 7 LSAs for the not-so-stubby area. Overall, we finished our lab by successfully setting up OSPF and EIGRP and the stubby areas, and were able to ping across and identify the stubby areas through Wireshark.

Lab Commands

For this lab, we used many different commands, including ones that we did know, and others we had just learned. Firstly, we started by setting up all of our addresses by using the “ip address” and “ipv6 address” command and the “no shut” commands to enable the interfaces. After setting up the addresses, we also set up OSPF and OSPFv3 on routers R1 through R7. We did this for OSPF by using the “router ospf 1” command, the “router-id” command, and the “network” commands. For OSPFv3, we did the “ipv6 router ospf 1” command, the “router-id” command, and, in each interface, the “ipv6 ospf 1 area” commands. After this, we also set up EIGRP and EIPGRPv3 on R4 and R5 with the “router eigrp 1” and “ipv6 router eigrp 1” commands, network commands, router-id commands, and the “ipv6 eigrp 1” command on each interface. After this, we needed to redistribute OSPF and EIGRP in order for them to connect. On R4, we used the “redistribute ospf 1” and “redistribute eigrp 1” commands on each interface so they would be redistributed. After this, we also needed to set up the stubby areas. This was accomplished by doing “area 1 stub” for the stub area 1, “area 2 stub no-summary” for the totally stubby area 2, and “area 3 nssa” for the not-so-stubby area 3. After we set up all these commands, we were able to ping across and identify the stubby areas in Wireshark. Overall, we ended up using a lot of commands we did know, but we did learn a few new commands for using redistribution and stubby areas which we will use in future labs.

Problems

Throughout this lab, we had many problems that hindered our progress in finishing the lab. One of the first problems we had was in setting up OSPFv3. We started off by setting up IPv4 on all the routers and OSPF, which worked, and everything could ping. Then, we set up IPv6 and OSPFv3, and the routers could not ping, and there was a “Destination Net Unreachable” error. After some trial and error and looking, we found out that we had one of our commands misspelled on all the routers. We misspelled the “ipv6 ospf 1 area 0” command and had it set to IPv4, so it didn’t work. After figuring this out, all the routers could ping each other.

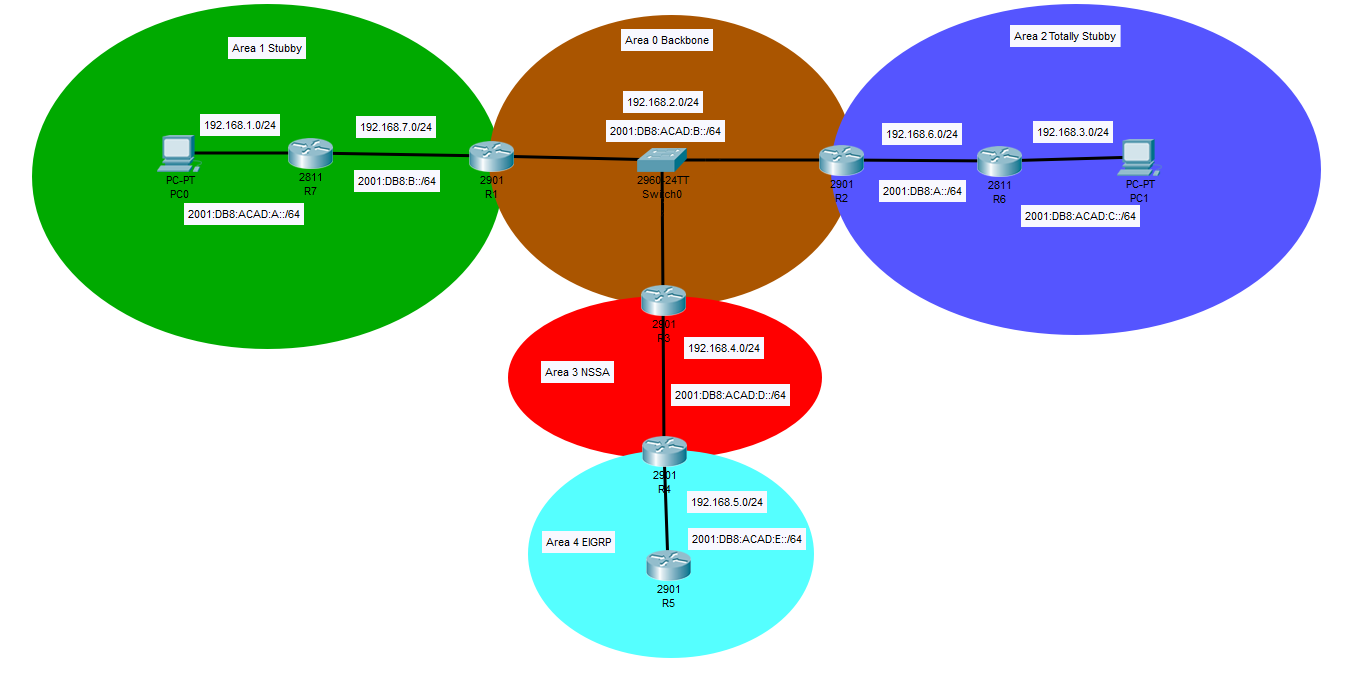
The next big problem we had was redistributing the OSPF and EIGRP processes. We had setup EIGRP on R5, and EIGRP and OSPF on R4, but the EIGRP network could not be accessed by the other routers. After some research online, we figured out that we had to redistribute OSPF by using the redistribute command on both sides of R4. After this, we immediately began seeing improvements in that R5 was able to be pinged by the PCs and routers.

The next big problem we had was with Wireshark. We opened up Wireshark, and there were no OSPF packets. After receiving some advice, we realized that we had to setup new routers within Areas 1 and 2. Doing this would allow us to see the OSPF packets going through these areas, because before there was only one router in each of these areas. We set up the new routers 6 and 7, and still we could not find any OSPF packets. Our next mistake was a smaller mistake, we were not capturing packets through the Ethernet. After this was resolved, we finally could find LSA packets and were able to find LSA type 7s representing not-so-stubby areas, but we could not find the correct LSA type 3s representing totally stubby areas. In order to figure this out, we needed help from our teacher, and we found out that we needed to place a switch in the totally stubby area and set up SPAN on it. After we set up SPAN on this switch and began to capture packets again, we finally found the correct LSA type 3s which have default routes in them of 0.0.0.0. Overall, this lab was really helpful for us not in just learning a lot about LSAs and how to set up stubby areas, but also in how to monitor packets with Wireshark and how to troubleshoot for big problems in our networks.

Conclusion

In this lab, we set up OSPF and EIGRP, created stubby, totally stubby, and not-so-stubby areas, and searched for these areas’ LSA packets through Wireshark. Throughout this lab, we learned a lot. We learned in a previous lab about what each LSA does and what stubby areas are, but in this lab we learned how to implement them and how to locate them in Wireshark. As we did this lab, a lot went wrong from the beginning all the way to the end. Whether it was misspelled commands, not knowing how to redistribute, or not being able to find the correct LSAs within Wireshark, we came across a lot of problems, but we were able to overcome all of them. While working through this lab, we learned a lot about stubby areas, OSPF, and troubleshooting that will help us a lot in the future.

Network Diagram



Configurations

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

R1

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

Last configuration change at 22:12:33 UTC Thu Oct 3 2019

version 15.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

hostname R1

boot-start-marker

boot-end-marker

no aaa new-model

memory-size iomem 10

ip cef

ipv6 unicast-routing

ipv6 cef

multilink bundle-name authenticated

voice-card 0

license udi pid CISCO2901/K9 sn FTX1704Y038

license accept end user agreement

license boot module c2900 technology-package securityk9

license boot module c2900 technology-package uck9

vtp domain cisco

vtp mode transparent

redundancy

interface Embedded-Service-Engine0/0

no ip address

shutdown

interface GigabitEthernet0/0

ip address 192.168.2.1 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::1 link-local

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

ipv6 ospf 1 area 0

interface GigabitEthernet0/1

ip address 192.168.7.2 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::1 link-local

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

ipv6 ospf 1 area 1

interface Serial0/0/0

no ip address

shutdown

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

router ospf 1

router-id 1.1.1.1

area 1 stub

network 192.168.2.0 0.0.0.255 area 0

network 192.168.7.0 0.0.0.255 area 1

ip forward-protocol nd

no ip http server

no ip http secure-server

ipv6 router ospf 1

router-id 1.1.1.1

area 1 stub

area 2 stub

control-plane

mgcp profile default

gatekeeper

shutdown

line con 0

line aux 0

line 2

no activation-character

no exec

transport preferred none

transport output pad telnet rlogin lapb-ta mop udptn v120 ssh

stopbits 1

line vty 0 4

login

transport input all

scheduler allocate 20000 1000

end

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

R2

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

Last configuration change at 21:56:34 UTC Thu Oct 3 2019

version 15.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

hostname R2

boot-start-marker

boot-end-marker

no aaa new-model

memory-size iomem 10

ip cef

ipv6 unicast-routing

ipv6 cef

multilink bundle-name authenticated

voice-card 0

license udi pid CISCO2901/K9 sn FTX15208075

license accept end user agreement

license boot module c2900 technology-package securityk9

license boot module c2900 technology-package uck9

vtp domain cisco

vtp mode transparent

redundancy

interface Embedded-Service-Engine0/0

no ip address

shutdown

interface GigabitEthernet0/0

ip address 192.168.2.4 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::2 link-local

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

ipv6 ospf 1 area 0

interface GigabitEthernet0/1

ip address 192.168.6.2 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::2 link-local

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

ipv6 ospf 1 area 2

interface Serial0/0/0

no ip address

shutdown

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

interface GigabitEthernet0/1/0

no ip address

shutdown

duplex auto

speed auto

router ospf 1

router-id 2.2.2.2

area 2 stub no-summary

network 192.168.2.0 0.0.0.255 area 0

network 192.168.6.0 0.0.0.255 area 2

ip forward-protocol nd

no ip http server

no ip http secure-server

ipv6 router ospf 1

router-id 2.2.2.2

area 2 stub no-summary

control-plane

mgcp profile default

gatekeeper

shutdown

line con 0

line aux 0

line 2

no activation-character

no exec

transport preferred none

transport input all

transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh

stopbits 1

line vty 0 4

login

transport input all

scheduler allocate 20000 1000

End

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

R3

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

Last configuration change at 15:33:00 UTC Thu Sep 26 2002

version 15.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

hostname R3

boot-start-marker

boot-end-marker

no aaa new-model

memory-size iomem 10

ip cef

ipv6 unicast-routing

ipv6 cef

multilink bundle-name authenticated

voice-card 0

license udi pid CISCO2901/K9 sn FTX1520806V

license accept end user agreement

license boot module c2900 technology-package securityk9

license boot module c2900 technology-package uck9

vtp domain cisco

vtp mode transparent

redundancy

interface Embedded-Service-Engine0/0

no ip address

shutdown

interface GigabitEthernet0/0

ip address 192.168.2.3 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::3 link-local

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

ipv6 ospf 1 area 0

interface GigabitEthernet0/1

ip address 192.168.4.1 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::3 link-local

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

ipv6 ospf 1 area 3

interface Serial0/0/0

no ip address

shutdown

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

interface GigabitEthernet0/1/0

no ip address

shutdown

duplex auto

speed auto

router ospf 1

router-id 3.3.3.3

area 3 nssa

network 192.168.2.0 0.0.0.255 area 0

network 192.168.4.0 0.0.0.255 area 3

ip forward-protocol nd

no ip http server

no ip http secure-server

ipv6 router ospf 1

router-id 3.3.3.3

area 3 nssa

control-plane

mgcp profile default

gatekeeper

shutdown

line con 0

line aux 0

line 2

no activation-character

no exec

transport preferred none

transport input all

transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh

stopbits 1

line vty 0 4

login

transport input all

scheduler allocate 20000 1000

end

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

R4

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

Last configuration change at 20:20:45 UTC Thu Oct 3 2019

version 15.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

hostname R4

boot-start-marker

boot-end-marker

no aaa new-model

memory-size iomem 10

ip cef

ipv6 unicast-routing

ipv6 cef

multilink bundle-name authenticated

voice-card 0

license udi pid CISCO2901/K9 sn FTX180180ME

license accept end user agreement

license boot module c2900 technology-package securityk9

license boot module c2900 technology-package uck9

vtp domain cisco

vtp mode transparent

redundancy

interface Embedded-Service-Engine0/0

no ip address

shutdown

interface GigabitEthernet0/0

ip address 192.168.5.1 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::4 link-local

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

ipv6 eigrp 1

interface GigabitEthernet0/1

ip address 192.168.4.2 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::4 link-local

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

ipv6 ospf 1 area 3

interface Serial0/0/0

no ip address

shutdown

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

interface GigabitEthernet0/1/0

no ip address

shutdown

duplex auto

speed auto

router eigrp 1

network 192.168.5.0

eigrp router-id 4.4.4.4

router ospf 1

router-id 4.4.4.4

area 3 nssa

redistribute eigrp 1

network 192.168.4.0 0.0.0.255 area 3

ip forward-protocol nd

no ip http server

no ip http secure-server

ip route 0.0.0.0 0.0.0.0 GigabitEthernet0/1

ipv6 router eigrp 1

eigrp router-id 4.4.4.4

redistribute connected metric 100 10 100 1 1500

redistribute ospf 1 metric 100 10 100 1 1500

ipv6 router ospf 1

router-id 4.4.4.4

area 3 nssa

redistribute connected

redistribute eigrp 1

control-plane

mgcp profile default

gatekeeper

shutdown

line con 0

line aux 0

line 2

no activation-character

no exec

transport preferred none

transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh

stopbits 1

line vty 0 4

login

transport input all

scheduler allocate 20000 1000

end

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

R5

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

Last configuration change at 20:36:11 UTC Thu Oct 3 2019

version 15.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

hostname R5

boot-start-marker

boot-end-marker

no aaa new-model

memory-size iomem 10

ip cef

ipv6 unicast-routing

ipv6 cef

multilink bundle-name authenticated

voice-card 0

license udi pid CISCO2901/K9 sn FTX180180MA

license accept end user agreement

license boot module c2900 technology-package securityk9

license boot module c2900 technology-package uck9

vtp domain cisco

vtp mode transparent

redundancy

interface Embedded-Service-Engine0/0

no ip address

shutdown

interface GigabitEthernet0/0

no ip address

duplex auto

speed auto

interface GigabitEthernet0/1

ip address 192.168.5.2 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::5 link-local

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

ipv6 eigrp 1

interface Serial0/0/0

no ip address

shutdown

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

router eigrp 1

network 192.168.5.0

eigrp router-id 5.5.5.5

ip forward-protocol nd

no ip http server

no ip http secure-server

ip route 0.0.0.0 0.0.0.0 GigabitEthernet0/1

ip route 192.168.4.2 255.255.255.255 192.168.5.1

ipv6 router eigrp 1

eigrp router-id 5.5.5.5

control-plane

mgcp profile default

gatekeeper

shutdown

line con 0

line aux 0

line 2

no activation-character

no exec

transport preferred none

transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh

stopbits 1

line vty 0 4

login

transport input all

scheduler allocate 20000 1000

end

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

R6

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

Last configuration change at 13:08:01 UTC Mon Jan 2 2006

version 15.1

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

hostname R6

boot-start-marker

boot-end-marker

no aaa new-model

memory-size iomem 10

dot11 syslog

ip source-route

ip cef

ipv6 unicast-routing

ipv6 cef

multilink bundle-name authenticated

voice-card 0

crypto pki token default removal timeout 0

license udi pid CISCO2811 sn FTX1233A58D

vtp domain cisco

vtp mode transparent

redundancy

interface FastEthernet0/0

ip address 192.168.3.2 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::6 link-local

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

ipv6 ospf 1 area 2

interface FastEthernet0/1

ip address 192.168.6.1 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::6 link-local

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

ipv6 ospf 1 area 2

interface Serial0/0/0

no ip address

shutdown

no fair-queue

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

interface Serial0/1/0

no ip address

shutdown

clock rate 2000000

interface Serial0/1/1

no ip address

shutdown

clock rate 2000000

interface FastEthernet0/3/0

no ip address

interface FastEthernet0/3/1

no ip address

interface FastEthernet0/3/2

no ip address

interface FastEthernet0/3/3

no ip address

interface FastEthernet0/3/4

no ip address

interface FastEthernet0/3/5

no ip address

interface FastEthernet0/3/6

no ip address

interface FastEthernet0/3/7

no ip address

interface FastEthernet0/3/8

no ip address

interface Vlan1

no ip address

router ospf 1

router-id 6.6.6.6

area 2 stub no-summary

network 192.168.3.0 0.0.0.255 area 2

network 192.168.6.0 0.0.0.255 area 2

ip forward-protocol nd

no ip http server

no ip http secure-server

ipv6 router ospf 1

router-id 6.6.6.6

area 2 stub no-summary

control-plane

mgcp profile default

line con 0

line aux 0

line vty 0 4

login

transport input all

scheduler allocate 20000 1000

end

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

R7

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

version 12.4

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

hostname R7

boot-start-marker

boot-end-marker

logging message-counter syslog

no aaa new-model

memory-size iomem 10

dot11 syslog

ip source-route

ip cef

ipv6 unicast-routing

ipv6 cef

multilink bundle-name authenticated

voice-card 0

no dspfarm

vtp domain cisco

vtp mode transparent

archive

log config

hidekey

interface FastEthernet0/0

ip address 192.168.1.2 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::7 link-local

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

ipv6 ospf 1 area 1

interface FastEthernet0/1

ip address 192.168.7.1 255.255.255.0

duplex auto

speed auto

ipv6 address FE80::7 link-local

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

ipv6 ospf 1 area 1

interface FastEthernet0/3/0

interface FastEthernet0/3/1

interface FastEthernet0/3/2

interface FastEthernet0/3/3

interface Serial0/0/0

no ip address

shutdown

no fair-queue

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

interface Vlan1

no ip address

router ospf 1

router-id 7.7.7.7

log-adjacency-changes

area 1 stub

network 192.168.1.0 0.0.0.255 area 1

network 192.168.7.0 0.0.0.255 area 1

ip forward-protocol nd

no ip http server

no ip http secure-server

ipv6 router ospf 1

router-id 7.7.7.7

log-adjacency-changes

area 1 stub

control-plane

voice-port 0/1/0

voice-port 0/1/1

voice-port 0/2/0

voice-port 0/2/1

line con 0

line aux 0

line vty 0 4

login

scheduler allocate 20000 1000

end

Pings and Traceroutes

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

PC-1 -> PC-2 and R5

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

C:\Users\cisco>ping 192.168.3.2

Pinging 192.168.3.2 with 32 bytes of data:

Reply from 192.168.3.2: bytes=32 time=1ms TTL=252

Reply from 192.168.3.2: bytes=32 time=1ms TTL=252

Reply from 192.168.3.2: bytes=32 time=1ms TTL=252

Reply from 192.168.3.2: bytes=32 time=1ms TTL=252

Ping statistics for 192.168.3.2:

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

Approximate round trip times in milli-seconds:

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

C:\Users\cisco>ping 192.168.5.2

Pinging 192.168.5.2 with 32 bytes of data:

Reply from 192.168.5.2: bytes=32 time=1ms TTL=251

Reply from 192.168.5.2: bytes=32 time=1ms TTL=251

Reply from 192.168.5.2: bytes=32 time=1ms TTL=251

Reply from 192.168.5.2: bytes=32 time=1ms TTL=251

Ping statistics for 192.168.5.2:

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

Approximate round trip times in milli-seconds:

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

C:\Users\cisco>ping 2001:db8:acad:c::2

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

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

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

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

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

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

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

Approximate round trip times in milli-seconds:

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

C:\Users\cisco>ping 2001:db8:acad:e::2

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

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

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

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

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

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

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

Approximate round trip times in milli-seconds:

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

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

PC-2 -> PC-1 and R5

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

C:\Users\cisco>ping 192.168.1.1

Pinging 192.168.1.1 with 32 bytes of data:

Reply from 192.168.1.1: bytes=32 time=1ms TTL=124

Reply from 192.168.1.1: bytes=32 time=1ms TTL=124

Reply from 192.168.1.1: bytes=32 time=1ms TTL=124

Reply from 192.168.1.1: bytes=32 time=1ms TTL=124

Ping statistics for 192.168.1.1:

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

Approximate round trip times in milli-seconds:

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

C:\Users\cisco>ping 2001:db8:acad:a::1

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

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

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

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

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

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

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

Approximate round trip times in milli-seconds:

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

C:\Users\cisco>ping 192.168.5.2

Pinging 192.168.5.2 with 32 bytes of data:

Reply from 192.168.5.2: bytes=32 time=1ms TTL=251

Reply from 192.168.5.2: bytes=32 time=1ms TTL=251

Reply from 192.168.5.2: bytes=32 time=1ms TTL=251

Reply from 192.168.5.2: bytes=32 time=1ms TTL=251

Ping statistics for 192.168.5.2:

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

Approximate round trip times in milli-seconds:

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

C:\Users\cisco>ping 2001:db8:acad:e::2

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

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

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

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

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

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

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

Approximate round trip times in milli-seconds:

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

C:\Users\cisco>tracert 192.168.1.1

Tracing route to 192.168.1.1 over a maximum of 30 hops

1 1 ms <1 ms <1 ms 192.168.3.2

2 <1 ms <1 ms <1 ms 192.168.6.2

3 1 ms <1 ms <1 ms 192.168.2.1

4 1 ms 1 ms 1 ms 192.168.7.1

5 1 ms 1 ms 1 ms 192.168.1.1

Trace complete.

C:\Users\cisco>tracert 2001:db8:acad:a::1

Tracing route to 2001:db8:acad:a::1 over a maximum of 30 hops

1 <1 ms <1 ms <1 ms 2001:db8:acad:c::2

2 <1 ms <1 ms <1 ms 2001:db8:a::2

3 1 ms <1 ms <1 ms 2001:db8:acad:b::1

4 1 ms 1 ms 1 ms 2001:db8:b::1

5 1 ms 1 ms 1 ms 2001:db8:acad:a::1

Trace complete.

C:\Users\cisco>tracert 192.168.5.2

Tracing route to 192.168.5.2 over a maximum of 30 hops

1 <1 ms <1 ms <1 ms 192.168.3.2

2 1 ms <1 ms <1 ms 192.168.6.2

3 <1 ms <1 ms <1 ms 192.168.2.3

4 1 ms 1 ms <1 ms 192.168.4.2

5 1 ms 1 ms 1 ms 192.168.5.2

Trace complete.

C:\Users\cisco>tracert 2001:db8:acad:e::2

Tracing route to 2001:db8:acad:e::2 over a maximum of 30 hops

1 <1 ms <1 ms <1 ms 2001:db8:acad:c::2

2 <1 ms <1 ms <1 ms 2001:db8:a::2

3 1 ms <1 ms <1 ms 2001:db8:acad:b::3

4 1 ms 1 ms 1 ms 2001:db8:acad:d::2

5 1 ms 1 ms 1 ms 2001:db8:acad:e::2

Trace complete.

OSPF Databases

-----------

R1

-----------

R1#show ip ospf database

OSPF Router with ID (1.1.1.1) (Process ID 1)

Router Link States (Area 0)

Link ID ADV Router Age Seq# Checksum Link count

1.1.1.1 1.1.1.1 1250 0x80000004 0x00AF9C 1

2.2.2.2 2.2.2.2 1341 0x80000004 0x008DB3 1

3.3.3.3 3.3.3.3 1070 0x80000005 0x0037FF 1

Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

192.168.2.3 3.3.3.3 1251 0x80000002 0x008220

Summary Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

192.168.1.0 1.1.1.1 1230 0x80000001 0x00C20A

192.168.3.0 2.2.2.2 983 0x80000001 0x008E38

192.168.4.0 3.3.3.3 1061 0x80000001 0x005B67

192.168.6.0 2.2.2.2 1367 0x80000001 0x006361

192.168.7.0 1.1.1.1 1272 0x80000001 0x007651

Router Link States (Area 1)

Link ID ADV Router Age Seq# Checksum Link count

1.1.1.1 1.1.1.1 1240 0x80000003 0x00380E 1

7.7.7.7 7.7.7.7 1241 0x80000005 0x007723 2

Net Link States (Area 1)

Link ID ADV Router Age Seq# Checksum

192.168.7.1 7.7.7.7 1241 0x80000001 0x00038B

Summary Net Link States (Area 1)

Link ID ADV Router Age Seq# Checksum

0.0.0.0 1.1.1.1 1282 0x80000001 0x0093A6

192.168.2.0 1.1.1.1 1282 0x80000001 0x00CB03

192.168.3.0 1.1.1.1 982 0x80000001 0x00D4F6

192.168.4.0 1.1.1.1 1060 0x80000001 0x00BF0C

192.168.6.0 1.1.1.1 1245 0x80000001 0x00A920

Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

192.168.5.0 3.3.3.3 1020 0x80000001 0x002591 0

-----------

R2

-----------

R2#show ip ospf database

OSPF Router with ID (2.2.2.2) (Process ID 1)

Router Link States (Area 0)

Link ID ADV Router Age Seq# Checksum Link count

1.1.1.1 1.1.1.1 1185 0x80000004 0x00AF9C 1

2.2.2.2 2.2.2.2 1275 0x80000004 0x008DB3 1

3.3.3.3 3.3.3.3 1004 0x80000005 0x0037FF 1

Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

192.168.2.3 3.3.3.3 1185 0x80000002 0x008220

Summary Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

192.168.1.0 1.1.1.1 1166 0x80000001 0x00C20A

192.168.3.0 2.2.2.2 917 0x80000001 0x008E38

192.168.4.0 3.3.3.3 995 0x80000001 0x005B67

192.168.6.0 2.2.2.2 1301 0x80000001 0x006361

192.168.7.0 1.1.1.1 1208 0x80000001 0x007651

Router Link States (Area 2)

Link ID ADV Router Age Seq# Checksum Link count

2.2.2.2 2.2.2.2 1244 0x80000003 0x00DF5F 1

6.6.6.6 6.6.6.6 923 0x80000006 0x00DFC0 2

Net Link States (Area 2)

Link ID ADV Router Age Seq# Checksum

192.168.6.2 2.2.2.2 1244 0x80000001 0x00EAB7

Summary Net Link States (Area 2)

Link ID ADV Router Age Seq# Checksum

0.0.0.0 2.2.2.2 1302 0x80000001 0x0075C0

Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

192.168.5.0 3.3.3.3 954 0x80000001 0x002591 0

-----------

R3

-----------

R3#show ip ospf database

OSPF Router with ID (3.3.3.3) (Process ID 1)

Router Link States (Area 0)

Link ID ADV Router Age Seq# Checksum Link count

1.1.1.1 1.1.1.1 1298 0x80000004 0x00AF9C 1

2.2.2.2 2.2.2.2 1388 0x80000004 0x008DB3 1

3.3.3.3 3.3.3.3 1116 0x80000005 0x0037FF 1

Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

192.168.2.3 3.3.3.3 1296 0x80000002 0x008220

Summary Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

192.168.1.0 1.1.1.1 1278 0x80000001 0x00C20A

192.168.3.0 2.2.2.2 1030 0x80000001 0x008E38

192.168.4.0 3.3.3.3 1106 0x80000001 0x005B67

192.168.6.0 2.2.2.2 1414 0x80000001 0x006361

192.168.7.0 1.1.1.1 1320 0x80000001 0x007651

Router Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Link count

3.3.3.3 3.3.3.3 1071 0x80000007 0x00DE4F 1

4.4.4.4 4.4.4.4 1072 0x80000008 0x009B89 1

Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

192.168.4.2 4.4.4.4 1068 0x80000003 0x00F5A0

Summary Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

192.168.1.0 3.3.3.3 1116 0x80000001 0x003687

192.168.2.0 3.3.3.3 1116 0x80000001 0x0017A7

192.168.3.0 3.3.3.3 1029 0x80000001 0x00209B

192.168.6.0 3.3.3.3 1116 0x80000001 0x00F4C4

192.168.7.0 3.3.3.3 1116 0x80000001 0x00E9CE

Type-7 AS External Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Tag

192.168.5.0 4.4.4.4 1112 0x80000006 0x00683B 0

Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

192.168.5.0 3.3.3.3 1066 0x80000001 0x002591 0

OSPF and EIGRP

-----------

R4

-----------

R4#show ip ospf database

OSPF Router with ID (4.4.4.4) (Process ID 1)

Router Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Link count

3.3.3.3 3.3.3.3 1097 0x80000007 0x00DE4F 1

4.4.4.4 4.4.4.4 1096 0x80000008 0x009B89 1

Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

192.168.4.2 4.4.4.4 1092 0x80000003 0x00F5A0

Summary Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

192.168.1.0 3.3.3.3 1303 0x80000001 0x003687

192.168.2.0 3.3.3.3 1489 0x80000001 0x0017A7

192.168.3.0 3.3.3.3 1055 0x80000001 0x00209B

192.168.6.0 3.3.3.3 1409 0x80000001 0x00F4C4

192.168.7.0 3.3.3.3 1318 0x80000001 0x00E9CE

Type-7 AS External Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Tag

192.168.5.0 4.4.4.4 1137 0x80000006 0x00683B 0

R4#show ip eigrp 1 neighbors

EIGRP-IPv4 Neighbors for AS(1)

H Address Interface Hold Uptime SRTT RTO Q Seq

(sec) (ms) Cnt Num

0 192.168.5.2 Gi0/0 13 00:27:19 1 100 0 1

Only EIGRP

-----------

R5

-----------

R5#show ip eigrp 1 neighbors

EIGRP-IPv4 Neighbors for AS(1)

H Address Interface Hold Uptime SRTT RTO Q Seq

(sec) (ms) Cnt Num

0 192.168.5.1 Gi0/1 11 00:27:49 1 100 0 1

-----------

R6

-----------

R6#show ip ospf database

OSPF Router with ID (6.6.6.6) (Process ID 1)

Router Link States (Area 2)

Link ID ADV Router Age Seq# Checksum Link count

2.2.2.2 2.2.2.2 1549 0x80000003 0x00DF5F 1

6.6.6.6 6.6.6.6 1225 0x80000006 0x00DFC0 2

Net Link States (Area 2)

Link ID ADV Router Age Seq# Checksum

192.168.6.2 2.2.2.2 1549 0x80000001 0x00EAB7

Summary Net Link States (Area 2)

Link ID ADV Router Age Seq# Checksum

0.0.0.0 2.2.2.2 1606 0x80000001 0x0075C0

-----------

R7

-----------

R7#show ip ospf database

OSPF Router with ID (7.7.7.7) (Process ID 1)

Router Link States (Area 1)

Link ID ADV Router Age Seq# Checksum Link count

1.1.1.1 1.1.1.1 1591 0x80000003 0x00380E 1

7.7.7.7 7.7.7.7 1590 0x80000005 0x007723 2

Net Link States (Area 1)

Link ID ADV Router Age Seq# Checksum

192.168.7.1 7.7.7.7 1590 0x80000001 0x00038B

Summary Net Link States (Area 1)

Link ID ADV Router Age Seq# Checksum

0.0.0.0 1.1.1.1 1633 0x80000001 0x0093A6

192.168.2.0 1.1.1.1 1633 0x80000001 0x00CB03

192.168.3.0 1.1.1.1 1333 0x80000001 0x00D4F6

192.168.4.0 1.1.1.1 1410 0x80000001 0x00BF0C

192.168.6.0 1.1.1.1 1596 0x80000001 0x00A920

IPv4 and IPv6 Routing Tables

-----------

R1

-----------

R1#show ip route

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

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

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

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

i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

ia - IS-IS inter area, \* - candidate default, U - per-user static route

o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP

+ - replicated route, % - next hop override

Gateway of last resort is not set

O 192.168.1.0/24 [110/2] via 192.168.7.1, 00:27:48, GigabitEthernet0/1

192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.2.0/24 is directly connected, GigabitEthernet0/0

L 192.168.2.1/32 is directly connected, GigabitEthernet0/0

O IA 192.168.3.0/24 [110/3] via 192.168.2.4, 00:23:41, GigabitEthernet0/0

O IA 192.168.4.0/24 [110/2] via 192.168.2.3, 00:24:58, GigabitEthernet0/0

O E2 192.168.5.0/24 [110/20] via 192.168.2.3, 00:24:17, GigabitEthernet0/0

O IA 192.168.6.0/24 [110/2] via 192.168.2.4, 00:28:03, GigabitEthernet0/0

192.168.7.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.7.0/24 is directly connected, GigabitEthernet0/1

L 192.168.7.2/32 is directly connected, GigabitEthernet0/1

R1#show ipv6 route

IPv6 Routing Table - default - 10 entries

Codes: C - Connected, L - Local, S - Static, U - Per-user Static route

B - BGP, R - RIP, H - NHRP, I1 - ISIS L1

I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP

EX - EIGRP external, ND - ND Default, NDp - ND Prefix, DCE - Destination

NDr - Redirect, O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1

OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2

OI 2001:DB8:A::/64 [110/2]

via FE80::2, GigabitEthernet0/0

C 2001:DB8:B::/64 [0/0]

via GigabitEthernet0/1, directly connected

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

via GigabitEthernet0/1, receive

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

via FE80::7, GigabitEthernet0/1

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

via GigabitEthernet0/0, directly connected

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

via GigabitEthernet0/0, receive

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

via FE80::2, GigabitEthernet0/0

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

via FE80::3, GigabitEthernet0/0

OE2 2001:DB8:ACAD:E::/64 [110/20]

via FE80::3, GigabitEthernet0/0

L FF00::/8 [0/0]

via Null0, receive

-----------

R2

-----------

R2#show ip route

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

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

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

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

i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

ia - IS-IS inter area, \* - candidate default, U - per-user static route

o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP

+ - replicated route, % - next hop override

Gateway of last resort is not set

O IA 192.168.1.0/24 [110/3] via 192.168.2.1, 00:28:34, GigabitEthernet0/0

192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.2.0/24 is directly connected, GigabitEthernet0/0

L 192.168.2.4/32 is directly connected, GigabitEthernet0/0

O 192.168.3.0/24 [110/2] via 192.168.6.1, 00:24:26, GigabitEthernet0/1

O IA 192.168.4.0/24 [110/2] via 192.168.2.3, 00:25:44, GigabitEthernet0/0

O E2 192.168.5.0/24 [110/20] via 192.168.2.3, 00:25:03, GigabitEthernet0/0

192.168.6.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.6.0/24 is directly connected, GigabitEthernet0/1

L 192.168.6.2/32 is directly connected, GigabitEthernet0/1

O IA 192.168.7.0/24 [110/2] via 192.168.2.1, 00:28:49, GigabitEthernet0/0

R2#show ipv6 route

IPv6 Routing Table - default - 10 entries

Codes: C - Connected, L - Local, S - Static, U - Per-user Static route

B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP

H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea

IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO

ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect

O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2

ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, l - LISP

C 2001:DB8:A::/64 [0/0]

via GigabitEthernet0/1, directly connected

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

via GigabitEthernet0/1, receive

OI 2001:DB8:B::/64 [110/2]

via FE80::1, GigabitEthernet0/0

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

via FE80::1, GigabitEthernet0/0

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

via GigabitEthernet0/0, directly connected

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

via GigabitEthernet0/0, receive

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

via FE80::6, GigabitEthernet0/1

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

via FE80::3, GigabitEthernet0/0

OE2 2001:DB8:ACAD:E::/64 [110/20]

via FE80::3, GigabitEthernet0/0

L FF00::/8 [0/0]

via Null0, receive

-----------

R3

-----------

R3#show ip route

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

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

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

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

i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

ia - IS-IS inter area, \* - candidate default, U - per-user static route

o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP

+ - replicated route, % - next hop override

Gateway of last resort is not set

O IA 192.168.1.0/24 [110/3] via 192.168.2.1, 00:00:09, GigabitEthernet0/0

192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.2.0/24 is directly connected, GigabitEthernet0/0

L 192.168.2.3/32 is directly connected, GigabitEthernet0/0

O IA 192.168.3.0/24 [110/3] via 192.168.2.4, 00:00:09, GigabitEthernet0/0

192.168.4.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.4.0/24 is directly connected, GigabitEthernet0/1

L 192.168.4.1/32 is directly connected, GigabitEthernet0/1

O IA 192.168.6.0/24 [110/2] via 192.168.2.4, 00:00:09, GigabitEthernet0/0

O IA 192.168.7.0/24 [110/2] via 192.168.2.1, 00:00:09, GigabitEthernet0/0

R3#show ipv6 route

IPv6 Routing Table - default - 9 entries

Codes: C - Connected, L - Local, S - Static, U - Per-user Static route

B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP

H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea

IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO

ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect

O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2

ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, l - LISP

OI 2001:DB8:A::/64 [110/2]

via FE80::2, GigabitEthernet0/0

OI 2001:DB8:B::/64 [110/2]

via FE80::1, GigabitEthernet0/0

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

via FE80::1, GigabitEthernet0/0

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

via GigabitEthernet0/0, directly connected

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

via GigabitEthernet0/0, receive

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

via FE80::2, GigabitEthernet0/0

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

via GigabitEthernet0/1, directly connected

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

via GigabitEthernet0/1, receive

L FF00::/8 [0/0]

via Null0, receive

-----------

R4

-----------

R4#show ip route

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

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

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

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

i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

ia - IS-IS inter area, \* - candidate default, U - per-user static route

o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP

+ - replicated route, % - next hop override

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

S\* 0.0.0.0/0 is directly connected, GigabitEthernet0/1

O IA 192.168.1.0/24 [110/4] via 192.168.4.1, 00:00:02, GigabitEthernet0/1

O IA 192.168.2.0/24 [110/2] via 192.168.4.1, 00:00:02, GigabitEthernet0/1

O IA 192.168.3.0/24 [110/4] via 192.168.4.1, 00:00:02, GigabitEthernet0/1

192.168.4.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.4.0/24 is directly connected, GigabitEthernet0/1

L 192.168.4.2/32 is directly connected, GigabitEthernet0/1

192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.5.0/24 is directly connected, GigabitEthernet0/0

L 192.168.5.1/32 is directly connected, GigabitEthernet0/0

O IA 192.168.6.0/24 [110/3] via 192.168.4.1, 00:00:02, GigabitEthernet0/1

O IA 192.168.7.0/24 [110/3] via 192.168.4.1, 00:00:02, GigabitEthernet0/1

R4#show ipv6 route

IPv6 Routing Table - default - 10 entries

Codes: C - Connected, L - Local, S - Static, U - Per-user Static route

B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP

H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea

IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO

ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect

O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2

ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, l - LISP

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

via FE80::3, GigabitEthernet0/1

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

via FE80::3, GigabitEthernet0/1

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

via FE80::3, GigabitEthernet0/1

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

via FE80::3, GigabitEthernet0/1

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

via FE80::3, GigabitEthernet0/1

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

via GigabitEthernet0/1, directly connected

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

via GigabitEthernet0/1, receive

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

via GigabitEthernet0/0, directly connected

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

via GigabitEthernet0/0, receive

L FF00::/8 [0/0]

via Null0, receive

-----------

R5

-----------

R5#show ip route

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

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

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

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

i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

ia - IS-IS inter area, \* - candidate default, U - per-user static route

o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP

+ - replicated route, % - next hop override

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

S\* 0.0.0.0/0 is directly connected, GigabitEthernet0/1

192.168.4.0/32 is subnetted, 1 subnets

S 192.168.4.2 [1/0] via 192.168.5.1

192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.5.0/24 is directly connected, GigabitEthernet0/1

L 192.168.5.2/32 is directly connected, GigabitEthernet0/1

R5#show ipv6 route

IPv6 Routing Table - default - 9 entries

Codes: C - Connected, L - Local, S - Static, U - Per-user Static route

B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP

H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea

IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO

ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect

O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2

ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, l - LISP

EX 2001:DB8:A::/64 [170/25602816]

via FE80::4, GigabitEthernet0/1

EX 2001:DB8:B::/64 [170/25602816]

via FE80::4, GigabitEthernet0/1

EX 2001:DB8:ACAD:A::/64 [170/25602816]

via FE80::4, GigabitEthernet0/1

EX 2001:DB8:ACAD:B::/64 [170/25602816]

via FE80::4, GigabitEthernet0/1

EX 2001:DB8:ACAD:C::/64 [170/25602816]

via FE80::4, GigabitEthernet0/1

EX 2001:DB8:ACAD:D::/64 [170/25602816]

via FE80::4, GigabitEthernet0/1

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

via GigabitEthernet0/1, directly connected

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

via GigabitEthernet0/1, receive

L FF00::/8 [0/0]

via Null0, receive

-----------

R6

-----------

R6#show ip route

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

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

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

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

i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

ia - IS-IS inter area, \* - candidate default, U - per-user static route

o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP

+ - replicated route, % - next hop override

Gateway of last resort is 192.168.6.2 to network 0.0.0.0

O\*IA 0.0.0.0/0 [110/2] via 192.168.6.2, 00:26:08, FastEthernet0/1

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.3.0/24 is directly connected, FastEthernet0/0

L 192.168.3.2/32 is directly connected, FastEthernet0/0

192.168.6.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.6.0/24 is directly connected, FastEthernet0/1

L 192.168.6.1/32 is directly connected, FastEthernet0/1

R6#show ipv6 route

IPv6 Routing Table - default - 6 entries

Codes: C - Connected, L - Local, S - Static, U - Per-user Static route

B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP

I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary

D - EIGRP, EX - EIGRP external, NM - NEMO, ND - Neighbor Discovery

l - LISP

O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2

ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2

OI ::/0 [110/2]

via FE80::2, FastEthernet0/1

C 2001:DB8:A::/64 [0/0]

via FastEthernet0/1, directly connected

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

via FastEthernet0/1, receive

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

via FastEthernet0/0, directly connected

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

via FastEthernet0/0, receive

L FF00::/8 [0/0]

via Null0, receive

-----------

R7

-----------

R7#show ip route

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

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

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

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

i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

ia - IS-IS inter area, \* - candidate default, U - per-user static route

o - ODR, P - periodic downloaded static route

Gateway of last resort is 192.168.7.2 to network 0.0.0.0

O IA 192.168.4.0/24 [110/3] via 192.168.7.2, 00:23:57, FastEthernet0/1

O IA 192.168.6.0/24 [110/3] via 192.168.7.2, 00:26:53, FastEthernet0/1

C 192.168.7.0/24 is directly connected, FastEthernet0/1

C 192.168.1.0/24 is directly connected, FastEthernet0/0

O IA 192.168.2.0/24 [110/2] via 192.168.7.2, 00:26:53, FastEthernet0/1

O IA 192.168.3.0/24 [110/4] via 192.168.7.2, 00:22:40, FastEthernet0/1

O\*IA 0.0.0.0/0 [110/2] via 192.168.7.2, 00:26:53, FastEthernet0/1

R7#show ipv6 route

IPv6 Routing Table - Default - 10 entries

Codes: C - Connected, L - Local, S - Static, U - Per-user Static route

B - BGP, M - MIPv6, R - RIP, I1 - ISIS L1

I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP

EX - EIGRP external

O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2

ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2

OI ::/0 [110/2]

via FE80::1, FastEthernet0/1

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

via FE80::1, FastEthernet0/1

C 2001:DB8:B::/64 [0/0]

via FastEthernet0/1, directly connected

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

via FastEthernet0/1, receive

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

via FastEthernet0/0, directly connected

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

via FastEthernet0/0, receive

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

via FE80::1, FastEthernet0/1

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

via FE80::1, FastEthernet0/1

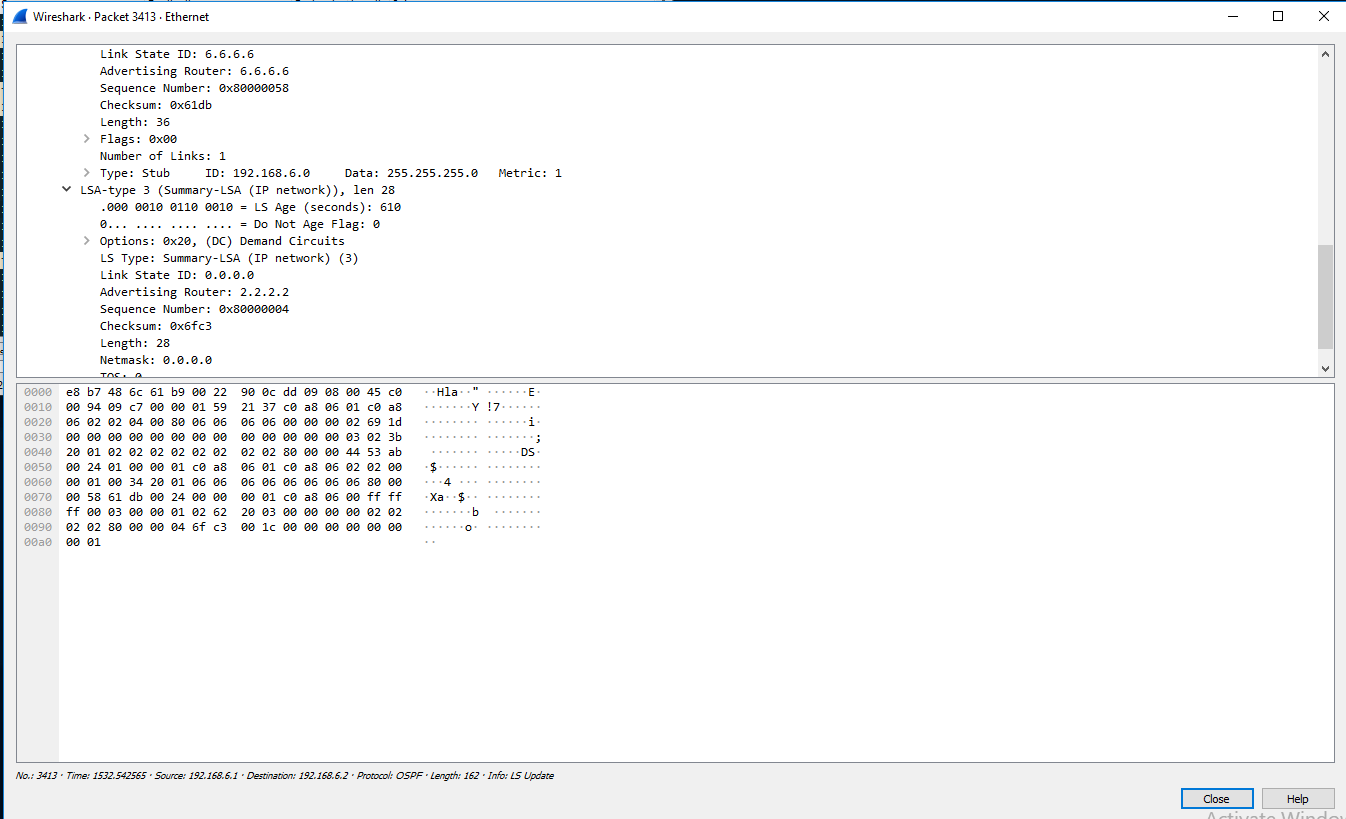
OI 2001:DB8:ACAD:D::/64 [110/3]

via FE80::1, FastEthernet0/1

L FF00::/8 [0/0]

via Null0, receive

Proof of Totally Stubby (LSA Type 3 with Default Route)



Proof of Not-So-Stubby (LSA Type 7)

