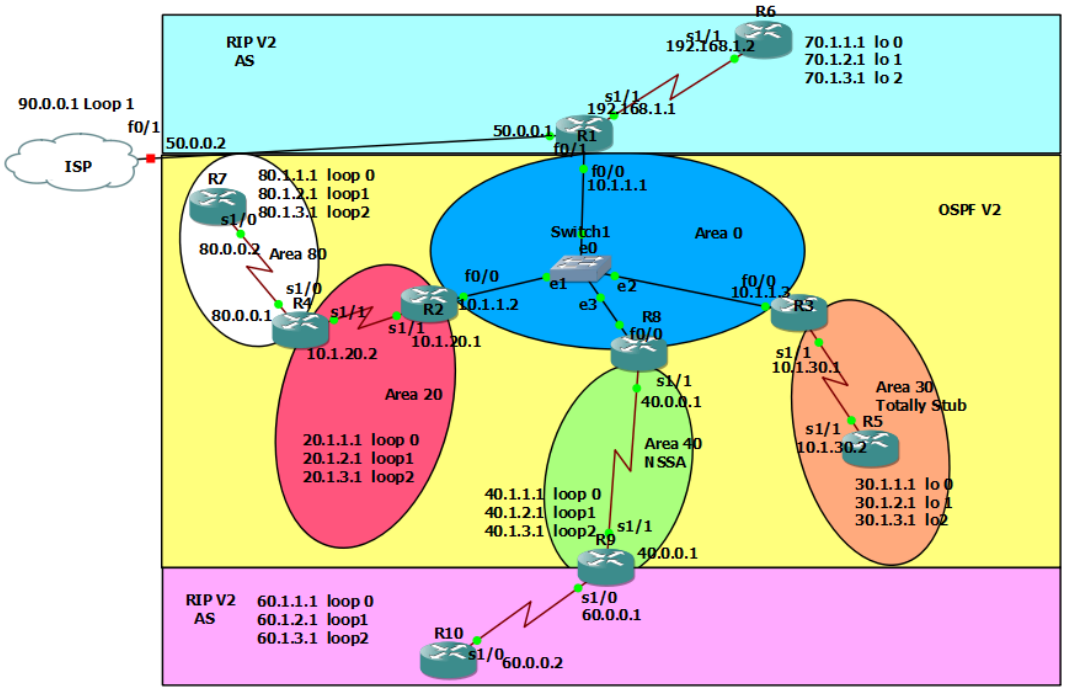
RIP & OSPF Multi-Area with Redistribution

1. Objective

- Configure a multi-area OSPF network with different area types (standard, stub, totally stub, NSSA).
- Connect the OSPF AS to RIP v2 domains.
- Configure redistribution between RIP and OSPF.
- Configure ISP connectivity with NAT.
- Verify full end-to-end communication (internal ↔ external).

2. Topology Overview

- **Routing Protocols**: RIP v2 and OSPF.
- **Routers**: R1–R10 + ISP router.
- **Special Areas**:
  - **Area 0**: Backbone.
  - **Area 20**: Standard OSPF.
  - **Area 30**: Totally Stubby Area.
  - **Area 40**: NSSA.
  - **Area 80**: Standard OSPF Area.
- **Redistribution Routers**: R1, R4, R8, R9.
- **ISP Connectivity**: R1 ↔ ISP router.
- **NAT Gateway**: R1.



3. Step-by-Step Configuration

Step 1 – Basic Device Setup

- Assign hostnames to all routers (R1–R10).
- Configure IP addresses on all interfaces as shown in the topology.
- **make this configuration on each router:**

#conf t

#int (interface-value)

#no shutdown

#ip address (ip-value subnet-value)

- **verify ip address on each router:**

```
R1#show  ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        10.1.1.1        YES NVRAM  up                    up
FastEthernet0/1        50.0.0.1        YES manual up                    up
Serial1/0              unassigned      YES NVRAM  administratively down down
Serial1/1              192.168.1.1     YES NVRAM  up                    up
Serial1/2              unassigned      YES NVRAM  administratively down down
Serial1/3              unassigned      YES NVRAM  administratively down down
FastEthernet2/0        unassigned      YES NVRAM  administratively down down
```

```
R2#show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        10.1.1.2        YES NVRAM  up                    up
FastEthernet0/1        unassigned      YES NVRAM  administratively down down
Serial1/0              unassigned      YES NVRAM  administratively down down
Serial1/1              10.1.20.1       YES NVRAM  up                    up
Serial1/2              unassigned      YES NVRAM  administratively down down
Serial1/3              unassigned      YES NVRAM  administratively down down
FastEthernet2/0        unassigned      YES NVRAM  administratively down down
```

```
R3#show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        10.1.1.3        YES NVRAM  up                    up
FastEthernet0/1        unassigned      YES NVRAM  administratively down down
Serial1/0              unassigned      YES NVRAM  administratively down down
Serial1/1              10.1.30.1       YES NVRAM  up                    up
Serial1/2              unassigned      YES NVRAM  administratively down down
Serial1/3              unassigned      YES NVRAM  administratively down down
FastEthernet2/0        unassigned      YES NVRAM  administratively down down
```

in R4 & R5 & R7 & R9 & R10 we we add loopback

#conf t

#int loopback no.

ip address ip-value subnet value

R4#sh ip int br

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	unassigned	YES	NVRAM	administratively down	down
FastEthernet0/1	unassigned	YES	NVRAM	administratively down	down
Serial1/0	80.0.0.1	YES	NVRAM	up	up
Serial1/1	10.1.20.2	YES	NVRAM	up	up
Serial1/2	unassigned	YES	NVRAM	administratively down	down
Serial1/3	unassigned	YES	NVRAM	administratively down	down
FastEthernet2/0	unassigned	YES	NVRAM	administratively down	down
Loopback0	20.1.1.1	YES	NVRAM	up	up
Loopback1	20.1.2.1	YES	NVRAM	up	up
Loopback2	20.1.3.1	YES	NVRAM	up	up

R5#sh ip int br

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	unassigned	YES	NVRAM	administratively down	down
FastEthernet0/1	unassigned	YES	NVRAM	administratively down	down
Serial1/0	unassigned	YES	NVRAM	administratively down	down
Serial1/1	10.1.30.2	YES	NVRAM	up	up
Serial1/2	unassigned	YES	NVRAM	administratively down	down
Serial1/3	unassigned	YES	NVRAM	administratively down	down
FastEthernet2/0	unassigned	YES	NVRAM	administratively down	down
Loopback0	30.1.1.1	YES	NVRAM	up	up
Loopback1	30.1.2.1	YES	NVRAM	up	up
Loopback2	30.1.3.1	YES	NVRAM	up	up

and so on for all routers

- Verify connectivity with **ping** between directly connected routers.

R1 ping R6

R1#ping 192.168.1.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/29/32 ms

R2 ping R4

R2#ping 10.1.20.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.20.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 72/76/80 ms

Observation: All IP addresses were configured successfully, and direct connectivity was verified using ping.

Step 2 – RIP v2 Configuration

- Enable RIP v2 on routers in the RIP AS (R1, R6, R9, R10, and ISP router).
- Advertise directly connected networks.
- Use `version 2` and `no auto-summary`.

R1#conf t
R1(config)#router rip
R1(config-router)#v 2
R1(config-router)#no auto
R1(config-router)#no auto-summary
R1(config-router)#network 192.168.1.0

R6#conf t
R6(config)#router rip
R6(config-router)#v 2
R6(config-router)#no auto-summary
R6(config-router)#network 192.168.1.0
R6(config-router)#network 70.0.0.0

```
R9#conf t
R9(config)#router rip
R9(config-router)#v 2
R9(config-router)#no auto-summary
R9(config-router)#network 60.0.0.0
```

```
R10#conf t
R10(config)#router rip
R10(config-router)#v 2
R10(config-router)#no auto-summary
R10(config-router)#network 60.0.0.0
R10(config-router)#network 60.1.0.0
```

Observation: RIP neighbors formed correctly. Internal subnets were exchanged, and `show ip route` confirmed RIP routes installed.

Step 3 – OSPF Area 0 Configuration

- Configure OSPF process ID (e.g., 1).
- Place routers R1,R2, R3, and R8 into **Area 0**.
- Verify adjacency using `show ip ospf neighbor`.

```
R1#CONF T
R1(config)#router ospf 1
R1(config-router)#router-id 1.1.1.1
R1(config-router)#network 10.1.1.1 0.0.0.0 area 0
```

```
R2#conf t
R2(config)#router ospf 1
R2(config-router)#router-id 2.2.2.2
R2(config-router)#network 10.1.1.2 0.0.0.0 area 0
```

```
R3#conf t
R3(config)#router ospf 1
R3(config-router)#router-id 3.3.3.3
R3(config-router)#network 10.1.1.3 0.0.0.0 area 0
```

```
R8#conf t
R8(config)#router ospf 1
R8(config-router)#router-id 8.8.8.8
R8(config-router)#network 10.1.1.4 0.0.0.0 area 0
```

Step 4 – Other OSPF Areas

- **Area 20** : Configure R2 ↔ R4 link and Lo interfaces on R4.

```
R2#conf t
R2(config)#router ospf 1
R2(config-router)#router-id 2.2.2.2
R2(config-router)#network 10.1.20.1 0.0.0.0 area 20
R2(config-router)#network 20.1.0.0 0.0.0.0 area 20
```

```
R4#conf t
R4(config)#router ospf 1
R4(config-router)#router-id 4.4.4.4
R4(config-router)#network 10.1.20.2 0.0.0.0 area 20
R4(config-router)#network 20.1.0.0 0.0.0.0 area 20
```

- **Area 30** : Configure R3 ↔ R5 link and Lo interfaces on R5

```
R3#conf t
R3(config)#router ospf 1
R3(config-router)#network 10.1.30.1 0.0.0.0 area 30
R3(config-router)#network 30.1.0.0 0.0.0.0 area 30
```

```
R5#conf t
R5(config)#router ospf 1
R5(config-router)#router-id 5.5.5.5
R5(config-router)#network 10.1.30.2 0.0.0.0 area 30
R5(config-router)#network 30.1.0.0 0.0.0.0 area 30
```

- **Area 40** : Configure R8 ↔ R9 link and Lo interfaces on R9

```
R8#conf t
R8(config)#router ospf 1
R8(config-router)#router-id 8.8.8.8
R8(config-router)#network 40.0.0.1 0.0.0.0 area 40
```

```
R9#conf t
R9(config)#router ospf 1
R9(config-router)#router-id 9.9.9.9
R9(config-router)#network 40.0.0.2 0.0.0.0 area 40
R9(config-router)#network 40.1.0.0 0.0.0.0 area 40
```

- **Area 80**: Connect R4 ↔ R7. Configure R7 Lo interfaces under OSPF.

```
R4(config)#router ospf 1
R4(config-router)#network 80.0.0.1 0.0.0.0 area 80
```

```
R7#conf t
R7(config)#router ospf 1
R7(config-router)#router-id 7.7.7.7
R7(config-router)#network 80.0.0.2 0.0.0.0 area 80
R7(config-router)#network 80.1.0.0 0.0.0.0 area 80
```

Verify OSPF

Verify with `show ip ospf neighbor`.

```
R1#show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           1   FULL/DR         00:00:35    10.1.1.2        FastEthernet0/0
3.3.3.3           1   FULL/DROTHER    00:00:32    10.1.1.3        FastEthernet0/0
8.8.8.8           1   FULL/DROTHER    00:00:31    10.1.1.4        FastEthernet0/0
```

R2#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
1.1.1.1	1	FULL/BDR	00:00:39	10.1.1.1	FastEthernet0/0
3.3.3.3	1	FULL/DROTHER	00:00:39	10.1.1.3	FastEthernet0/0
8.8.8.8	1	FULL/DROTHER	00:00:39	10.1.1.4	FastEthernet0/0
4.4.4.4	0	FULL/ -	00:00:39	10.1.20.2	

R3#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
1.1.1.1	1	FULL/BDR	00:00:36	10.1.1.1	FastEthernet0/0
2.2.2.2	1	FULL/DR	00:00:35	10.1.1.2	FastEthernet0/0
8.8.8.8	1	2WAY/DROTHER	00:00:31	10.1.1.4	FastEthernet0/0
5.5.5.5	0	FULL/ -	00:00:38	10.1.30.2	

R4#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.2.2	0	FULL/ -	00:00:39	10.1.20.1	Serial1/1
7.7.7.7	0	FULL/ -	00:00:31	80.0.0.2	

R5#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
3.3.3.3	0	FULL/ -	00:00:34	10.1.30.1	

R7#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
4.4.4.4	0	FULL/ -	00:00:34	80.0.0.1	

R8#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
1.1.1.1	1	FULL/BDR	00:00:38	10.1.1.1	FastEthernet0/0
2.2.2.2	1	FULL/DR	00:00:37	10.1.1.2	FastEthernet0/0
3.3.3.3	1	2WAY/DROTHER	00:00:34	10.1.1.3	FastEthernet0/0
9.9.9.9	0	FULL/ -	00:00:38	40.0.0.2	Serial1/1

```
R9#sh ip ospf nei
Neighbor ID     Pri   State           Dead Time   Address         Interface
8.8.8.8           0   FULL/  -        00:00:32    40.0.0.1
```

- **Area 30 (Totally Stub)**: Configure R3 ↔ R5 link. Mark it as `area 30 stub no-summary`.

```
R3#conf t
R3(config)#router ospf 1
R3(config-router)#area 30 stub no-summary  → totally stub
```

```
R5#conf t
R5(config)#router ospf 1
R5(config-router)#area 30 stub no-summary
```

- **Area 40 (NSSA)**: Configure R8 ↔ R9 link as NSSA using `area 40 nssa`.

```
R8(config)#router ospf 1
R8(config-router)#area 40 nssa no-summary → prevent type-3 and convert type-5 to type-7
```

```
R9(config)#router ospf 1
R9(config-router)#area 40 nssa
```

Observation:

- OSPF adjacencies came up successfully. Backbone and non-backbone areas were connected, and routing tables were updated with OSPF intra-area and inter-area routes.
- In Area 30 (Totally Stub), only a default route was learned as expected.
- In Area 40 (NSSA), redistributed routes appeared as **Type 7 LSAs**, which were later translated into Type 5 LSAs by the ABR.

Step 5 – OSPF Database Verification, Virtual Link, and RIP Redistribution

- Used the command `show ip ospf database` on multiple routers to verify OSPF operation.
- Confirmed that OSPF areas were exchanging LSAs as expected.
- Observed missing routes in some areas, which indicated the need for additional configuration.
- Identified two required actions based on the database output:

- **Configure a Virtual Link** → to connect isolated areas back to Area 0.
- **Redistribute RIP into OSPF** → to advertise RIP-learned routes (Area 60) into the OSPF domain.

- Collected screenshots of OSPF database outputs (R2, R4, R7, and R9) to show:
  - Correct Router-ID assignments.
  - LSAs in Backbone Area 0.
  - LSAs in Stub, Totally Stub, and NSSA areas (Type-3, Type-5, Type-7).
- Verification step confirmed that OSPF was functioning correctly after applying the fixes.

R1#sh 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         1605        0x80000003 0x003FC5 1
2.2.2.2         2.2.2.2         1220        0x80000004 0x0002F7 1
3.3.3.3         3.3.3.3         491         0x80000004 0x00C32D 1
8.8.8.8         8.8.8.8         99          0x80000005 0x00586C 1

          Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.2        2.2.2.2         466         0x80000004 0x008F51

          Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.20.0       2.2.2.2         1220        0x80000002 0x006272
10.1.30.0       3.3.3.3         491         0x80000002 0x00D5F0
40.0.0.0        8.8.8.8         581         0x80000001 0x0011A3
```

R2#sh 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         1641        0x80000003 0x003FC5 1
2.2.2.2         2.2.2.2         1255        0x80000004 0x0002F7 1
3.3.3.3         3.3.3.3         526         0x80000004 0x00C32D 1
8.8.8.8         8.8.8.8         134         0x80000005 0x00586C 1

            Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.2        2.2.2.2         500         0x80000004 0x008F51

            Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.20.0       2.2.2.2         1255        0x80000002 0x006272
10.1.30.0       3.3.3.3         526         0x80000002 0x00D5F0
40.0.0.0        8.8.8.8         616         0x80000001 0x0011A3

            Router Link States (Area 20)

Link ID         ADV Router      Age         Seq#       Checksum Link count
2.2.2.2         2.2.2.2         753         0x80000003 0x003B07 2
4.4.4.4         4.4.4.4         753         0x80000002 0x006BCF 2

            Summary Net Link States (Area 20)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.0        2.2.2.2         1259        0x80000002 0x001608
10.1.30.0       2.2.2.2         506         0x80000002 0x005868
40.0.0.0        2.2.2.2         620         0x80000001 0x002A98

            Summary ASB Link States (Area 20)

Link ID         ADV Router      Age         Seq#       Checksum
8.8.8.8         2.2.2.2         134         0x80000001 0x0032D7
```

R3#sh 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         1679        0x80000003 0x003FC5 1
2.2.2.2         2.2.2.2         1294        0x80000004 0x0002F7 1
3.3.3.3         3.3.3.3         564         0x80000004 0x00C32D 1
8.8.8.8         8.8.8.8         173         0x80000005 0x00586C 1

            Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.2        2.2.2.2         539         0x80000004 0x008F51

            Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.20.0       2.2.2.2         1294        0x80000002 0x006272
10.1.30.0       3.3.3.3         564         0x80000002 0x00D5F0
40.0.0.0        8.8.8.8         655         0x80000001 0x0011A3

            Router Link States (Area 30)

Link ID         ADV Router      Age         Seq#       Checksum Link count
3.3.3.3         3.3.3.3         321         0x80000006 0x007EA2 2
5.5.5.5         5.5.5.5         326         0x80000004 0x00B06A 2

            Summary Net Link States (Area 30)

Link ID         ADV Router      Age         Seq#       Checksum
0.0.0.0         3.3.3.3         373         0x80000001 0x0057DA
```

R4#sh ip ospf database

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

            Router Link States (Area 20)

Link ID         ADV Router      Age         Seq#       Checksum Link count
2.2.2.2         2.2.2.2         832         0x80000003 0x003B07 2
4.4.4.4         4.4.4.4         825         0x80000002 0x006BCF 2

            Summary Net Link States (Area 20)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.0        2.2.2.2         1333        0x80000002 0x001608
10.1.30.0       2.2.2.2         579         0x80000002 0x005868
40.0.0.0        2.2.2.2         693         0x80000001 0x002A98

            Summary ASB Link States (Area 20)

Link ID         ADV Router      Age         Seq#       Checksum
8.8.8.8         2.2.2.2         207         0x80000001 0x0032D7

            Router Link States (Area 80)

Link ID         ADV Router      Age         Seq#       Checksum Link count
4.4.4.4         4.4.4.4         1656        0x80000002 0x00794C 2
7.7.7.7         7.7.7.7         1660        0x80000001 0x003E7B 2
```

R5#sh ip ospf database

```
        OSPF Router with ID (5.5.5.5) (Process ID 1)

            Router Link States (Area 30)

Link ID         ADV Router      Age         Seq#       Checksum Link count
3.3.3.3         3.3.3.3         413         0x80000006 0x007EA2 2
5.5.5.5         5.5.5.5         412         0x80000004 0x00B06A 2

            Summary Net Link States (Area 30)

Link ID         ADV Router      Age         Seq#       Checksum
0.0.0.0         3.3.3.3         460         0x80000001 0x0057DA
```

R7#sh ip ospf database

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

            Router Link States (Area 80)

Link ID         ADV Router      Age         Seq#       Checksum Link count
4.4.4.4         4.4.4.4         1774        0x80000002 0x00794C 2
7.7.7.7         7.7.7.7         1773        0x80000001 0x003E7B 2
```

since R7 and R4 don't see other OSPF routers so we need to make virtual link

Step 6 - Virtual Link:

R2#conf t
R2(config)#router ospf 1
R2(config-router)#area 20 virtual-link 4.4.4.4

R4#conf t
R4(config)#router ospf 1
R4(config-router)#area 20 virtual-link 2.2.2.2

so Recheck R4 & R7

R4#sh ip ospf database

```
        OSPF Router with ID (4.4.4.4) (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         1052  (DNA) 0x80000003 0x0059A7 1
2.2.2.2         2.2.2.2         1     (DNA) 0x80000004 0x000571 2
3.3.3.3         3.3.3.3         1052  (DNA) 0x80000003 0x00D916 1
4.4.4.4         4.4.4.4         448         0x80000005 0x00267D 1
8.8.8.8         8.8.8.8         1052  (DNA) 0x80000003 0x007054 1

            Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.4        8.8.8.8         1052  (DNA) 0x80000001 0x00BB0E

            Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.20.0       2.2.2.2         1087  (DNA) 0x80000001 0x006471
10.1.20.0       4.4.4.4         448         0x80000004 0x0022A8
10.1.30.0       3.3.3.3         1088  (DNA) 0x80000001 0x00D7EF
40.0.0.0        8.8.8.8         1087  (DNA) 0x80000001 0x0011A3
80.0.0.0        4.4.4.4         450         0x80000004 0x007920

            Router Link States (Area 20)

Link ID         ADV Router      Age         Seq#       Checksum Link count
2.2.2.2         2.2.2.2         501         0x80000005 0x0043F8 2
4.4.4.4         4.4.4.4         452         0x80000007 0x0070C0 2

            Summary Net Link States (Area 20)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.0        2.2.2.2         1496        0x80000005 0x00100B
10.1.30.0       2.2.2.2         1498        0x80000004 0x00546A
40.0.0.0        2.2.2.2         1498        0x80000004 0x00249B
80.0.0.0        4.4.4.4         454         0x80000004 0x007920

            Summary ASB Link States (Area 20)

Link ID         ADV Router      Age         Seq#       Checksum
1.1.1.1         2.2.2.2         1498        0x80000004 0x006FB3
1.1.1.1         4.4.4.4         455         0x80000004 0x00B525
```

```
8.8.8.8         2.2.2.2         1500        0x80000004 0x002CDA
8.8.8.8         4.4.4.4         456         0x80000004 0x00724C

                Router Link States (Area 80)

Link ID         ADV Router      Age         Seq#       Checksum Link count
4.4.4.4         4.4.4.4         456         0x80000006 0x00744C 2
7.7.7.7         7.7.7.7         1550        0x80000005 0x00367F 2

                Summary Net Link States (Area 80)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.0        4.4.4.4         457         0x80000004 0x00587B
10.1.20.0       4.4.4.4         458         0x80000004 0x0022A8
10.1.30.0       4.4.4.4         458         0x80000004 0x009ADB
40.0.0.0        4.4.4.4         459         0x80000004 0x006A0D

                Summary ASB Link States (Area 80)

Link ID         ADV Router      Age         Seq#       Checksum
1.1.1.1         4.4.4.4         459         0x80000004 0x00B525
8.8.8.8         4.4.4.4         460         0x80000004 0x00724C

                Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#       Checksum Tag
0.0.0.0         1.1.1.1         1510        0x80000004 0x001794 1
60.0.0.0        8.8.8.8         534         0x80000003 0x00B95E 0
60.1.1.0        8.8.8.8         534         0x80000003 0x00A273 0
60.1.2.0        8.8.8.8         535         0x80000003 0x00977D 0
60.1.3.0        8.8.8.8         535         0x80000003 0x008C87 0
70.1.1.0        1.1.1.1         1512        0x80000004 0x001B36 0
70.1.2.0        1.1.1.1         1513        0x80000004 0x001040 0
70.1.3.0        1.1.1.1         1513        0x80000004 0x00054A 0
192.168.1.0     1.1.1.1         1513        0x80000004 0x000728 0
```

R7#sh ip ospf database

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

            Router Link States (Area 80)

Link ID         ADV Router      Age         Seq#       Checksum Link count
4.4.4.4         4.4.4.4         376         0x80000006 0x00744C 2
7.7.7.7         7.7.7.7         1467        0x80000005 0x00367F 2

            Summary Net Link States (Area 80)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.0        4.4.4.4         376         0x80000004 0x00587B
10.1.20.0       4.4.4.4         376         0x80000004 0x0022A8
10.1.30.0       4.4.4.4         376         0x80000004 0x009ADB
40.0.0.0        4.4.4.4         376         0x80000004 0x006A0D

            Summary ASB Link States (Area 80)

Link ID         ADV Router      Age         Seq#       Checksum
1.1.1.1         4.4.4.4         376         0x80000004 0x00B525
8.8.8.8         4.4.4.4         376         0x80000004 0x00724C

            Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#       Checksum Tag
0.0.0.0         1.1.1.1         1426        0x80000004 0x001794 1
60.0.0.0        8.8.8.8         454         0x80000003 0x00B95E 0
60.1.1.0        8.8.8.8         454         0x80000003 0x00A273 0
60.1.2.0        8.8.8.8         454         0x80000003 0x00977D 0
60.1.3.0        8.8.8.8         454         0x80000003 0x008C87 0
70.1.1.0        1.1.1.1         1432        0x80000004 0x001B36 0
70.1.2.0        1.1.1.1         1432        0x80000004 0x001040 0
70.1.3.0        1.1.1.1         1432        0x80000004 0x00054A 0
192.168.1.0     1.1.1.1         1433        0x80000004 0x000728 0
```

R8#sh ip ospf database

```
        OSPF Router with ID (8.8.8.8) (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         1300        0x80000002 0x005BA6 1
2.2.2.2         2.2.2.2         1311        0x80000004 0x0080F5 2
3.3.3.3         3.3.3.3         1311        0x80000003 0x00D916 1
4.4.4.4         4.4.4.4         2     (DNA) 0x80000002 0x002C7A 1
8.8.8.8         8.8.8.8         1310        0x80000003 0x007054 1

            Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.4        8.8.8.8         1300        0x80000002 0x00B90F

            Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.20.0       2.2.2.2         1347        0x80000001 0x006471
10.1.20.0       4.4.4.4         11    (DNA) 0x80000001 0x0028A5
10.1.30.0       3.3.3.3         1347        0x80000001 0x00D7EF
40.0.0.0        8.8.8.8         1345        0x80000001 0x0011A3
80.0.0.0        4.4.4.4         11    (DNA) 0x80000001 0x007F1D

            Router Link States (Area 40)

Link ID         ADV Router      Age         Seq#       Checksum Link count
8.8.8.8         8.8.8.8         1353        0x80000002 0x00865E 2
9.9.9.9         9.9.9.9         1355        0x80000002 0x0023BD 2

            Summary Net Link States (Area 40)

Link ID         ADV Router      Age         Seq#       Checksum
0.0.0.0         8.8.8.8         105         0x80000001 0x0048CD

            Type-7 AS External Link States (Area 40)

Link ID         ADV Router      Age         Seq#       Checksum Tag
60.0.0.0        9.9.9.9         1362        0x80000001 0x000B01 0
60.1.1.0        9.9.9.9         1361        0x80000001 0x00F316 0
60.1.2.0        9.9.9.9         1361        0x80000001 0x00E820 0
60.1.3.0        9.9.9.9         1363        0x80000001 0x00DD2A 0
```

```
            Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#       Checksum Tag
0.0.0.0         1.1.1.1         1343        0x80000001 0x001D91 1
60.0.0.0        8.8.8.8         1348        0x80000001 0x00BD5C 0
60.1.1.0        8.8.8.8         1348        0x80000001 0x00A671 0
60.1.2.0        8.8.8.8         1348        0x80000001 0x009B7B 0
60.1.3.0        8.8.8.8         1349        0x80000001 0x009085 0
70.1.1.0        1.1.1.1         1350        0x80000001 0x002133 0
70.1.2.0        1.1.1.1         1350        0x80000001 0x00163D 0
70.1.3.0        1.1.1.1         1350        0x80000001 0x000B47 0
192.168.1.0     1.1.1.1         1352        0x80000001 0x000D25 0
```

R9#sh ip ospf database

```
        OSPF Router with ID (9.9.9.9) (Process ID 1)

            Router Link States (Area 40)

Link ID         ADV Router      Age         Seq#       Checksum Link count
8.8.8.8         8.8.8.8         442         0x80000003 0x00845F 2
9.9.9.9         9.9.9.9         438         0x80000005 0x0017C8 2

            Summary Net Link States (Area 40)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.0        8.8.8.8         470         0x80000002 0x0007F8
10.1.20.0       8.8.8.8         470         0x80000002 0x00B7F4
10.1.30.0       8.8.8.8         470         0x80000002 0x004959
```

since R9 & R1 didn’t see RIP so we need to make redistribution

---

Step 7 – Redistribution

- Configure redistribution points:
  - **R1**: Redistribute between RIP and OSPF Area 0.
  - **R4**: Redistribute between OSPF Area 20 and RIP.
  - **R8/R9**: Redistribute between OSPF NSSA and RIP.
- Use route filtering if needed to prevent routing loops.

R1#conf t
R1(config)#router ospf 1
R1(config-router)#redistribute rip subnets
R1(config-router)#default-information originate → by5ly al defult route global l kol al routers y3ni ay 7aga m7taga to5rg bt5rog mn R1

R1#sh 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         1671        0x80000006 0x0053AA 1
2.2.2.2         2.2.2.2         674         0x80000007 0x00FE74 2
3.3.3.3         3.3.3.3         1660        0x80000006 0x00D319 1
4.4.4.4         4.4.4.4         3     (DNA) 0x80000002 0x002C7A 1
8.8.8.8         8.8.8.8         1701        0x80000006 0x006A57 1

            Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.4        8.8.8.8         1701        0x80000004 0x00B511

            Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.20.0       2.2.2.2         1668        0x80000004 0x005E74
10.1.20.0       4.4.4.4         37    (DNA) 0x80000001 0x0028A5
10.1.30.0       3.3.3.3         1660        0x80000004 0x00D1F2
40.0.0.0        8.8.8.8         1701        0x80000004 0x000BA6
80.0.0.0        4.4.4.4         37    (DNA) 0x80000001 0x007F1D

            Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#       Checksum Tag
0.0.0.0         1.1.1.1         1675        0x80000004 0x001794 1
60.0.0.0        8.8.8.8         701         0x80000003 0x00B95E 0
60.1.1.0        8.8.8.8         701         0x80000003 0x00A273 0
60.1.2.0        8.8.8.8         701         0x80000003 0x00977D 0
60.1.3.0        8.8.8.8         701         0x80000003 0x008C87 0
70.1.1.0        1.1.1.1         1677        0x80000004 0x001B36 0
70.1.2.0        1.1.1.1         1677        0x80000004 0x001040 0
70.1.3.0        1.1.1.1         1677        0x80000004 0x00054A 0
192.168.1.0     1.1.1.1         1678        0x80000004 0x000728 0
```

R9#sh ip ospf database

```
        OSPF Router with ID (9.9.9.9) (Process ID 1)

            Router Link States (Area 40)

Link ID         ADV Router      Age         Seq#       Checksum Link count
8.8.8.8         8.8.8.8         47          0x80000001 0x00885D 2
9.9.9.9         9.9.9.9         41          0x80000002 0x0023BD 2

            Summary Net Link States (Area 40)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.0        8.8.8.8         32          0x80000002 0x0007F8
10.1.20.0       8.8.8.8         2           0x80000001 0x00B9F3
10.1.30.0       8.8.8.8         2           0x80000001 0x004B58
80.0.0.0        8.8.8.8         2           0x80000001 0x0093A8

            Type-7 AS External Link States (Area 40)

Link ID         ADV Router      Age         Seq#       Checksum Tag
60.0.0.0        9.9.9.9         47          0x80000001 0x000B01 0
60.1.1.0        9.9.9.9         43          0x80000001 0x00F316 0
60.1.2.0        9.9.9.9         43          0x80000001 0x00E820 0
60.1.3.0        9.9.9.9         43          0x80000001 0x00DD2A 0
```

Since R9 is NSSA so the external networks appears as Type-7 Not Type-5

Step 8 – Default Route Configuration

- Configure a default route on the ISP router (`ip route 0.0.0.0 0.0.0.0 ...`).
- Redistribute into RIP → OSPF → other areas.
- Verify propagation into stub areas.

defult route 3la R1 , R6 & R10

R1(config)#ip route 0.0.0.0 0.0.0.0 50.0.0.2

R6(config)#ip route 0.0.0.0 0.0.0.0 192.168.1.1

R10(config)#ip route 0.0.0.0 0.0.0.0 60.0.0.1

Step 9 - ISP Configuration

```
ISP#CONF T
ISP(config)#int f0/1
ISP(config-if)#ip add
ISP(config-if)#ip address 50.0.0.2 255.255.255.0
ISP(config-if)#exit
ISP(config)#int f0/1

ISP(config-if)#no sh
ISP(config-if)#exit

ISP(config)#int loop
ISP(config)#int loopback 1
ISP(config-if)#ip address 90.0.0.1 255.255.255.0
```

Step 10 - NATING

```
R1#conf t
R1(config)#int f0/1
R1(config-if)#ip nat outside
R1(config-if)#int f0/0

R1(config-if)#ip nat inside
R1(config-if)#int s1/1

R1(config-if)#ip nat inside
R1(config-if)#exit
R1(config)#access-list 1 permit 20.1.0.0 0.0.255.255
R1(config)#access-list 1 permit 30.1.0.0 0.0.255.255
R1(config)#access-list 1 permit 40.1.0.0 0.0.255.255
R1(config)#access-list 1 permit 60.1.0.0 0.0.255.255
R1(config)#access-list 1 permit 70.1.0.0 0.0.255.255
R1(config)#access-list 1 permit 80.1.0.0 0.0.255.255
R1(config)#access-list 1 permit 90.0.0.0 0.0.255.255

R1(config)#ip nat inside source list 1 interface f0/1 overload
```

Step 1 – Verification

- Use these commands:

  `show ip route` **– verify route entries.**

```
R1#sh 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 50.0.0.2 to network 0.0.0.0

    50.0.0.0/24 is subnetted, 1 subnets
C       50.0.0.0 is directly connected, FastEthernet0/1
70.0.0.0/24 is subnetted, 3 subnets
R       70.1.3.0 [120/1] via 192.168.1.2, 00:00:21, Serial1/1
R       70.1.2.0 [120/1] via 192.168.1.2, 00:00:21, Serial1/1
R       70.1.1.0 [120/1] via 192.168.1.2, 00:00:21, Serial1/1
40.0.0.0/24 is subnetted, 1 subnets
O IA    40.0.0.0 [110/74] via 10.1.1.4, 00:10:34, FastEthernet0/0
10.0.0.0/24 is subnetted, 3 subnets
C       10.1.1.0 is directly connected, FastEthernet0/0
O IA    10.1.30.0 [110/74] via 10.1.1.3, 00:10:36, FastEthernet0/0
O IA    10.1.20.0 [110/74] via 10.1.1.2, 00:10:36, FastEthernet0/0
C    192.168.1.0/24 is directly connected, Serial1/1
S*   0.0.0.0/0 [1/0] via 50.0.0.2
```

```
R2#sh 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 10.1.1.1 to network 0.0.0.0

    70.0.0.0/24 is subnetted, 3 subnets
O E2    70.1.3.0 [110/20] via 10.1.1.1, 00:22:09, FastEthernet0/0
O E2    70.1.2.0 [110/20] via 10.1.1.1, 00:22:09, FastEthernet0/0
O E2    70.1.1.0 [110/20] via 10.1.1.1, 00:22:09, FastEthernet0/0
80.0.0.0/24 is subnetted, 1 subnets
O IA    80.0.0.0 [110/128] via 10.1.20.2, 00:04:48, Serial1/1
40.0.0.0/24 is subnetted, 1 subnets
O IA    40.0.0.0 [110/74] via 10.1.1.4, 00:22:19, FastEthernet0/0
10.0.0.0/24 is subnetted, 3 subnets
C       10.1.1.0 is directly connected, FastEthernet0/0
O IA    10.1.30.0 [110/74] via 10.1.1.3, 00:22:21, FastEthernet0/0
C       10.1.20.0 is directly connected, Serial1/1
O E2 192.168.1.0/24 [110/20] via 10.1.1.1, 00:22:11, FastEthernet0/0
O*E2 0.0.0.0/0 [110/1] via 10.1.1.1, 00:22:12, FastEthernet0/0
```

```
R3#sh 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 10.1.1.1 to network 0.0.0.0

    70.0.0.0/24 is subnetted, 3 subnets
O E2    70.1.3.0 [110/20] via 10.1.1.1, 00:11:47, FastEthernet0/0
O E2    70.1.2.0 [110/20] via 10.1.1.1, 00:11:47, FastEthernet0/0
O E2    70.1.1.0 [110/20] via 10.1.1.1, 00:11:47, FastEthernet0/0
40.0.0.0/24 is subnetted, 1 subnets
O IA    40.0.0.0 [110/74] via 10.1.1.4, 00:11:47, FastEthernet0/0
10.0.0.0/24 is subnetted, 3 subnets
C       10.1.1.0 is directly connected, FastEthernet0/0
C       10.1.30.0 is directly connected, Serial1/1
O IA    10.1.20.0 [110/74] via 10.1.1.2, 00:11:49, FastEthernet0/0
O E2 192.168.1.0/24 [110/20] via 10.1.1.1, 00:11:49, FastEthernet0/0
O*E2 0.0.0.0/0 [110/1] via 10.1.1.1, 00:11:49, FastEthernet0/0
```

```
R4#sh 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 10.1.20.1 to network 0.0.0.0

    70.0.0.0/24 is subnetted, 3 subnets
O E2    70.1.3.0 [110/20] via 10.1.20.1, 00:06:20, Serial1/1
O E2    70.1.2.0 [110/20] via 10.1.20.1, 00:06:20, Serial1/1
O E2    70.1.1.0 [110/20] via 10.1.20.1, 00:06:20, Serial1/1
80.0.0.0/24 is subnetted, 1 subnets
C       80.0.0.0 is directly connected, Serial1/0
20.0.0.0/24 is subnetted, 3 subnets
C       20.1.1.0 is directly connected, Loopback0
C       20.1.3.0 is directly connected, Loopback2
C       20.1.2.0 is directly connected, Loopback1
40.0.0.0/24 is subnetted, 1 subnets
O IA    40.0.0.0 [110/138] via 10.1.20.1, 00:05:43, Serial1/1
10.0.0.0/24 is subnetted, 3 subnets
O       10.1.1.0 [110/74] via 10.1.20.1, 00:05:44, Serial1/1
O IA    10.1.30.0 [110/138] via 10.1.20.1, 00:05:45, Serial1/1
C       10.1.20.0 is directly connected, Serial1/1
O E2 192.168.1.0/24 [110/20] via 10.1.20.1, 00:06:25, Serial1/1
O*E2 0.0.0.0/0 [110/1] via 10.1.20.1, 00:06:26, Serial1/1
```

```
R5#sh 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 10.1.30.1 to network 0.0.0.0

    10.0.0.0/24 is subnetted, 1 subnets
C       10.1.30.0 is directly connected, Serial1/1
30.0.0.0/24 is subnetted, 3 subnets
C       30.1.3.0 is directly connected, Loopback2
C       30.1.2.0 is directly connected, Loopback1
C       30.1.1.0 is directly connected, Loopback0
O*IA 0.0.0.0/0 [110/65] via 10.1.30.1, 00:13:19, Serial1/1
```

```
R7#sh 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 80.0.0.1 to network 0.0.0.0

    70.0.0.0/24 is subnetted, 3 subnets
O E2    70.1.3.0 [110/20] via 80.0.0.1, 00:03:59, Serial1/0
O E2    70.1.2.0 [110/20] via 80.0.0.1, 00:03:59, Serial1/0
O E2    70.1.1.0 [110/20] via 80.0.0.1, 00:03:59, Serial1/0
80.0.0.0/24 is subnetted, 4 subnets
C       80.1.1.0 is directly connected, Loopback0
C       80.0.0.0 is directly connected, Serial1/0
C       80.1.3.0 is directly connected, Loopback2
C       80.1.2.0 is directly connected, Loopback1
40.0.0.0/24 is subnetted, 1 subnets
O IA    40.0.0.0 [110/202] via 80.0.0.1, 00:04:06, Serial1/0
10.0.0.0/24 is subnetted, 3 subnets
O IA    10.1.1.0 [110/138] via 80.0.0.1, 00:04:06, Serial1/0
O IA    10.1.30.0 [110/202] via 80.0.0.1, 00:04:07, Serial1/0
O IA    10.1.20.0 [110/128] via 80.0.0.1, 00:04:41, Serial1/0
O E2 192.168.1.0/24 [110/20] via 80.0.0.1, 00:04:03, Serial1/0
O*E2 0.0.0.0/0 [110/1] via 80.0.0.1, 00:04:03, Serial1/0
```

```
R8#sh 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 10.1.1.1 to network 0.0.0.0

    70.0.0.0/24 is subnetted, 3 subnets
O E2    70.1.3.0 [110/20] via 10.1.1.1, 00:24:02, FastEthernet0/0
O E2    70.1.2.0 [110/20] via 10.1.1.1, 00:24:02, FastEthernet0/0
O E2    70.1.1.0 [110/20] via 10.1.1.1, 00:24:02, FastEthernet0/0
80.0.0.0/24 is subnetted, 1 subnets
O IA    80.0.0.0 [110/138] via 10.1.1.2, 00:06:21, FastEthernet0/0
40.0.0.0/24 is subnetted, 1 subnets
C       40.0.0.0 is directly connected, Serial1/1
10.0.0.0/24 is subnetted, 3 subnets
C       10.1.1.0 is directly connected, FastEthernet0/0
O IA    10.1.30.0 [110/74] via 10.1.1.3, 00:24:04, FastEthernet0/0
O IA    10.1.20.0 [110/74] via 10.1.1.2, 00:24:04, FastEthernet0/0
O E2 192.168.1.0/24 [110/20] via 10.1.1.1, 00:24:04, FastEthernet0/0
O*E2 0.0.0.0/0 [110/1] via 10.1.1.1, 00:24:06, FastEthernet0/0
```

```
R9#sh 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 40.0.0.1 to network 0.0.0.0

  80.0.0.0/24 is subnetted, 1 subnets
O IA    80.0.0.0 [110/202] via 40.0.0.1, 00:48:28, Serial1/1
40.0.0.0/24 is subnetted, 4 subnets
C       40.1.1.0 is directly connected, Loopback0
C       40.0.0.0 is directly connected, Serial1/1
C       40.1.3.0 is directly connected, Loopback2
C       40.1.2.0 is directly connected, Loopback1
10.0.0.0/24 is subnetted, 3 subnets
O IA    10.1.1.0 [110/74] via 40.0.0.1, 01:06:39, Serial1/1
O IA    10.1.30.0 [110/138] via 40.0.0.1, 01:06:10, Serial1/1
O IA    10.1.20.0 [110/138] via 40.0.0.1, 01:06:10, Serial1/1
60.0.0.0/24 is subnetted, 4 subnets
R       60.1.1.0 [120/1] via 60.0.0.2, 00:00:10, Serial1/0
C       60.0.0.0 is directly connected, Serial1/0
R       60.1.3.0 [120/1] via 60.0.0.2, 00:00:12, Serial1/0
R       60.1.2.0 [120/1] via 60.0.0.2, 00:00:12, Serial1/0
S*   0.0.0.0/0 [1/0] via 40.0.0.1
```

```
R10#sh 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 60.0.0.1 to network 0.0.0.0

  60.0.0.0/24 is subnetted, 4 subnets
C       60.1.1.0 is directly connected, Loopback0
C       60.0.0.0 is directly connected, Serial1/0
C       60.1.3.0 is directly connected, Loopback2
C       60.1.2.0 is directly connected, Loopback1
S*   0.0.0.0/0 [1/0] via 60.0.0.1
```

`show ip ospf neighbor` **– check OSPF adjacencies.**

```
R1#sh ip ospf nei
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           1   2WAY/DROTHER    00:00:30    10.1.1.2        FastEthernet0/0
3.3.3.3           1   FULL/BDR        00:00:30    10.1.1.3        FastEthernet0/0
8.8.8.8           1   FULL/DR         00:00:30    10.1.1.4        FastEthernet0/0
```

```
R2#sh ip ospf nei
Neighbor ID     Pri   State           Dead Time   Address         Interface
4.4.4.4           0   FULL/  -        -           10.1.20.2       OSPF_VL0
1.1.1.1           1   2WAY/DROTHER    00:00:37    10.1.1.1        FastEthernet0/0
3.3.3.3           1   FULL/BDR        00:00:37    10.1.1.3        FastEthernet0/0
8.8.8.8           1   FULL/DR         00:00:37    10.1.1.4        FastEthernet0/0
4.4.4.4           0   FULL/  -        00:00:37    10.1.20.2       Serial1/1
```

R3#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
1.1.1.1	1	FULL/DROTHER	00:00:33	10.1.1.1	FastEthernet0/0
2.2.2.2	1	FULL/DROTHER	00:00:33	10.1.1.2	FastEthernet0/0
8.8.8.8	1	FULL/DR	00:00:33	10.1.1.4	FastEthernet0/0
5.5.5.5	0	FULL/ -	00:00:33	10.1.30.2	Serial1/1

R4#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.2.2	0	FULL/ -	-	10.1.20.1	OSPF_VL0
2.2.2.2	0	FULL/ -	00:00:36	10.1.20.1	Serial1/1
7.7.7.7	0	FULL/ -	00:00:36	80.0.0.2	Serial1/0

R5#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
3.3.3.3	0	FULL/ -	00:00:30	10.1.30.1	Serial1/1

R7#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
4.4.4.4	0	FULL/ -	00:00:35	80.0.0.1	Serial1/0

R8#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
1.1.1.1	1	FULL/DROTHER	00:00:34	10.1.1.1	FastEthernet0/0
2.2.2.2	1	FULL/DROTHER	00:00:34	10.1.1.2	FastEthernet0/0
3.3.3.3	1	FULL/BDR	00:00:34	10.1.1.3	FastEthernet0/0
9.9.9.9	0	FULL/ -	00:00:34	40.0.0.2	Serial1/1

R9#sh ip ospf nei

Neighbor ID	Pri	State	Dead Time	Address	Interface
8.8.8.8	0	FULL/ -	00:00:35	40.0.0.1	Serial1/1

`ping` and `traceroute` end-to-end between loopbacks.

R10#ping 70.1.1.1 source 60.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 70.1.1.1, timeout is 2 seconds:
Packet sent with a source address of 60.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 100/122/140 ms

R6#ping 90.0.0.1 source 70.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 90.0.0.1, timeout is 2 seconds:
Packet sent with a source address of 70.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 36/58/64 ms

R10#ping 90.0.0.1 source 60.1.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 90.0.0.1, timeout is 2 seconds:
Packet sent with a source address of 60.1.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 144/171/192 ms

R5#ping 90.0.0.1 source 30.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 90.0.0.1, timeout is 2 seconds:
Packet sent with a source address of 30.1.1.1
.....
Success rate is 0 percent (0/5)

R5#ping 80.0.0.1 source 30.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 80.0.0.1, timeout is 2 seconds:
Packet sent with a source address of 30.1.1.1
.....
Success rate is 0 percent (0/5)

R5 couldn’t ping to the other areas or on internet as itis totally stub

R9#ping 30.1.1.1 source 60.0.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.1.1.1, timeout is 2 seconds:
Packet sent with a source address of 60.0.0.1
.....
Success rate is 0 percent (0/5)

R9#ping 70.1.1.1 source 60.0.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 70.1.1.1, timeout is 2 seconds:
Packet sent with a source address of 60.0.0.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 64/88/108 ms

R9 couldn’t ping to other areas but ping to the external network

R4#ping 60.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 60.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 104/120/132 ms

R4#ping 70.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 70.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 64/96/112 ms

R4#ping 30.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.1.1.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)

R4 ping to any network expect totally stub and nssa

R7#ping 60.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 60.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 132/158/176 ms

R7#ping 70.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 70.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 96/119/148 ms

---

Key Summary

- **Network Configuration:** Successfully configured a multi-area OSPF network with various area types (standard, totally stub, NSSA) interconnected with RIP domains.
- **Protocol Redistribution:** Established bidirectional communication between OSPF and RIP through proper route redistribution.
- **External Connectivity:** Implemented NAT for internet access via the ISP router.
- **Area Restrictions:** Confirmed that totally stub areas (Area 30) cannot reach external networks, while NSSA areas have limited connectivity based on configuration.
- **Virtual Links:** Successfully implemented virtual links to maintain OSPF backbone connectivity requirements.
- **End-to-End Testing:** Verified connectivity through ping and traceroute tests between internal networks and to external destinations.

Lessons Learned

- **Verification is essential:** Commands like `show ip route` and `show ip ospf database` are critical to confirm routing operations and quickly identify issues such as missing LSAs or unreachable networks.
- **Backbone connectivity matters:** OSPF requires all areas to connect to Area 0. When this is not possible, a **Virtual Link** is needed to maintain proper OSPF functionality.
- **Redistribution must be planned carefully:** Injecting RIP routes into OSPF (and vice versa) ensures connectivity but must be controlled to avoid routing loops or inconsistencies.
- **Default routes are key for external reachability:** Configuring static default routes or redistributing them ensures that traffic destined for unknown networks can still be forwarded.
- **NAT testing is a critical step:** Even when routing is correct, NAT must be verified using source-based pings to confirm real-world communication across domains.
- **Step-by-step troubleshooting is effective:** Dividing the lab into phases (OSPF configuration, redistribution, NAT, verification) made it easier to isolate and solve problems.