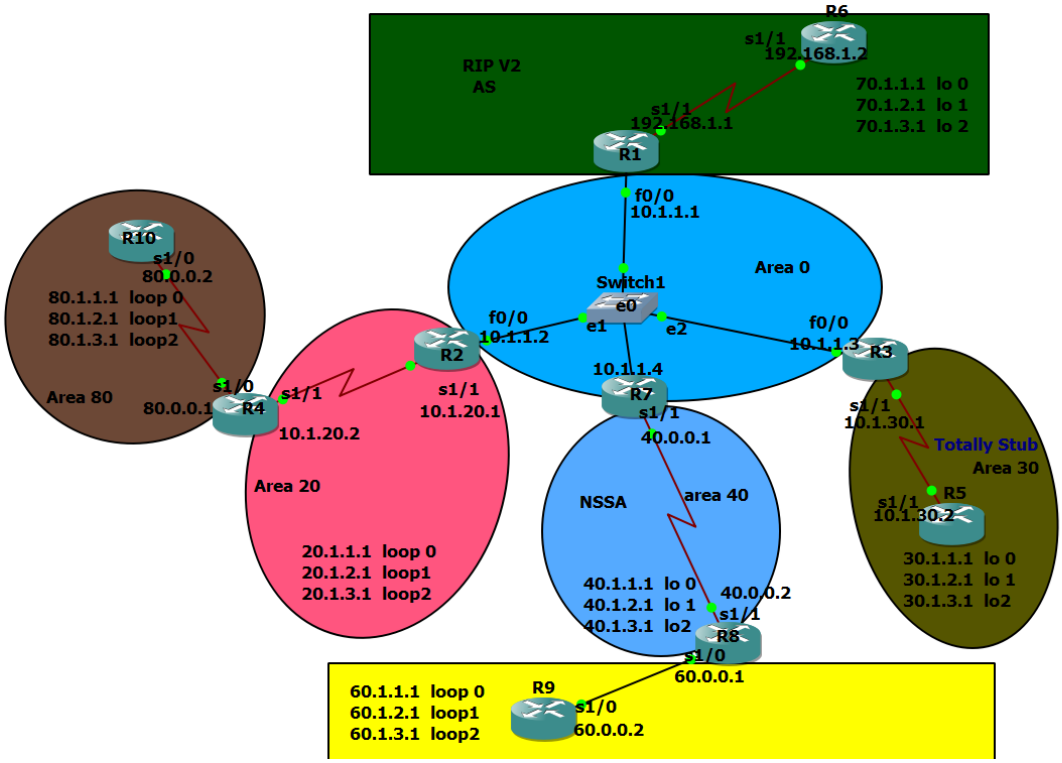
OSPF, RIP, Virtual Link, and NAT Full Project Configuration Using GNS3

This project demonstrates how to integrate multiple routing protocols (OSPF & RIP), configure special OSPF areas (Stub, NSSA, Virtual Link), and finally provide Internet access through NAT on the ISP router.



1- Design decision: Why each step

- Assign IPs & bring interfaces up: - OSPF/RIP only advertises interfaces that are up with correct IPs.
- OSPF Areas: - keep backbone Area 0 for inter-area routing. Separate areas for scaling and policy (20,30,40).
- Area 30 as Totally Stub: - reduces Type-5 LSAs in area, only a default route comes from ABR, simpler forwarding for that area.
- Area 40 as NSSA: - allows an ASBR inside area 40 to originate external routes (as Type-7 LSAs) while still limiting Type-5 LSAs into the NSSA.
- Virtual Link for Area 80: - when Area 80 is not physically attached to Area 0, a virtual link connects it logically to the backbone.

- RIP v2 for green/yellow regions: - legacy simple IGP segments; we redistribute to make them reachable.
- Redistribution on R1: - R1 is the border: advertise RIP routes into OSPF and OSPF learned routes into RIP so all domains' interconnect.
- Default route on R1 and default-information originate: - make the ISP the gateway of last resort and push that default into OSPF; redistribute to RIP too.
- NAT + ACL (PAT) on the edge router: - translate many internal addresses to the single public IP presented to the ISP.
- Verification: - show OSPF neighbors, routing table, NAT translations and ping/traceroute from loopbacks.

2- Topology & IP plan

R1

- f0/0 = 10.1.1.1
- s1/1 = 192.168.1.1
- f0/1 = 50.0.0.1
- Loopbacks: 70.1.1.1, 70.1.2.1, 70.1.3.1

R2

- s1/1 = 10.1.20.1 (Area 20)
- f0/0 = 10.1.1.2 (Area 0)

R3

- f0/0 = 10.1.1.3 (Area 0)
- s1/1 = 10.1.30.1 (Area 30)

R4

- s1/1 = 10.1.20.2 (Area 20)
- s1/0 = 80.0.0.1 (Area 80)

R5

- s1/1 = 10.1.30.2
- Loopbacks: 30.1.1.1, 30.1.2.1, 30.1.3.1
- Area 30

R6

- s1/1 = 192.168.1.2
- Loopbacks: 70.1.1.1, 70.1.2.1, 70.1.3.1

R7

- f0/0 = 10.1.1.4 (Area 0)
- s1/1 = 40.0.0.1 (Area 40)

R8

- s1/1 = 40.0.0.2 (Area 40)
- s1/0 = 60.0.0.1

R9

- s1/0 = 60.0.0.2
- Loopbacks: 60.1.1.1, 60.1.2.1, 60.1.3.1

R10

- s1/0 = 80.0.0.2
- Loopbacks: 80.1.1.1, 80.1.2.1, 80.1.3.1
- Area 80

ISP

- f0/1 = 50.0.0.2
- Loopback: 90.0.0.1

Step-by-step commands

Step 1: Configure OSPF Backbone (Area 0)

🔹 Why?

Every OSPF design must have a backbone area (Area 0). All other areas must connect to it directly or indirectly (via virtual links). This ensures inter-area communication.

Run OSPF with Areas 0, 20, 30 (totally-stub), 40 (NSSA) and 80 (via virtual-link).
Run RIP v2 for the “green/yellow” parts.
Redistribute OSPF ↔ RIP at the border router (R1).

Make every loopback reachable to the Internet (ISP) and enable Internet access via NAT (PAT) on the edge router.

R1 (backbone + multiple area networks + virtual link):

```
#router ospf 1
 #router-id 1.1.1.1
 #network 10.0.0.0 0.0.0.255 area 0
 #network 20.0.0.0 0.0.0.255 area 20
 #network 30.0.0.0 0.0.0.255 area 30
 #network 40.0.0.0 0.0.0.255 area 40
 #network 70.0.0.0 0.255.255.255 area 0
 #area 0 virtual-link 10.10.10.10    ! Router-ID of the remote virtual-link peer
 #default-information originate
```

#redistribute rip subnets

R2 (Area 20 ABR example):

```
router ospf 1
 router-id 2.2.2.2
 network 20.0.0.0 0.0.0.255 area 20
```

R3 (Area 30 ABR & make area 30 totally stub on ABR):

```
router ospf 1
 router-id 3.3.3.3
 network 30.0.0.0 0.0.0.255 area 30
```

R10 (Area 80 routers) — virtual link peer config on R10 example:

```
router ospf 1
 router-id 10.10.10.10
 network 80.0.0.0 0.0.0.255 area 80
 area 0 virtual-link 1.1.1.1     ! Router-ID of R1 (backbone)
```

R4 (Area 40 NSSA on ABR):

```
router ospf 1
 router-id 4.4.4.4
 network 40.0.0.0 0.0.0.255 area 40
 area 40 nssa
```

Step 2: Configure RIP v2 on green/yellow regions (WHY: legacy/simple IGP segments)

R6 (RIP router example):

```
router rip
 version 2
 network 60.0.0.0
 network 192.168.1.0
 no auto-summary
```

R7 (RIP):

```
router rip
 version 2
 network 90.0.0.0
 no auto-summary
```

On R1:

```
router rip
 version 2
 network 60.0.0.0
 network 90.0.0.0
 network 192.168.1.0
 no auto-summary
```

-If a router runs both OSPF and RIP (redistributor), configure both — see Step 3.

Step 3: Redistribution OSPF ↔ RIP on the border (R1) (WHY: make RIP networks visible to OSPF and vice versa)

On R1:

```
router ospf 1
redistribute rip subnets
redistribute ospf 1 metric 1
```

-Use metric when redistributing into RIP (RIP needs a hop metric). subnets is important to include non-/24 prefixes.

At (R8) do similar redistribute commands there (e.g., redistribute rip subnets under OSPF and redistribute ospf 1 metric 1 under RIP).

Step 4: Make Area 30 totally stub and Area 40 NSSA (WHY: control LSA types)

On Area 30 ABR (R3):

```
router ospf 1
 area 30 stub no-summary
```

On Area 30 internal routers (R5 etc):

```
router ospf 1
 area 30 stub
```

On Area 40 ABR (R4):

```
router ospf 1
 area 40 nssa
```

On Area 40 ABR to inject default into NSSA (optional—Totally NSSA):

```
router ospf 1
 area 40 nssa no-summary
```

Step 4: Virtual link (Area 80 → Area 0) (WHY: logical backbone attachment)
On the transit ABR (the router in the transit area that is in Area 0 and also sees Area 80)
On the remote Area 80 router (R10):

```
router ospf 1
 area <transit-area> virtual-link <local-backbone-router-id>
```

Example where transit is area 20 and router IDs are 2.2.2.2 (R2) and 10.10.10.10 (R10):

- On R2:

```
router ospf 1
 area 20 virtual-link 10.10.10.10
```

On the remote Area 80 router (R10):

- On R10:

```
router ospf 1
 area 20 virtual-link 2.2.2.2
```

After configuring, clear OSPF process if needed:

```
clear ip ospf process
```

Step 6: Default route on edge (R1) and advertise to OSPF / RIP (WHY: Internet gateway)

On R1:

```
ip route 0.0.0.0 0.0.0.0 50.0.0.2
router ospf 1
 default-information originate
router rip
 redistribute static     ! or redistribute static metric 1
```

default-information originate pushes the default into OSPF. redistribute static lets RIP learn the static default.

Step 7: NAT (PAT) + ACL on the edge (WHY: let many internal addresses share the single public IP)
On R1 (example: outside interface f0/1, inside interfaces f0/0 and s1/1):

-Build ACL for internal ranges (permit all internal nets)

access-list 1 permit 10.0.0.0 0.255.255.255
access-list 1 permit 20.0.0.0 0.255.255.255
access-list 1 permit 30.0.0.0 0.255.255.255
access-list 1 permit 40.0.0.0 0.255.255.255
access-list 1 permit 60.0.0.0 0.255.255.255
access-list 1 permit 70.0.0.0 0.255.255.255
access-list 1 permit 80.0.0.0 0.255.255.255
access-list 1 permit 90.0.0.0 0.255.255.255

-Mark inside/outside

interface f0/0
 ip nat inside

interface s1/1
 ip nat inside

interface f0/1
 ip nat outside

ip nat inside source list 1 interface f0/1 overload

After this, any internal host (or loopback when used as source) that matches ACL 1 will be PATed to R1's f0/1 IP.

Step 8: - ISP: return routes (WHY: ISP must know how to reach internal networks or at least the NATed source)

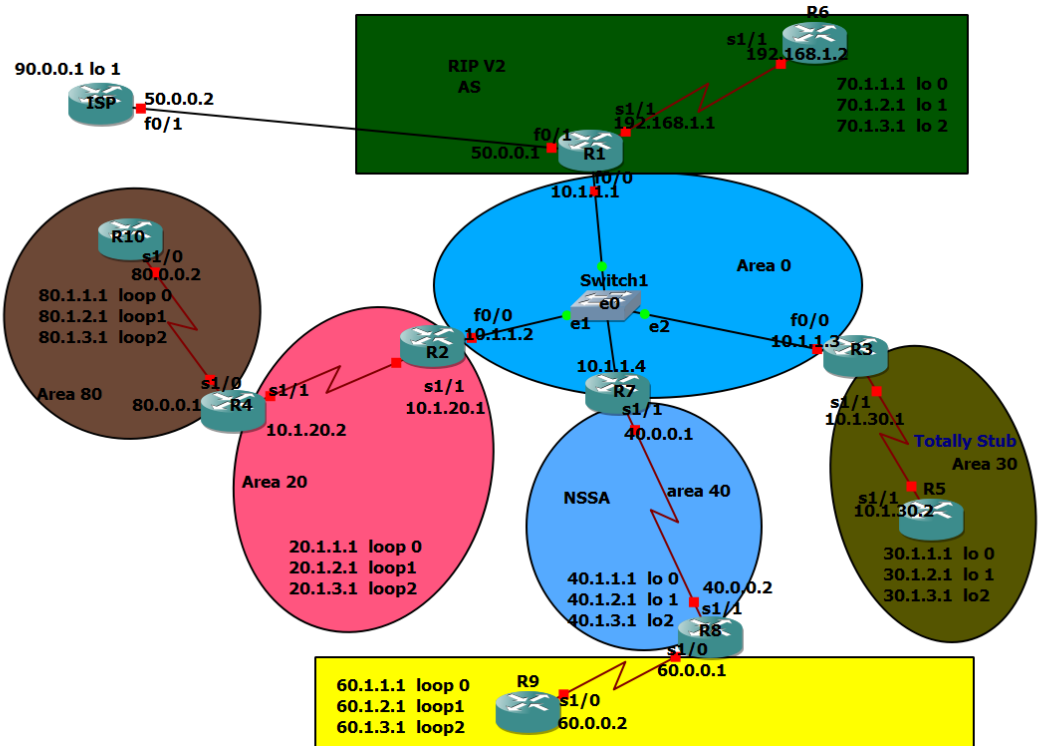
On ISP router:

interface f0/0
 ip address 50.0.0.2 255.255.255.0
 no shutdown

interface loopback0
ip address 90.0.0.1 255.255.255.255

If using NAT on R1, ISP only needs a route to R1's external IP. If not using NAT, add per-prefix static routes:
ip route 0.0.0.0 0.0.0.0 50.0.0.1

4: Full example configs



R1 (Border — OSPF + RIP + NAT + redistribute)

interface s1/1
 ip address 192.168.1.1 255.255.255.0
 ip nat inside
 no shutdown

interface f0/0
 ip address 10.0.0.1 255.255.255.0
 ip nat inside
 no shutdown

interface f0/1
 ip address 50.0.0.1 255.255.255.0
 ip nat outside
 no shutdown

interface loopback0
 ip address 70.1.1.1 255.255.255.0

```
 ip nat inside

interface loopback1
 ip address 70.1.2.1 255.255.255.0
 ip nat inside

interface loopback2
 ip address 70.1.3.1 255.255.255.0
 ip nat inside

 router ospf 1
 router-id 1.1.1.1
 network 10.0.0.0 0.0.0.255 area 0
 network 20.0.0.0 0.0.0.255 area 20
 network 30.0.0.0 0.0.0.255 area 30
 network 40.0.0.0 0.0.0.255 area 40
 network 70.0.0.0 0.255.255.255 area 0
 area 0 virtual-link 10.10.10.10
 default-information originate
 redistribute rip subnets

router rip
 version 2
 network 60.0.0.0
 network 90.0.0.0
 network 192.168.1.0
 no auto-summary
 redistribute ospf 1 metric 1

ip route 0.0.0.0 0.0.0.0 50.0.0.2

access-list 1 permit 10.0.0.0 0.255.255.255
access-list 1 permit 20.0.0.0 0.255.255.255
access-list 1 permit 30.0.0.0 0.255.255.255
access-list 1 permit 40.0.0.0 0.255.255.255
```

access-list 1 permit 60.0.0.0 0.255.255.255
access-list 1 permit 70.0.0.0 0.255.255.255
access-list 1 permit 80.0.0.0 0.255.255.255
access-list 1 permit 90.0.0.0 0.255.255.255
access-list 1 permit 192.168.0.0 0.0.255.255

ip nat inside source list 1 interface f0/1 overload

R2 (Area 20)

```
interface s1/0
 ip address 20.1.1.2 255.255.255.0
 no shutdown
router ospf 1
 router-id 2.2.2.2
 network 20.0.0.0 0.0.0.255 area 20
```

R3 (Area 30 ABR — make area totally-stub)

```
interface s1/0
 ip address 30.1.1.3 255.255.255.0
 no shutdown
router ospf 1
 router-id 3.3.3.3
 network 30.0.0.0 0.0.0.255 area 30
 area 30 stub no-summary
```

R4 (Area 40 ABR — NSSA)

```
interface s1/0
 ip address 40.1.1.4 255.255.255.0
 no shutdown
router ospf 1
 router-id 4.4.4.4
 network 40.0.0.0 0.0.0.255 area 40
 area 40 nssa
```

R5 (Area 30 — virtual link peer)

```
 interface s1/0
 ip address 10.1.30.1 255.255.255.0
 no shutdown
```

```
router ospf 1
 router-id 5.5.5.5
 network 30.0.0.0 0.0.0.255 area 80
```

R6 (RIP)

```
interface s1/1
 ip address 192.168.1.2 255.255.255.0
 no shutdown
interface loopback0
 ip address 60.1.1.1 255.255.255.0
interface loopback1
 ip address 60.1.2.1 255.255.255.0
interface loopback2
 ip address 60.1.3.1 255.255.255.0
router rip
 version 2
 network 60.0.0.0
 network 192.168.1.0
 no auto-summary
```

R7 (RIP)

```
interface loopback0
 ip address 90.1.1.1 255.255.255.0
router rip
 version 2
 network 90.0.0.0
 no auto-summary
```

R8 (OSPF backbone / or OSPF ↔ RIP translator depending on topology)

```
interface s1/0
 ip address 10.0.0.2 255.255.255.0
 no shutdown
router ospf 1
 router-id 8.8.8.8
 network 10.0.0.0 0.0.0.255 area 0
 default-information originate
```

R9 (OSPF)

```
interface s1/0
 ip address 10.1.1.9 255.255.255.0
 no shutdown
router ospf 1
 router-id 9.9.9.9
 network 10.0.0.0 0.0.0.255 area 0
```

R10 (Area 80 + virtual-link back to R1)

```
interface s1/0
 ip address 80.1.2.10 255.255.255.0
 no shutdown
interface loopback0
 ip address 30.1.10.1 255.255.255.0
router ospf 1
 router-id 10.10.10.10
 network 80.0.0.0 0.0.0.255 area 80
 network 30.0.0.0 0.0.0.255 area 30
 area 0 virtual-link 1.1.1.1
```

ISP

```
interface f0/0
 ip address 50.0.0.2 255.255.255.0
 no shutdown
interface loopback0
 ip address 90.0.0.1 255.255.255.255
! Optional return route if NAT not used:
ip route 10.0.0.0 255.0.0.0 50.0.0.1
ip route 20.0.0.0 255.0.0.0 50.0.0.1
ip route 30.0.0.0 255.0.0.0 50.0.0.1
ip route 40.0.0.0 255.0.0.0 50.0.0.1
ip route 60.0.0.0 255.0.0.0 50.0.0.1
ip route 70.0.0.0 255.0.0.0 50.0.0.1
ip route 80.0.0.0 255.0.0.0 50.0.0.1
ip route 90.0.0.0 255.0.0.0 50.0.0.1
```

5 — Verification & troubleshooting (what to run, and why)

OSPF adjacency

show ip ospf neighbor

- expect FULL for neighbors in same subnet / area. If missing, check interface up, area mismatch or wrong network statement.

OSPF database

show ip ospf database

- verify Type-1/2/3/5/7 LSAs as expected (no Type-5 in Totally-Stub area).

Check Area 30 default injection

On router inside area30:

show ip route | include 0.0.0.0

- Expect default (0.0.0.0/0) learned via OSPF from ABR.

Check NSSA translation (Area 40)

On ABR for area 40:

show ip ospf database | include Type-7

- Should see Type-7 LSAs from ASBR and Type-5 generated on other side.

RIP checks

show ip route rip

show ip protocols

Default route propagation

On a RIP-only router (e.g., R6 or R10):

show ip route 0.0.0.0

- Should show an R* or S* (if static redistributed) default pointing toward R1/R8 depending on topology.

NAT verification

On the NAT router:

show ip nat translations

show ip nat statistics

- After you ping <ISP IP> source <loopback> from an internal router you should see translations.

Ping tests

From each loopback do:

ping 90.0.0.1 source <loopback-IP>

traceroute 90.0.0.1 source <loopback-IP>

- Confirm traffic reaches ISP and return path works.

6 — Final notes / best practices

- Use explicit router-id values for OSPF to avoid unpredictable ID choice.
- area X stub no-summary must be configured on the **ABR**; internal stub routers use area X stub.
- When redistributing, always consider *route maps* and picking metrics/policies — uncontrolled redistribution can create loops or suboptimal routing. For production, add route-maps to filter unwanted networks.
- For NAT in labs, PAT (overload) is common. For production use, coordinate with your firewall/ISP.