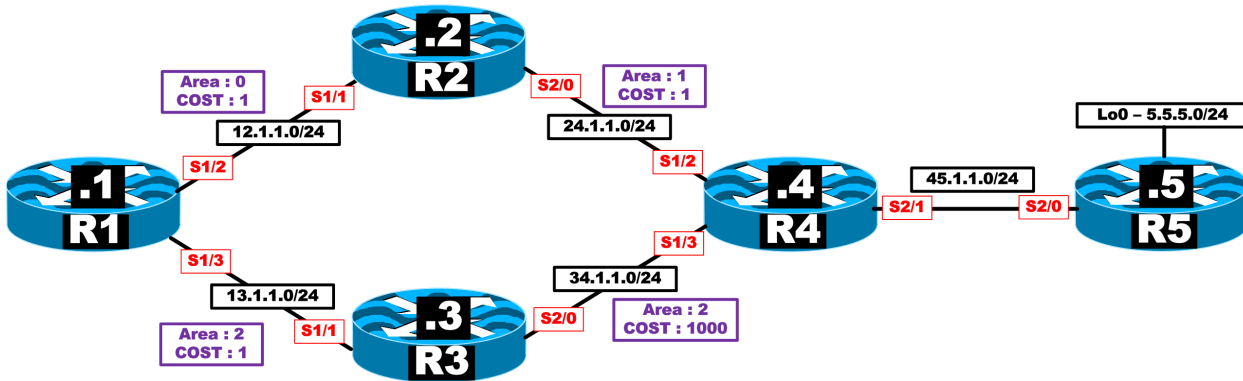


# SCENARIO - 1



Let's check R1's routing table:

On R1:

```
R1#sh ip rou ospf | b Gate
```

```
Gateway of last resort is not set
```

```
5.0.0.0/24 is subnetted, 1 subnets
O E2    5.5.5.0 [110/20] via 13.1.1.3, 00:01:48, Serial1/3
24.0.0.0/24 is subnetted, 1 subnets
O IA    24.1.1.0 [110/2] via 12.1.1.2, 00:01:48, Serial1/2
34.0.0.0/24 is subnetted, 1 subnets
O       34.1.1.0 [110/1001] via 13.1.1.3, 00:01:58, Serial1/3
45.0.0.0/24 is subnetted, 1 subnets
O E2    45.1.1.0 [110/20] via 13.1.1.3, 00:01:58, Serial1/3
```

```
R1#sh ip rou | i 5.5.5.0
```

```
O E2    5.5.5.0 [110/20] via 13.1.1.3, 00:03:27, Serial1/3
```

```
R1#sh ip rou 5.5.5.0
```

```
Routing entry for 5.5.5.0/24
```

```
Known via "ospf 1", distance 110, metric 20, type extern 2, forward  
metric 1001
```

```
Last update from 13.1.1.3 on Serial1/3, 00:04:05 ago
```

```
Routing Descriptor Blocks:
```

```
* 13.1.1.3, from 0.0.0.4, 00:04:05 ago, via Serial1/3  
Route metric is 20, traffic share count is 1
```

**We can see that R1 goes through R3 to get to network 5.5.5.0/24. Why?**

**Let's look at the OSPF External Database:**

```
R1#sh ip ospf database external 5.5.5.0
```

```
OSPF Router with ID (0.0.0.1) (Process ID 1)
```

```
Type-5 AS External Link States
```

```
Routing Bit Set on this LSA in topology Base with MTID 0
```

```
LS age: 354
```

```
Options: (No TOS-capability, DC, Upward)
```

```
LS Type: AS External Link
```

```
Link State ID: 5.5.5.0 (External Network Number )
```

```
Advertising Router: 0.0.0.4
```

```
LS Seq Number: 80000001
```

```
Checksum: 0x1B72
```

```
Length: 36
```

```
Network Mask: /24
```

```
Metric Type: 2 (Larger than any link state path)
```

```
MTID: 0
```

```
Metric: 20
```

```
Forward Address: 0.0.0.0
```

```
External Route Tag: 0
```

**The output of the above show command reveals that the FA is suppressed, this means that R1 will take the best path or the path with the lowest cost to reach the ASBR. Let's examine this:**

**R1 has two paths to reach R4:**

- 1. An intra-area route via R3 with a cost of 1001.**
- 2. An inter-area route via R2 with a cost of 2.**

**In this case, R1 prefers the intra-area over inter-area route regardless of their cost. To see the actual costs of the links:**

```
R1#sh ip ospf border-routers | i via
```

```
i 0.0.0.2 [1] via 12.1.1.2, Serial1/2, ABR, Area 0, SPF 8
```

```
i 0.0.0.4 [1001] via 13.1.1.3, Serial1/3, ASBR, Area 2, SPF 8
```

```
R1#sh ip ospf da asbr-summary adv-router 0.0.0.2
```

OSPF Router with ID (0.0.0.1) (Process ID 1)

Summary ASB Link States (Area 0)

LS age: 409  
Options: (No TOS-capability, DC, Upward)  
LS Type: Summary Links (AS Boundary Router)  
**Link State ID: 0.0.0.4** (AS Boundary Router address)  
**Advertising Router: 0.0.0.2**  
LS Seq Number: 80000001  
Checksum: 0x51E3  
Length: 28  
Network Mask: /0  
MTID: 0                   **Metric: 1**

**We can see that the cost from R2's perspective is 1, and R1's cost to R2 is 1 therefore, the total cost to the ASBR through R2 is 2.**

**So our cost to R3 is 1 and R3's cost to R4 is 1000, therefore, the total cost through R3 to reach R4 is 1001.**

**Let's shutdown R1's link to R3:**

```
R1(config)#int s1/3  
R1(config-if)#shut
```

**Let's verify the routing table of R1:**

```
R1#sh ip rou | i 5.5.5.0  
O E2       5.5.5.0 [110/20] via 12.1.1.2, 00:00:10, Serial1/2
```

```
R1#sh ip rou 5.5.5.0  
Routing entry for 5.5.5.0/24  
  Known via "ospf 1", distance 110, metric 20, type extern 2, forward  
metric 2  
  Last update from 12.1.1.2 on Serial1/2, 00:01:07 ago  
  Routing Descriptor Blocks:  
  * 12.1.1.2, from 0.0.0.4, 00:01:07 ago, via Serial1/2  
    Route metric is 20, traffic share count is 1
```

```
R1#sh ip ospf border-routers | b via  
i 0.0.0.2 [1] via 12.1.1.2, Serial1/2, ABR, Area 0, SPF 9  
I 0.0.0.4 [2] via 12.1.1.2, Serial1/2, ASBR, Area 0, SPF 9
```

**Let's "no shutdown" R1's link to R3:**

```
R1(config)#int s1/3  
R1(config-if)#no shut
```

### Let's convert areas 1 and 2 to NSSA:

```
R1(config)#router ospf 1
R1(config-router)#area 2 nssa
```

```
R3(config)#router ospf 1
R3(config-router)#area 2 nssa
```

```
R4(config)#router ospf 1
R4(config-router)#area 2 nssa
R4(config-router)#area 1 nssa
```

```
R2(config)#router ospf 1
R2(config-router)#area 1 nssa
```

### Let's check the routing table of R1:

```
R1#sh ip route | i 5.5.5.0
O E2      5.5.5.0 [110/20] via 12.1.1.2, 00:00:40, Serial1/2
```

### R1 is installing an E2 route instead of N2 through R3, why?

### R4 originates two LSA Type-7s:

1. One with a Forward Address of 24.1.1.4, and floods it into area 1 as N2, the ABR, R2, converts the "N2" to "E2" and floods it into area 0, in that process it copies the "FA" from the LSA Type-7 into the LSA Type-5 in the conversion process.
2. An LSA Type-7 with a FA of 34.1.1.4 and floods it into area 2.

### Let's verify this information:

```
R1#sh ip ospf da nssa 5.5.5.0

      OSPF Router with ID (0.0.0.1) (Process ID 1)

      Type-7 AS External Link States (Area 2)

LS age: 209
Options: (No TOS-capability, Type 7/5 translation, DC, Upward)
LS Type: AS External Link
Link State ID: 5.5.5.0 (External Network Number )
Advertising Router: 0.0.0.4
LS Seq Number: 80000001
Checksum: 0x4F0C
Length: 36
```

```
Network Mask: /24
  Metric Type: 2 (Larger than any link state path)
  MTID: 0
  Metric: 20
  Forward Address: 34.1.1.4
  External Route Tag: 0
```

```
R1#sh ip ospf da exter 5.5.5.0
```

```
OSPF Router with ID (0.0.0.1) (Process ID 1)
```

```
Type-5 AS External Link States
```

```
Routing Bit Set on this LSA in topology Base with MTID 0
LS age: 273
Options: (No TOS-capability, DC, Upward)
LS Type: AS External Link
Link State ID: 5.5.5.0 (External Network Number )
Advertising Router: 0.0.0.2
LS Seq Number: 80000001
Checksum: 0x81EF
Length: 36
Network Mask: /24
  Metric Type: 2 (Larger than any link state path)
  MTID: 0
  Metric: 20
  Forward Address: 24.1.1.4
  External Route Tag: 0
```

**R1 looks at the best OSPF path (The path with the lowest cost) to reach the FAs 24.1.1.4 and 34.1.1.4.**

```
R1#sh ip rou 24.1.1.4
```

```
Routing entry for 24.1.1.0/24
  Known via "ospf 1", distance 110, metric 2, type inter area
  Last update from 12.1.1.2 on Serial1/2, 00:07:03 ago
  Routing Descriptor Blocks:
  * 12.1.1.2, from 0.0.0.2, 00:07:03 ago, via Serial1/2
    Route metric is 2, traffic share count is 1
```

```
R1#sh ip rou 34.1.1.4
```

```
Routing entry for 34.1.1.0/24
  Known via "ospf 1", distance 110, metric 1001, type intra area
  Last update from 13.1.1.3 on Serial1/3, 00:06:30 ago
  Routing Descriptor Blocks:
  * 13.1.1.3, from 0.0.0.3, 00:06:30 ago, via Serial1/3
    Route metric is 1001, traffic share count is 1
```

Since the two OSPF routes (Intra and inter-area) are pointing to different destinations, it can no longer prefer the intra over inter-area route, it has to choose the path with the lowest cost.

To prove this, let's increase the cost for the path through R2 to be higher than the cost through R3.

```
R1(config)#int s1/2
R1(config-if)#ip ospf cost 1002
```

```
R1#sh ip route 34.1.1.4
Routing entry for 34.1.1.0/24
  Known via "ospf 1", distance 110, metric 1001, type intra area
  Last update from 13.1.1.3 on Serial1/3, 00:09:13 ago
  Routing Descriptor Blocks:
    * 13.1.1.3, from 0.0.0.3, 00:09:13 ago, via Serial1/3
      Route metric is 1001, traffic share count is 1
```

```
R1#sh ip rou 24.1.1.4
Routing entry for 24.1.1.0/24
  Known via "ospf 1", distance 110, metric 1003, type inter area
  Last update from 12.1.1.2 on Serial1/2, 00:00:21 ago
  Routing Descriptor Blocks:
    * 12.1.1.2, from 0.0.0.2, 00:00:21 ago, via Serial1/2
      Route metric is 1003, traffic share count is 1
```

Since the cost through R2 is higher than the cost through R3, R1 takes the path through R3.

```
R1#sh ip rou | i 5.5.5.0
O N2      5.5.5.0 [110/20] via 13.1.1.3, 00:02:09, Serial1/3
```

```
R1#sh ip rou 5.5.5.0
```

```
Routing entry for 5.5.5.0/24
  Known via "ospf 1", distance 110, metric 20, type NSSA extern 2, forward
  metric 1001
  Last update from 13.1.1.3 on Serial1/3, 00:03:03 ago
  Routing Descriptor Blocks:
    * 13.1.1.3, from 0.0.0.4, 00:03:03 ago, via Serial1/3
      Route metric is 20, traffic share count is 1
```

Let's change the cost of R1's link to R2 to 1000:

```
R1(config)#int s1/2
R1(config-if)#ip ospf cost 1000
```

```
R1#sh ip rou 24.1.1.4
Routing entry for 24.1.1.0/24
```

```
Known via "ospf 1", distance 110, metric 1001, type inter area
Last update from 12.1.1.2 on Serial1/2, 00:00:57 ago
Routing Descriptor Blocks:
* 12.1.1.2, from 0.0.0.2, 00:00:57 ago, via Serial1/2
  Route metric is 1001, traffic share count is 1
```

```
R1#sh ip route 34.1.1.4
```

```
Routing entry for 34.1.1.0/24
  Known via "ospf 1", distance 110, metric 1001, type intra area
  Last update from 13.1.1.3 on Serial1/3, 00:16:05 ago
  Routing Descriptor Blocks:
  * 13.1.1.3, from 0.0.0.3, 00:16:05 ago, via Serial1/3
    Route metric is 1001, traffic share count is 1
```

**Since the two OSPF routes (Intra and Inter Area) are pointing to two different IP addresses, Intra-Area routes are no longer preferred over the Inter-Area route. In this case we have to look at the total cost, and in this case the total cost is also the same, therefore, RFC 3101, which is the default RFC implemented in the IOS is looked at. This RFC will prefer the "N" route over the "E" route. Let's verify:**

```
R1#sh ip ospf | i RFC
  Supports NSSA (compatible with RFC 3101)
```

```
R1#sh ip route ospf | b Gate
Gateway of last resort is not set
```

```
5.0.0.0/24 is subnetted, 1 subnets
O N2 5.5.5.0 [110/20] via 13.1.1.3, 00:13:04, Serial1/3
  24.0.0.0/24 is subnetted, 1 subnets
O IA 24.1.1.0 [110/1001] via 12.1.1.2, 00:07:02, Serial1/2
  34.0.0.0/24 is subnetted, 1 subnets
O 34.1.1.0 [110/1001] via 13.1.1.3, 00:22:01, Serial1/3
45.0.0.0/24 is subnetted, 1 subnets
O N2 45.1.1.0 [110/20] via 13.1.1.3, 00:13:04, Serial1/3
```

**As we can see the "N" routes are preferred over the "E" routes. Let's change the RFC to 1587:**

```
R1(config)#router ospf 1
R1(config-router)#compatible rfc1587
```

```
R1#sh ip ospf | i RFC
  Supports NSSA (compatible with RFC 1587)
```

```
R1#sh ip route ospf | b Gate
Gateway of last resort is not set
```

**5.0.0.0/24 is subnetted, 1 subnets**

**O E2 5.5.5.0 [110/20] via 12.1.1.2, 00:01:03, Serial1/2**

24.0.0.0/24 is subnetted, 1 subnets

O IA 24.1.1.0 [110/1001] via 12.1.1.2, 00:09:44, Serial1/2

34.0.0.0/24 is subnetted, 1 subnets

O 34.1.1.0 [110/1001] via 13.1.1.3, 00:24:43, Serial1/3

**45.0.0.0/24 is subnetted, 1 subnets**

**O E2 45.1.1.0 [110/20] via 12.1.1.2, 00:01:03, Serial1/2**