

Multi-Area OSPFv3

Fundamentals of OSPFv3 for IPv6

Adapted by Michael Anderson
from a slide deck courtesy of Bob Vachon

OSPFv3 - Theory of Operation

- Everything you've learned about how OSPFv2 works is identical under OSPFv3:
 - It's still the same link-state protocol, using the same SPF calculation
 - Three main data structures: Adjacency Database, LSDB, protocol routing table
 - Packets: Hello, DBD, LSR, LSU, LSAck
 - 5 steps for convergence: Neighbours, exchange LSA, build LSDB, SPF, routes
 - Single & Multi-Area: same reasons for choosing; same numbering; same rules
 - Same 7 states: Down, Init, 2-way, ExStart, Exchange, Loading, Full
 - DR/BDR elections on broadcast links (seldom used in 2022?!)
 - Same timers: Hello & dead (10 sec, 40 sec), update (30 mins)
 - Router types (Internal, Backbone, ABR, ASBR)
 - Same LSA type 1, 2, 3, 5 and rules for conversion and/or propagation
 - Same route types (O, O IA, OE1, OE2)
- As more advanced topics (NET3008), there are some additions and differences:
 - extra LSA types are used (8, 9)
 - the L3 protocol for transport of OSPFv3 is always via IPv6 link-local addresses*
- Notice the length of each section: Similarities = Long, differences = short!

* see slide 20 for additional implications

Steps to Configuring OSPFv3 for IPv6

1. Complete the OSPF network strategy and planning for your IPv6 network. (E.g., are multiple areas required?).
2. Enable OSPFv3 for IPv6 unicast routing: `ipv6 unicast-routing`
3. Configure a OSPFv3 for IPv6 router ID in router configuration mode.
 - `ipv6 router ospf process-id`
`router-id 32-bit-ip-address`
4. Enable OSPFv3 for IPv6 using the `ipv6 ospf area` interface command. Note: **no** option exists for using 'network ...' statements for OSPFv3
5. (Optional) Configure OSPFv3 for IPv6 interface specific settings.
 - Area, router priority, OSPFv3 path cost, ...
6. (Optional) Configure OSPFv3 for IPv6 routing specifics in router config mode:
 - Passive interfaces, reference bandwidth,
 - Advanced features such as Route summarization, stub areas, and so on.

Enter OSPFv3 for IPv6 Router Configuration Mode

- Configure the OSPFv3 for IPv6 routing process parameters.

```
Router(config)#
```

```
ipv6 router ospf process-id
```

- The `process-id` parameter identifies a unique OSPFv3 for IPv6 process local to the router and can be any positive integer.

```
R1(config)# ipv6 router ospf 10
```

```
R1(config-rtr)# ?
```

area	OSPF area parameters
auto-cost	Calculate OSPF interface cost according to bandwidth
default	Set a command to its defaults
default-information	Distribution of default information
default-metric	Set metric of redistributed routes
discard-route	Enable or disable discard-route installation
distance	Administrative distance
distribute-list	Filter networks in routing updates
ignore	Do not complain about specific event
log-adjacency-changes	Log changes in adjacency state
maximum-paths	Forward packets over multiple paths
passive-interface	Suppress routing updates on an interface
process-min-time	Percentage of quantum to be used before releasing CPU
redistribute	Redistribute IPv6 prefixes from another routing protocol
router-id	router-id for this OSPF process
summary-prefix	Configure IPv6 summary prefix
timers	Adjust routing timers

Configure the Router ID

- Define the router ID for OSPFv3 for IPv6.

```
Router(config-rtr)#
```

```
router-id {ip-address}
```

- The *ip-address* a number in a dotted-quad-decimal format.
 - The router ID must be unique on each router.
- The router ID selection process is the **same as for OSPFv2**.
 - Router ID is used if explicitly configured.
 - Otherwise, the highest loopback address is used.
 - Otherwise, the highest active IPv4 address.
 - Otherwise, the router ID must be explicitly configured.

```
R1(config-rtr)# router-id ?  
A.B.C.D OSPF router-id in IP address format  
  
R1(config-rtr)# router-id 10.10.10.1  
R1(config-rtr)#
```

Enable OSPFv3 for IPv6 on an Interface

- Enable an OSPFv3 for IPv6 instance on an interface.

```
Router(config-if) #
```

```
ipv6 ospf process-id area area-id
```

Parameter	Description
<i>process-id</i>	<ul style="list-style-type: none">Internal identifier for the OSPF process that is locally assigned and can be any positive integer.
<i>area-id</i>	<ul style="list-style-type: none">Specifies the area that is to be associated with the OSPF interface.

Enable OSPFv3 for IPv6 on an Interface

```
R1(config)# int fa0/0
R1(config-if)# ipv6 ospf ?
  <1-65535>          Process ID
  authentication    Enable authentication
  cost              Interface cost
  database-filter   Filter OSPF LSA during synchronization and flooding
  dead-interval     Interval after which a neighbor is declared dead
  demand-circuit   OSPF demand circuit
  flood-reduction   OSPF Flood Reduction
  hello-interval    Time between HELLO packets
  mtu-ignore        Ignores the MTU in DBD packets
  neighbor          OSPF neighbor
  network           Network type
  priority          Router priority
  retransmit-interval Time between retransmitting lost link state
                   advertisements
  transmit-delay    Link state transmit delay

R1(config-if)# ipv6 ospf 10 ?
  area Set the OSPF area ID

R1(config-if)# ipv6 ospf 10 area 0 ?
  instance Set the OSPF instance
  <cr>

R1(config-if)# ipv6 ospf 10 area 0
R1(config-if)#
```

Change the Interface Cost

- Specify the cost of sending a packet on an interface.

```
Router(config-if) #
```

```
ipv6 ospf cost interface-cost
```

- The *interface-cost* is a range from 1 to 65535.
- The default cost is the **same as IPv4**.

```
R1(config)# int fa0/0
R1(config-if)# ipv6 ospf cost ?
<1-65535> Cost

R1(config-if)# ipv6 ospf cost 1
R1(config-if)#
```


Change the Router Priority

- Change the OSPFv3 for IPv6 priority used in DR elections.

```
Router(config-if) #
```

```
ipv6 ospf priority number-value
```

- The *number-value* is a range from 0 to 255 with the default of 1.
 - A router with a router priority set to 0 is ineligible to become the DR or BDR.
- Higher router priority has precedence in an election.
 - If case of a tie, the higher router ID has precedence.

```
R1(config)# int fa0/0  
R1(config-if)# ipv6 ospf priority ?  
    <0-255>  Priority  
  
R1(config-if)# ipv6 ospf priority 10  
R1(config-if)#
```

Clear the OSPFv3 for IPv6 Process

- Trigger a new SPF recalculation and repopulation of the RIB.

```
Router(config-if) #
```

```
clear ipv6 ospf [process-id] {process | force-spf | redistribution |  
counters [neighbor [neighbor-interface | neighbor-id]]}
```

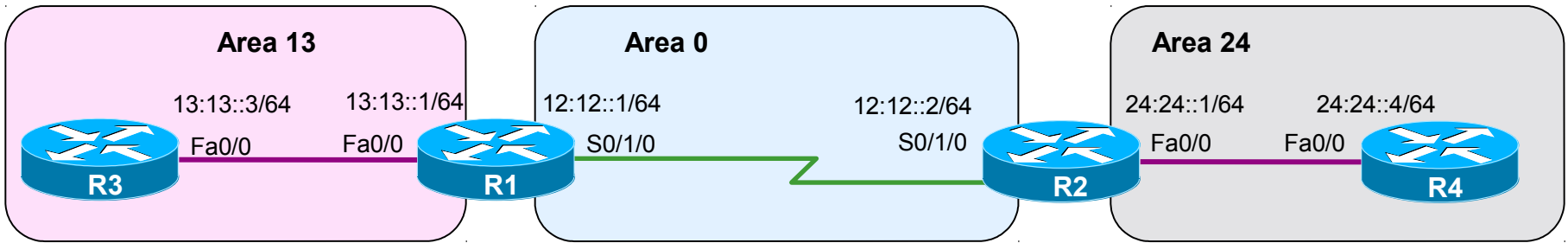
- Command is useful if OSPF settings have been altered.

```
R1# clear ipv6 ospf 10 ?  
  counters          OSPF counters  
  force-spf         Run SPF for OSPF process  
  process           Reset OSPF process  
  redistribution    Clear OSPF route redistribution  
R1# clear ipv6 ospf 10 counters  
R1#  
R1# clear ipv6 ospf 10 process  
Reset OSPF process? [no]: y  
R1#
```

Verifying OSPFv3 for IPv6

Command	Description
<pre>show ipv6 ospf [process-id] [area-id] neighbor [interface-type interface-number] [neighbor-id] [detail]</pre>	<ul style="list-style-type: none">• Displays OSPFv3 neighbor information.
<pre>show ipv6 ospf [process-id] [area-id] interface [type number] [brief]</pre>	<ul style="list-style-type: none">• Displays OSPFv3 interface information.
<pre>show ipv6 ospf [process-id] [area-id]</pre>	<ul style="list-style-type: none">• Displays general information about the IPv6 OSPF processes.

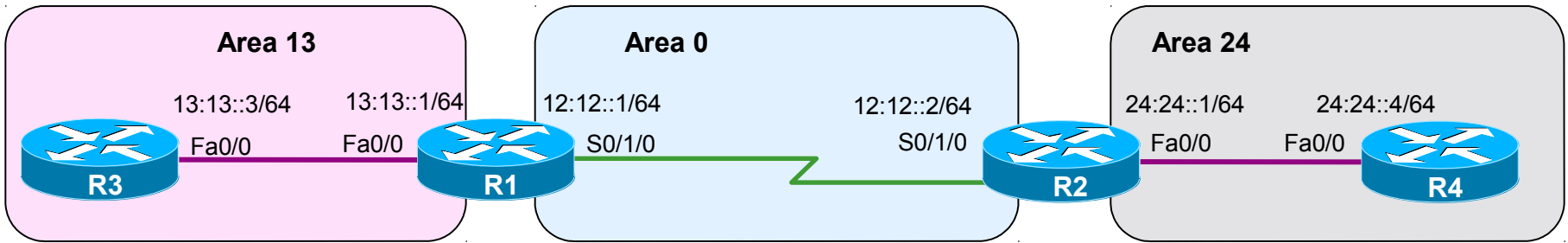
OSPFv3 for IPv6 Example 1



```
R1(config)# ipv6 unicast-routing
R1(config)#
R1(config)# interface s0/1/0
R1(config-if)# ipv6 ospf 1 area 0
R1(config-if)#
*Aug 14 06:24:23.040: %OSPFv3-4-NORTRID: OSPFv3 process 1 could not pick a routerid,
please configure manually
R1(config-if)# exit
R1(config)# ipv6 router ospf 1
R1(config-rtr)# router-id 0.0.0.1
R1(config-rtr)#exit
R1(config)# interface s0/1/0
R1(config-if)# ipv6 ospf 1 area 0
R1(config-if)# exit
R1(config)# interface fa0/0
R1(config-if)# ipv6 ospf 1 area 13
R1(config-if)#
```

- In this multi-area example, all four routers are supporting OSPFv3.

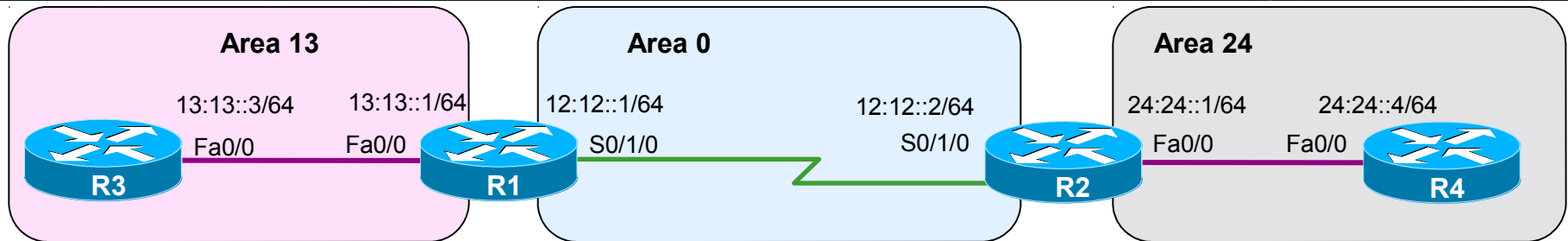
OSPFv3 for IPv6 Example 1



```
R2(config)# ipv6 unicast-routing
R2(config)#
R2(config)# ipv6 router ospf 1
R2(config-rtr)# router-id 0.0.0.2
R2(config-rtr)# exit
R2(config)#
R2(config)# interface s0/1/0
R2(config-if)# ipv6 ospf 1 area 0
*Aug 14 06:15:14.836: %OSPFv3-5-ADJCHG: Process 1, Nbr 0.0.0.1 on Serial0/1/0 from
LOADING to FULL, Loading Done
R2(config-if)#
R2(config)# interface fa0/0
R2(config-if)# ipv6 ospf 1 area 24
R2(config-if)#
```

- Notice how R2 immediately creates a neighbor adjacency with R1.

OSPFv3 for IPv6 Example 1



```
R2# show ipv6 ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Interface	ID	Interface
0.0.0.1	1	FULL/	-	00.00.33	6	Serial0/1/0

```
R2#
```

```
R2# show ipv6 ospf interface
```

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

```
Link Local Address FE80::219:55FF:FE92:B212, Interface ID 6
```

```
Area 0, Process ID 1, Instance ID 0, Router ID 0.0.0.2
```

```
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 00:00:09
```

```
Index 1/1/1, flood queue length 0
```

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

```
Last flood scan length is 1, maximum is 2
```

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

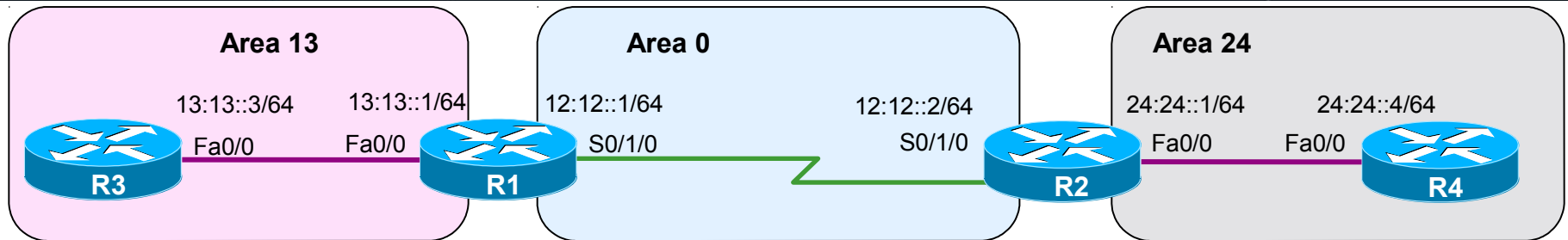
```
Neighbor Count is 1, Adjacent neighbor count is 1
```

```
Adjacent with neighbor 0.0.0.1
```

```
Suppress hello for 0 neighbor(s)
```

```
R2(config-if)#
```

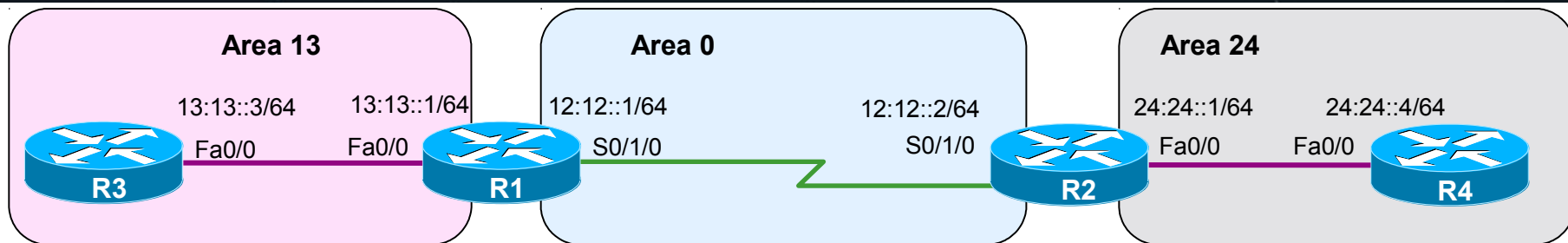
OSPFv3 for IPv6 Example 1



```
R4(config)# ipv6 unicast-routing
R4(config)# ipv6 router ospf 1
R4(config-rtr)# router-id 0.0.0.4
R4(config-rtr)# interface fa0/0
R4(config-if)# ipv6 ospf 1 area 24
*Aug 14 06:34:36.992: %OSPFv3-5-ADJCHG: Process 1, Nbr 0.0.0.2 on FastEthernet0/0
from LOADING to FULL, Loading Done
R4(config-if)# end
R4#
```

- R4 is configured and immediately forms an adjacency with R2.

OSPFv3 for IPv6 Example 1



```
R4# show ipv6 route ospf
```

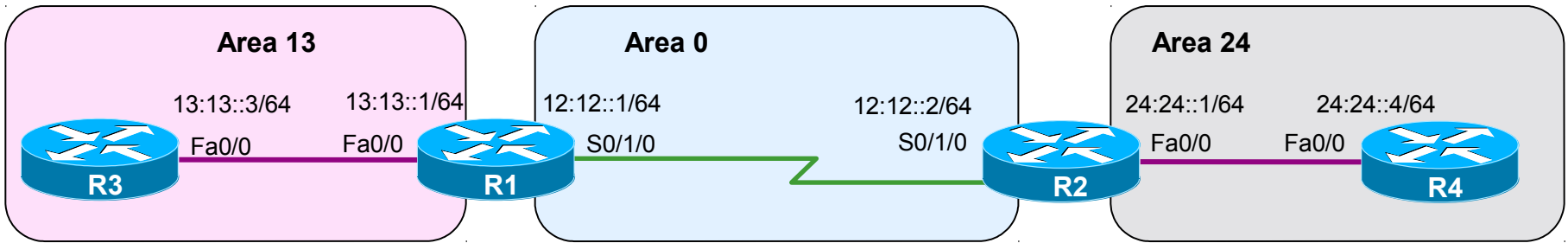
```
<output omitted>
```

```
OI 12:12::/64 [110/65]  
   via FE80::219:55FF:FE92:B212, FastEthernet0/0
```

```
R4#
```

- The routing table of R4 displays the Area 0 route 12:12::/64.

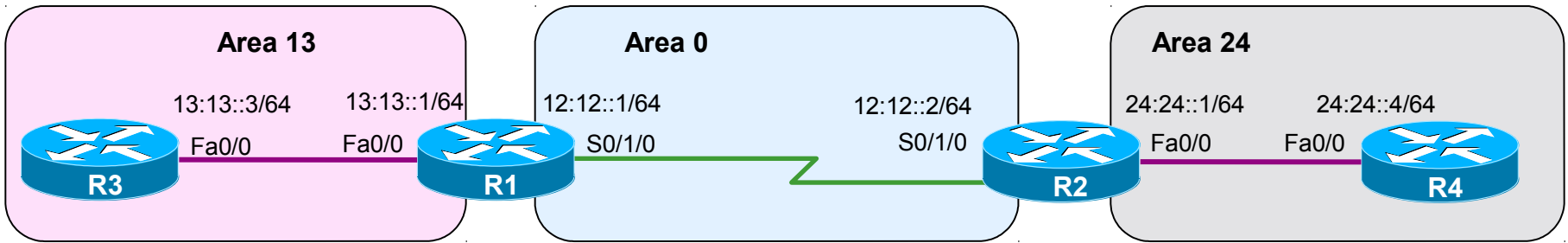
OSPFv3 for IPv6 Example 1



```
R3(config)# ipv6 unicast-routing
R3(config)# ipv6 router ospf 1
R3(config)#
*Aug 14 06:24:09.976: %OSPFv3-4-NORTRID: OSPFv3 process 1 could not pick a
router-id, please configure manually
R3(config-rtr)# router-id 0.0.0.3
R3(config-rtr)# exit
R3(config)# interface fa0/0
R3(config-if)# ipv6 ospf 1 area 13
R3(config-if)#
*Aug 14 06:40:43.804: %OSPFv3-5-ADJCHG: Process 1, Nbr 0.0.0.1 on FastEthernet0/0
from LOADING to FULL, Loading Done
R3(config-if)# end
R3#
```

- Finally R3 is configured and immediately forms an adjacency with R1.

OSPFv3 for IPv6 Example 1



```
R3# show ipv6 route ospf
```

```
<output omitted>
```

```
OI 12:12::/64 [110/65]
    via FE80::219:56FF:FE2C:9F60, FastEthernet0/0
OI 24:24::/64 [110/66]
    via FE80::219:56FF:FE2C:9F60, FastEthernet0/0
```

```
R3#
```

```
R3# ping 24:24::4
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 24:24::4, timeout is 2 seconds:
```

```
!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/16/16 ms
```

```
R3#
```

- The routing table of R3 reveals the Area 24 route.
- A ping to R4 verifies connectivity.

OSPFv3 and Address Families

- **OSPFv3 with the addresses family (AF)** unifies the OSPF configuration for both IPv4 and IPv6.
 - It supports the exchange of IPv6 and IPv4 routes.
- OSPFv3 utilizes a single OSPF process supporting both IPv4 and IPv6.
 - It combines neighbor tables and the LSDB under a single OSPF process.
 - The OSPF adjacencies are established separately for each address family.
 - Settings that are specific to an address family (IPv4/IPv6) are configured inside that address family router configuration mode.
- Running single OSPFv3 for both IPv4 and IPv6 is supported since Cisco IOS Software Release 15.1(3)S.

OSPFv3 and OSPFv2 Interoperability

- Bottom line: Zero, zilch, zip, nada, ixnay, none.
- This means: if you have OSPFv2 running on one device (regardless of the vendor), it will *never* be able to neighbour with another router running OSPFv3 (regardless of the vendor) even if the second router is configured for IPv4 as an address family
- Why?? The answer is entirely to do with the L3 transport protocol – IPv4 vs IPv6
 - OSPFv2 uses IPv4 exclusively
 - OSPFv3 uses IPv6 exclusively, even when exchanging IPv4 LSAs
 - ... and what have we learned about IPv4 vs IPv6? TOTALLY SEPARATE!(Now's the time to comment about the other Link-State routing protocol, ISIS!)

Imagine people of one country using their local language to talk about another country / language. That's similar to OSPFv3 using one language (IPv6) to communicate about another country / language (IPv4).

- **Suggestion:** for interoperability reasons (as well as for OSPFv3 support in PT), use OSPFv3 without Address Families and then no one will expect it to work and neighbour with OSPFv2 devices.
- But since AF is the newest (and greatest?), we'll have a look at configuring it.

Steps to Configuring OSPFv3 with AF

1. Complete the OSPF network strategy and planning for your IPv6 network. (E.g., are multiple areas required?).
2. Enable IPv6 unicast routing: `ipv6 unicast-routing`
3. Configure a router ID in OSPFv3 router configuration mode.
 - `ipv6 router ospf process-id` `router ospfv3 process-id`

Enable New-Style OSPFv3

- Configure the OSPFv3 routing process parameters.

```
Router(config)#
```

```
router ospfv3 process-id
```

Replaces the `ipv6 router ospf process-id` command.

```
R1(config)# router ospfv3 1
```

```
R1(config-router)# ?
```

```
Router configuration commands:
```

address-family	Enter Address Family command mode
area	OSPF area parameters
authentication	Authentication parameters
auto-cost	Calculate OSPF interface cost according to bandwidth
bfd	BFD configuration commands
compatible	Compatibility list
default	Set a command to its defaults
event-log	Event Logging
exit	Exit from routing protocol configuration mode
graceful-restart	Graceful-restart options
help	Description of the interactive help system
interface-id	Source of the interface ID
limit	Limit a specific OSPF feature
local-rib-criteria	Enable or disable usage of local RIB as route criteria
log-adjacency-changes	Log changes in adjacency state
max-lsa	Maximum number of non self-generated LSAs to accept
max-metric	Set maximum metric
no	Negate a command or set its defaults
passive-interface	Suppress routing updates on an interface
prefix-suppression	Enable prefix suppression
queue-depth	Hello/Router process queue depth
router-id	router-id for this OSPF process
shutdown	Shutdown the router process
timers	Adjust routing timers

```
R1(config-router)#
```

Clear the OSPFv3 Process

- Trigger a new SPF recalculation and repopulation of the RIB.

```
Router(config-if) #
```

```
clear ospfv3 [process-id] process
```

- Command is useful if OSPF settings have been altered.

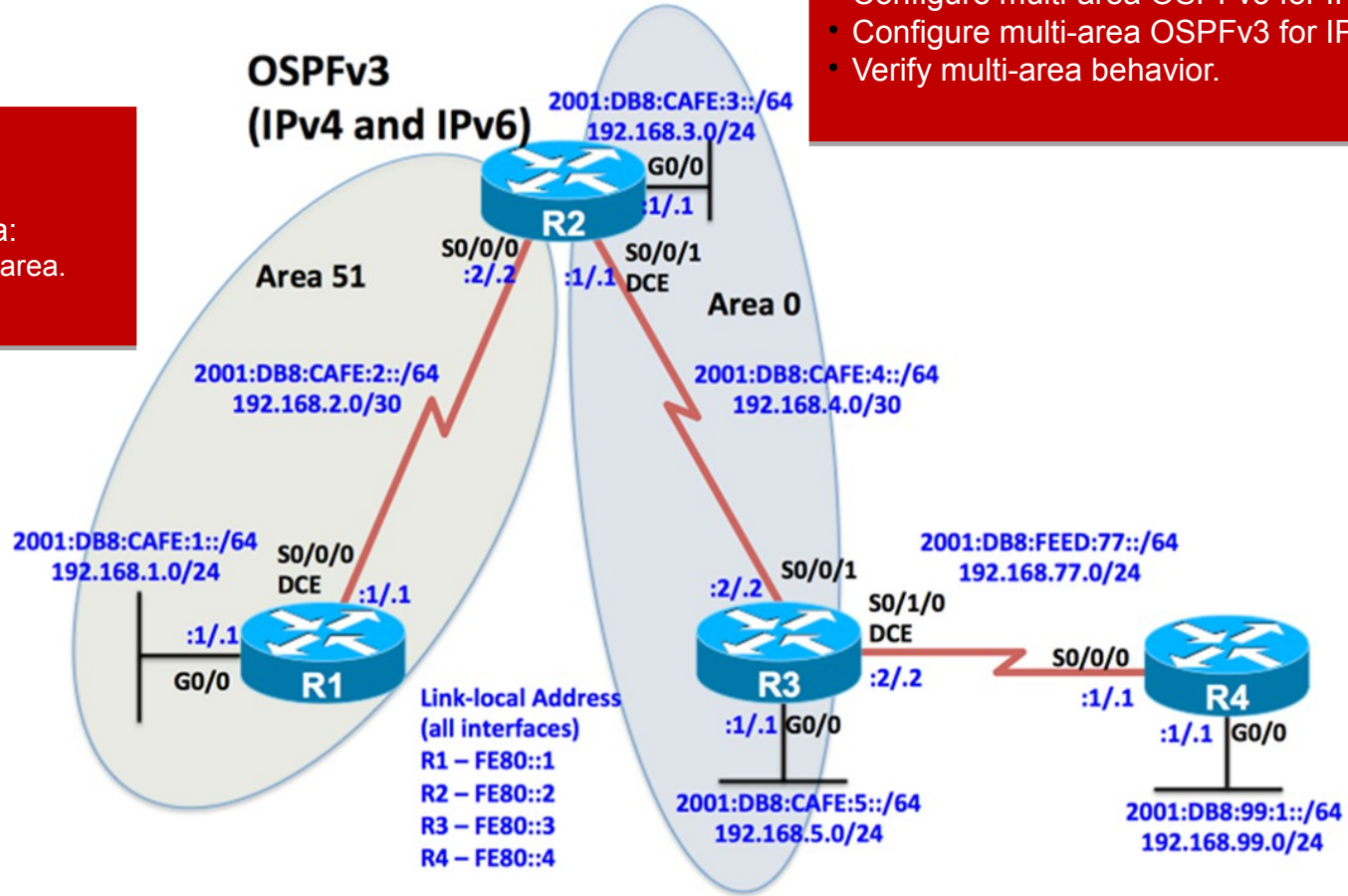
Example of OSPFv3 with AF

Area 51 will be configured as a:

- normal OSPF area.

Configuration Tasks:

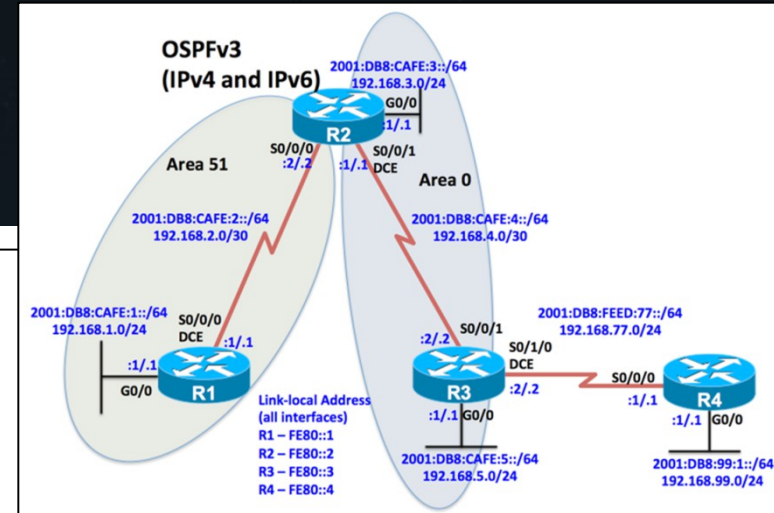
- Configure multi-area OSPFv3 for IPv4 AF.
- Configure multi-area OSPFv3 for IPv6 AF.
- Verify multi-area behavior.



Configure R1

```
R1(config)# ipv6 unicast-routing
R1(config)# router ospfv3 1
R1(config-router)# address-family ?
  ipv4 Address family
  ipv6 Address family
R1(config-router)#
R1(config-router)# address-family ipv4 unicast
R1(config-router-af)# ?
Router Address Family configuration commands:
  area                OSPF area parameters
  authentication      Authentication parameters
  auto-cost           Calculate OSPF interface cost according to bandwidth
  bfd                BFD configuration commands
  compatible          Compatibility list
  default             Set a command to its defaults
  default-information Control distribution of default information
  default-metric      Set metric of redistributed routes
  discard-route       Enable or disable discard-route installation
  distance            Define an administrative distance
  distribute-list     Filter networks in routing updates
  event-log           Event Logging
  exit-address-family Exit from Address Family configuration mode
  graceful-restart    Graceful-restart options
  help               Description of the interactive help system
  interface-id        Source of the interface ID
  limit              Limit a specific OSPF feature
  local-rib-criteria  Enable or disable usage of local RIB as route criteria
  log-adjacency-changes Log changes in adjacency state
  max-lsa            Maximum number of non self-generated LSAs to accept
  max-metric         Set maximum metric
  maximum-paths      Forward packets over multiple paths
  no                 Negate a command or set its defaults
  passive-interface   Suppress routing updates on an interface
  prefix-suppression Enable prefix suppression
  queue-depth        Hello/Router process queue depth
  redistribute        Redistribute information from another routing protocol
  router-id          router-id for this OSPF process
  shutdown           Shutdown the router process
  snmp               Modify snmp parameters
  summary-prefix     Configure IP address summaries
  timers             Adjust routing timers

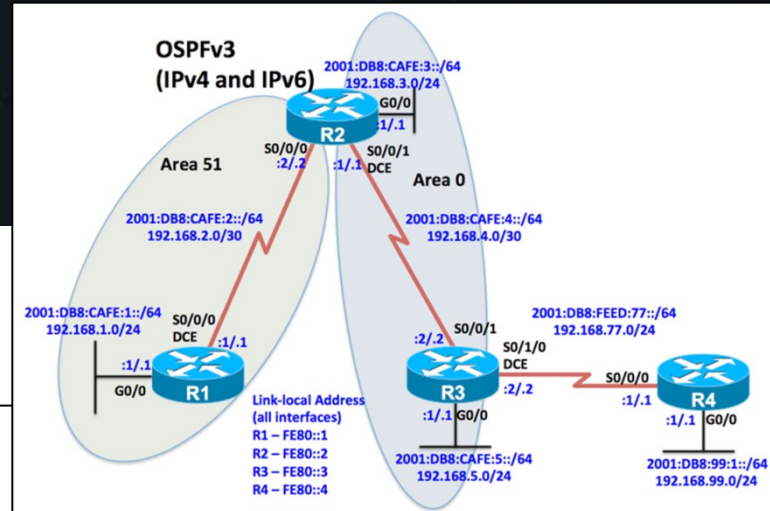
R1(config-router-af)#
```



Configure R1

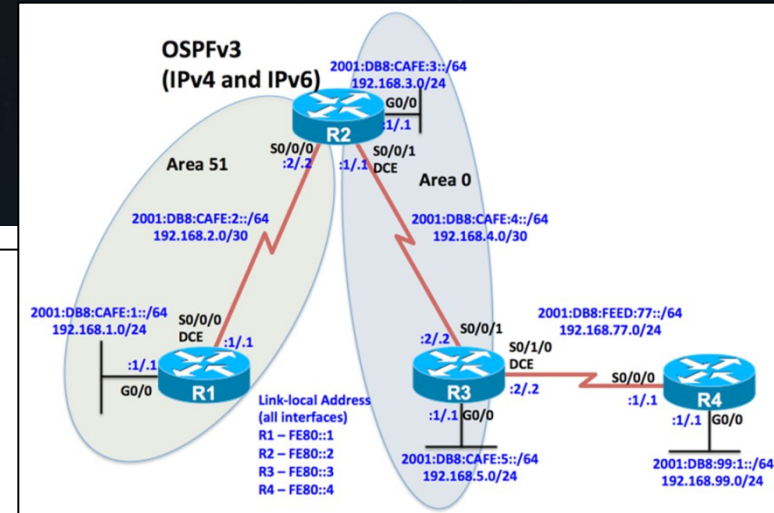
```
R1(config)# ipv6 unicast-routing
R1(config)# router ospfv3 1
R1(config-router)# address-family ipv4 unicast
R1(config-router-af)# router-id 1.1.1.1
R1(config-router-af)# passive-interface g0/0
R1(config-router-af)# exit-address-family
R1(config-router)#
R1(config-router)# address-family ipv6 unicast
R1(config-router-af)# router-id 1.1.1.6
R1(config-router-af)# passive-interface g0/0
R1(config-router-af)# exit-address-family
R1(config-router)# exit
R1(config)#
R1(config)# interface gigabitethernet 0/0
R1(config-if)# ospfv3 1 ipv4 area 51
R1(config-if)# ospfv3 1 ipv6 area 51
R1(config-if)# exit
R1(config)#
R1(config)# interface serial 0/0/0
R1(config-if)# ospfv3 1 ipv4 area 51
R1(config-if)# ospfv3 1 ipv6 area 51
R1(config-if)#
```

Replaces the `ipv6 ospf process-id area area-id` command.



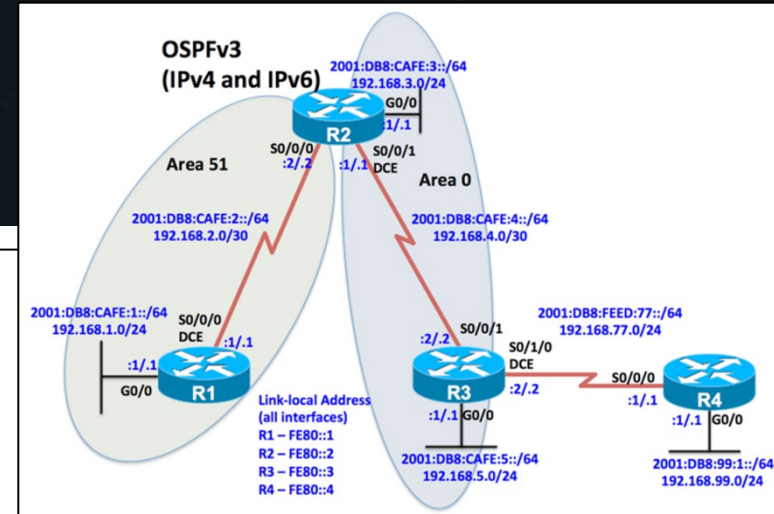
Configure R2

```
R2(config)# ipv6 unicast-routing
R2(config)# router ospfv3 1
R2(config-router)# address-family ipv4 unicast
R2(config-router-af)# router-id 2.2.2.2
R2(config-router-af)# passive-interface gigabitethernet 0/0
R2(config-router-af)# exit-address-family
R2(config-router)#
R2(config-router)# address-family ipv6 unicast
R2(config-router-af)# router-id 2.2.2.6
R2(config-router-af)# passive-interface gigabitethernet 0/0
R2(config-router-af)# exit-address-family
R2(config-router)#
R2(config-router)# interface serial 0/0/1
R2(config-if)# ospfv3 1 ipv4 area 0
R2(config-if)# ospfv3 1 ipv6 area 0
R2(config-if)# exit
R2(config)#
R2(config)# interface gigabitethernet 0/0
R2(config-if)# ospfv3 1 ipv4 area 0
R2(config-if)# ospfv3 1 ipv6 area 0
R2(config-if)# exit
R2(config)#
R2(config)# interface serial 0/0/0
R2(config-if)# ospfv3 1 ipv4 area 51
R2(config-if)# ospfv3 1 ipv6 area 51
R2(config-if)#
*Feb 16 01:59:57.727: %OSPFv3-5-ADJCHG: Process 1, IPv4, Nbr 1.1.1.1 on Serial0/0/0 from LOADING
to FULL,Loading Done
*Feb 16 01:59:57.727: %OSPFv3-5-ADJCHG: Process 1, IPv6, Nbr 1.1.1.6 on Serial0/0/0 from LOADING
to FULL,Loading Done
```



Configure R3

```
R3(config)# ipv6 unicast-routing
R3(config)# router ospfv3 1
R3(config-router)# address-family ipv4 unicast
R3(config-router-af)# router-id 3.3.3.3
R3(config-router-af)# passive-interface gigabitethernet 0/0
R3(config-router-af)# exit-address-family
R3(config-router)#
R3(config-router)# address-family ipv6 unicast
R3(config-router-af)# router-id 3.3.3.6
R3(config-router-af)# passive-interface gigabitethernet 0/0
R3(config-router-af)# exit-address-family
R3(config-router)# exit
R3(config)#
R3(config)# interface gigabitethernet 0/0
R3(config-if)# ospfv3 1 ipv4 area 0
R3(config-if)# ospfv3 1 ipv6 area 0
R3(config-if)# exit
R3(config)#
R3(config)# interface serial 0/0/1
R3(config-if)# ospfv3 1 ipv4 area 0
R3(config-if)# ospfv3 1 ipv6 area 0
R3(config-if)#
*Feb 16 01:49:29.535: %OSPFv3-5-ADJCHG: Process 1, IPv4, Nbr 2.2.2.2 on Serial0/0/1 from LOADING
to FULL, Loading Done
*Feb 16 01:49:29.555: %OSPFv3-5-ADJCHG: Process 1, IPv6, Nbr 2.2.2.6 on Serial0/0/1 from LOADING
to FULL, Loading Done
R3(config-if)#
```



Verify R2

```
R2# show ip ospf neighbor
R2#
R2# show ipv6 ospf neighbor
```

Command shows only OSPFv2 output.

```
OSPFv3 Router with ID (2.2.2.6) (Process ID 1)
```

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
3.3.3.6	0	FULL/ -	00:00:31	7	Serial0/0/1
1.1.1.6	0	FULL/ -	00:00:33	6	Serial0/0/0

```
R2#
R2# show ospfv3 neighbor
```

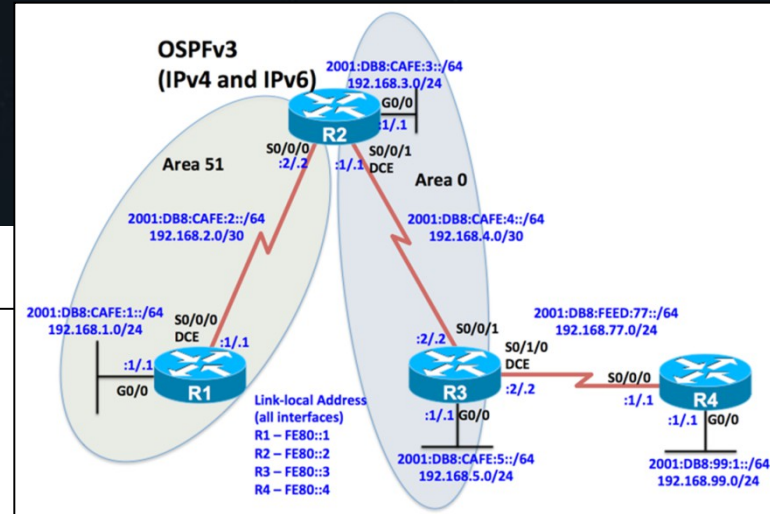
```
OSPFv3 1 address-family ipv4 (router-id 2.2.2.2)
```

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
3.3.3.3	0	FULL/ -	00:00:31	7	Serial0/0/1
1.1.1.1	0	FULL/ -	00:00:38	6	Serial0/0/0

```
OSPFv3 1 address-family ipv6 (router-id 2.2.2.6)
```

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
3.3.3.6	0	FULL/ -	00:00:36	7	Serial0/0/1
1.1.1.6	0	FULL/ -	00:00:38	6	Serial0/0/0

```
R2#
```



Command explicitly displays only OSPFv3 adjacencies.

Command displays adjacency information for IPv4 and IPv6 AFs.

Verify R3

Command displays only OSPF IPv4 information.

```
R3# show ip route | begin Gateway
Gateway of last resort is not set
```

```
O IA 192.168.1.0/24 [110/129] via 192.168.4.1, 00:24:32, Serial0/0/1
      192.168.2.0/30 is subnetted, 1 subnets
O IA   192.168.2.0 [110/128] via 192.168.4.1, 00:24:32, Serial0/0/1
O     192.168.3.0/24 [110/65] via 192.168.4.1, 00:24:32, Serial0/0/1
      192.168.4.0/24 is variably subnetted, 2 subnets, 2 masks
C     192.168.4.0/30 is directly connected, Serial0/0/1
L     192.168.4.2/32 is directly connected, Serial0/0/1
      192.168.77.0/24 is variably subnetted, 2 subnets, 2 masks
C     192.168.77.0/24 is directly connected, Serial0/0/0
L     192.168.77.2/32 is directly connected, Serial0/0/0
```

```
R3#
```

```
R3# show ip route ospf
```

Routes were not learned using OSPF2

```
R3#
```

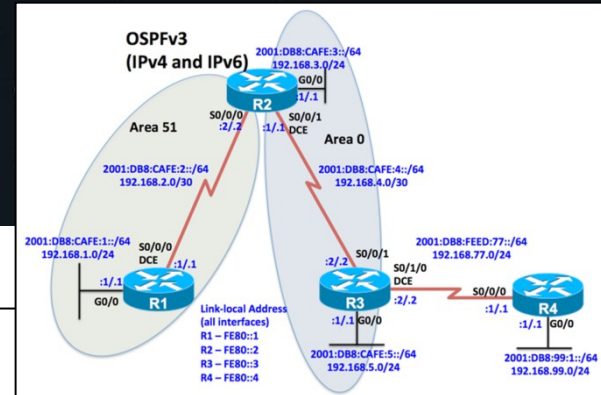
```
R3# show ip route ospfv3 | begin ^O
```

```
O IA 192.168.1.0/24 [110/129] via 192.168.4.1, 00:25:00, Serial0/0/1
      192.168.2.0/30 is subnetted, 1 subnets
O IA   192.168.2.0 [110/128] via 192.168.4.1, 00:25:00, Serial0/0/1
O     192.168.3.0/24 [110/65] via 192.168.4.1, 00:25:00, Serial0/0/1
```

```
R3#
```

```
R3# show ipv6 route ospf | begin ^O
```

```
OI 2001:DB8:CAFE:1::/64 [110/129]
    via FE80::2, Serial0/0/1
OI 2001:DB8:CAFE:2::/64 [110/128]
    via FE80::2, Serial0/0/1
O  2001:DB8:CAFE:3::/64 [110/65]
    via FE80::2, Serial0/0/1
```



Command displays OSPFv3 IPv4 AF information.

Propagate Default Routes on R3

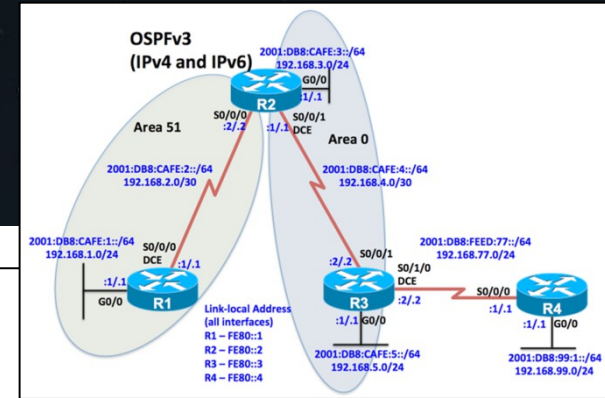
Configure IPv4 and IPv6 default routes on the ASBR R3 forwarding traffic to R4.

```
R3(config)# ip route 0.0.0.0 0.0.0.0 192.168.77.1
R3(config)#
R3(config)# ipv6 route ::/0 2001:db8:feed:77::1
R3(config)#
R3(config)# router ospfv3 1
R3(config-router)# address-family ipv4 unicast
R3(config-router-af)# default-information originate
R3(config-router-af)# exit-address-family
R3(config-router)#
R3(config-router)# address-family ipv6 unicast
R3(config-router-af)# default-information originate
R3(config-router-af)# exit-address-family
R3(config-router)# end
R3#
R3# show ip route static | begin ^Gateway
Gateway of last resort is 192.168.77.1 to network 0.0.0.0
S*    0.0.0.0/0 [1/0] via 192.168.77.1
R3#
R3# show ipv6 route static | begin ^S
S     ::/0 [1/0]
      via 2001:DB8:FEED:77::1
R3#
```

Configure R3 to propagate both default routes into OSPFv3 within the appropriate address family.

Verify if the IPv4 static route is installed in the routing table.

Verify if the IPv6 static route is installed in the routing table.



Propagate Static Routes on R3

Configure IPv4 and IPv6 static routes on the ASBR, R3 for the 192.168.99.0/24 and 2001:db8:99:1::/64 network on R4.

```
R3(config)# ip route 192.168.99.0 255.255.255.0 192.168.77.1
R3(config)#
R3(config)# ipv6 route 2001:db8:99:1::/64 2001:db8:feed:77::1
R3(config)#
R3(config)# router ospfv3 1
R3(config-router)# address-family ipv4 unicast
R3(config-router-af)# redistribute static
R3(config-router-af)# exit-address-family
R3(config-router)#
R3(config-router)# address-family ipv6 unicast
R3(config-router-af)# redistribute static
R3(config-router-af)#
```

Redistribute the static route into OSPFv3 IPv4 and IPv6 AFs using the **redistribute static** command in each address family configuration mode.

Verify if R1 is learning the IPv4 OSPFv3 routes.

```
R1# show ip route ospfv3 | begin Gateway
Gateway of last resort is 192.168.2.2 to network 0.0.0.0

O*E2 0.0.0.0/0 [110/1] via 192.168.2.2, 00:22:40, Serial0/0/0
O IA 192.168.3.0/24 [110/65] via 192.168.2.2, 01:04:55, Serial0/0/0
    192.168.4.0/30 is subnetted, 1 subnets
O IA 192.168.4.0 [110/128] via 192.168.2.2, 01:04:55, Serial0/0/0
O E2 192.168.99.0/24 [110/20] via 192.168.2.2, 00:04:14, Serial0/0/0
R1#
R1# show ipv6 route ospf | begin ^O
OE2 ::/0 [110/1], tag 1
    via FE80::2, Serial0/0/0
OE2 2001:DB8:99:1::/64 [110/20]
    via FE80::2, Serial0/0/0
OI 2001:DB8:CAFE:3::/64 [110/65]
    via FE80::2, Serial0/0/0
OI 2001:DB8:CAFE:4::/64 [110/128]
    via FE80::2, Serial0/0/0
```

Verify if R1 is learning the IPv6 routes

