Dynamic Routing Protocol – OSPF

1. OSPF stands for open shortest path first.
2. It is an open standard protocol. Open standard means that It supports different-2 vendor like – Cisco, Huawie, juniper etc.
3. It is a link state routing protocol. link state means In OSPF routers do not send periodically update, only send update whenever changes will occur in the topology and that information will be sent partial means in which changed occurred.
   And link state routing protocol whenever share own prefix information that time it also share own subnet mask information with its neighbors.
4. It is an IGP protocol. IGP means it works within AS.
5. OSPF uses SPF algorithm or you can say Dijkistra algorithm for best path selection.
6. Supports unlimited hop count that means no limitation of hop count in OSPF.
7. OSPF uses protocol no – 89
8. It is a layer-3 protocol
9. AD value is = 110
10. Hello and dead interval timer = 10 sec, 40 sec (by default).
    Broadcast and point to point = 10sec, 40sec.
    Non- broadcast and point to multipoint = 30sec, 120sec.
11. Metric = Cost.
    By default reference bandwidth = 100

    Ethernet cost = 10
    Fast Ethernet cost = 1
    Gigaethernet cost = 1
    Serial link cost = 64

   Note – OSPF do not consider decimal value while calculating cost.

12. It is a classless routing protocol; classless means whenever it will share prefix information/ Network information with its neighbors that time it share subnet mask information with the neighbors.
13. OSPF uses two multicast address-
    224.0.0.5   (All routers listen)
    224.0.0.6 (DR routers listen)

   In OSPF hello packets are sent through multicast address 224.0.0.0.5

   Note – In static case may be sent = 224.0.0.6

14. In OSPF must have one area called as area 0 and all the areas must connected to area 0.
15. Supports authentication.

Type 0 – Null authentication

Type 1 – Plain text authentication

Type2 – MD5 authentication
16. Incremental and triggered update.
17. Introduce the concept of areas to ease management & control traffic.
18. OSPF provides Hierarchical Network design with multiple different areas.
19. Routers send only changes in updates and not the entire routing table in periodic updates.
20. By default auto-summary is disabled
21. By default maximum path = 4 (Maximum up to 16).

How to calculate OSPF cost = (In serial link)
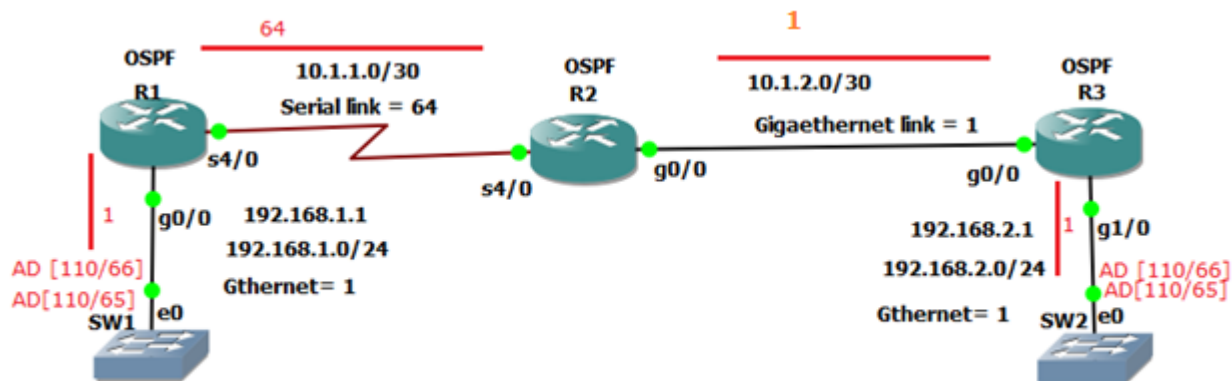
R1=

```
Gateway of last resort is not set

     10.0.0.0/30 is subnetted, 2 subnets
O       10.16.2.0 [110/65] via 10.16.1.2, 00:00:51, Serial4/0
C       10.16.1.0 is directly connected, Serial4/0
C    192.168.1.0/24 is directly connected, GigabitEthernet0/0
O    192.168.2.0/24 [110/66] via 10.16.1.2, 00:00:51, Serial4/0
R1#
```

R2=

```
Gateway of last resort is not set

     10.0.0.0/30 is subnetted, 2 subnets
C       10.16.2.0 is directly connected, GigabitEthernet0/0
C       10.16.1.0 is directly connected, Serial4/0
O    192.168.1.0/24 [110/65] via 10.16.1.1, 00:10:23, Serial4/0
O    192.168.2.0/24 [110/2] via 10.16.2.2, 00:10:51, GigabitEthernet0/0
R2#
```

R3=

```
Gateway of last resort is not set

    10.0.0.0/30 is subnetted, 2 subnets
C       10.16.2.0 is directly connected, GigabitEthernet0/0
O       10.16.1.0 [110/65] via 10.16.2.1, 00:11:57, GigabitEthernet0/0
O    192.168.1.0/24 [110/66] via 10.16.2.1, 00:11:23, GigabitEthernet0/0
C    192.168.2.0/24 is directly connected, GigabitEthernet1/0
R3#
```

Types of table in ospf -

OSPF maintains three routing table –

1. **Neighbor table**
2. **Database table**
3. **Routing table**

Neighbor table –

Neighbor table contains information about the directly connected OSPF neighbors forming adjacency (Keeps directly connected Nbrs.) See the below snapshot for reference purpose-

```
R2#show ip ospf neighbor

Neighbor ID     Pri   State          Dead Time   Address        Interface
3.3.3.3          1    FULL/DR        00:00:34    10.16.2.2      GigabitEthernet0/0
1.1.1.1          0    FULL/  -       00:00:39    10.16.1.1      Serial4/0
R2#
```

```
R1#show ip ospf neighbor

Neighbor ID     Pri   State          Dead Time   Address        Interface
2.2.2.2          0    FULL/  -       00:00:38    10.16.1.2      Serial4/0
R1#
```

 # show ip ospf neighbor

Database table-

Database table contains information about the entire view of the topology with respect to each other (Complete information of the same area but no information of the other area).

#show ip ospf database

```
R1#show ip ospf database

            OSPF Router with ID (1.1.1.1) (Process ID 100)

               Router Link States (Area 0)

Link ID          ADV Router       Age         Seq#        Checksum Link count
1.1.1.1          1.1.1.1          1326        0x80000002 0x00984B 3
2.2.2.2          2.2.2.2          1326        0x80000004 0x0060AC 3
3.3.3.3          3.3.3.3          1351        0x80000003 0x00461A 2

               Net Link States (Area 0)

Link ID          ADV Router       Age         Seq#        Checksum
10.16.2.2        3.3.3.3          1351        0x80000001 0x00906E
R1#
```

Routing table –

Routing table contains information about the best path calculated by SPF algorithm in data base table.

#show ip route ospf

```
R1#show ip route ospf
     10.0.0.0/30 is subnetted, 2 subnets
O       10.16.2.0 [110/65] via 10.16.1.2, 00:25:32, Serial4/0
O    192.168.2.0/24 [110/66] via 10.16.1.2, 00:25:32, Serial4/0
R1#
```

Point to be noted –

In ospf each router makes own database table and in that database table are LSA and in that LSA router Keeps Links information.

For an instance – R1 router.

```
R1#show ip ospf database router 1.1.1.1

            OSPF Router with ID (1.1.1.1) (Process ID 100)

                Router Link States (Area 0)

  LS age: 1938
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 1.1.1.1
  Advertising Router: 1.1.1.1
  LS Seq Number: 80000002
  Checksum: 0x984B
  Length: 60
  Number of Links: 3

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 2.2.2.2
     (Link Data) Router Interface address: 10.16.1.1
      Number of TOS metrics: 0
       TOS 0 Metrics: 64

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 10.16.1.0
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 64

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.1.0
     (Link Data) Network Mask: 255.255.255.0
      Number of TOS metrics: 0
       TOS 0 Metrics: 1

R1#
```

Router-id-

1. **Router-id is a 32 bit value. It used to identify the routers, Format will be In IPv4.(0.0.0.0).**
   In ospf routers choose router-id into three way.
   - ➢ Manual configuration
   - ➢ Highest active loopback interface ip address
   - ➢ Highest active physical interface ip address

How to configure ospf router-id –

- ➢ R1(config)#**router ospf 100**
- ➢ R1(config-router)#router
- ➢ R1(config-router)#router-id 1.1.1.1

```
R1(config)#router ospf 100
R1(config-router)#router
R1(config-router)#router-id 1.1.1.1
R1(config-router)#exit
R1(config)#
```

Note – If you configure router- id after configuring ospf then it will give you one message.

```
R1#clear ip ospf pro
R1#clear ip ospf process
Reset ALL OSPF processes? [no]: y
R1#
```

Process ID -

It is used to identify the ospf process, process id can be different in ospf. Range (<1-65535>).

```
R1(config)#router ospf ?
  <1-65535>  Process ID

R1(config)#router ospf
```

How to change ospf priority –

- ➢ By default priority is = 1
- ➢ Priority 0 means no participation in election (DR/BDR)
- ➢ At serial link no DR/BDR are elected as priority are 0 of serial link.

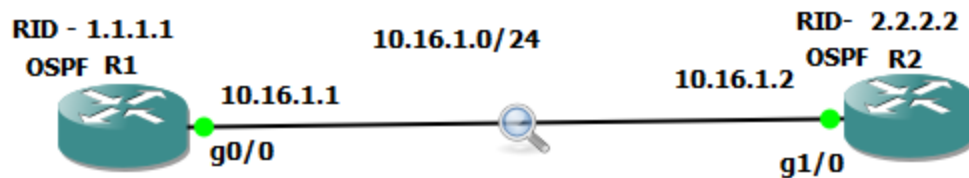   R1(config)#interface gigabitEthernet 0/0

- • R1(config-if)#ip ospf priority ?
- • R1(config-if)#ip ospf priority <0-255>

```
R1(config)#interface gigabitEthernet 0/0
R1(config-if)#ip ospf priority ?
  <0-255>  Priority

R1(config-if)#ip ospf priority
```

OSPF packet flow:- In case of Ethernets.

RID - 1.1.1.1
OSPF R1

10.16.1.0/24

RID- 2.2.2.2
OSPF R2

10.16.1.1

10.16.1.2

g0/0

g1/0

OSPF = Hello

———— IP header ————

L3->IP | Hello | 10.16.1.1 | 224.0.0.5 | P89 | TTL 1 |
        SIP   Multicast Protocol N TTL value

———————— Packet encapsulate ————————

It will handover to L2 ARPA protocol

———————— Ethernet header ————————

L2-ARPA-> Packet | ca04.0928.0008 | 01:00:5e:00:00:05 | 0X0800 |
                   Int src mac add   multicast mac add type code of IPv4

———————————— Frame encapsulate ————————————

```
R1#show ip interface gigabitEthernet 0/0
GigabitEthernet0/0 is up, line protocol is up
  Internet address is 10.16.1.1/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Multicast reserved groups joined: 224.0.0.5
  Outgoing access list is not set
  Inbound  access list is not set
  Proxy ARP is enabled
  Local Proxy ARP is disabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachables are always sent
  ICMP mask replies are never sent
```

```
R2#show ip interface gigabitEthernet 1/0
GigabitEthernet1/0 is up, line protocol is up
  Internet address is 10.16.1.2/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Multicast reserved groups joined: 224.0.0.5 224.0.0.6
  Outgoing access list is not set
  Inbound  access list is not set
  Proxy ARP is enabled
  Local Proxy ARP is disabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachables are always sent
  ICMP mask replies are never sent
```

OSPF message/packet type –

1. Hello packet
2. Database Description packet (DBDs)
3. Link state Request (LSR)
4. Link states update (LSU)
5. Link state Acknowledgement (ACK)

Hello:-

1. Hello packet are used to established & maintain Neighbor-ship. OR
2. Hello packets are used to discover neighbor-ship.
3. Keep-alive.
4. Periodically send after every 10sec/30sec (Brod, P2P/Non-Broadcast).
5. Dead timer 40sec/120sec (Brod, P2P/Non-Broadcast).
6. Hello messages are sent though multicast address – 224.0.0.5.
7. In static neighbor-ship hello messages/packet are sent unicast.

Hello packets content:-

1. OSPF version
2. Message type
3. Packet length
4. Router-id
5. Area-id
6. Checksum value
7. Authentication type
8. Authentication data
9. Subnet mask
10. Hello & Dead interval timer
11. Priority
12. DR & BDR ip address
13. Stub area flag.

1. Router-id must not match between the routers
2. Area-id must match
3. Authentication type and Authentication data must match
4. Subnet mask must match
5. Hello & Dead interval timer must match
6. MTU size must match
7. Stub area flag must match
8. OSPF network type should match

How to configure OSPF hello & dead interval timer:-

R(config)#interface gigabitEthernet 0/0

R(config-if)#ip ospf hello-interval <1-65535> Seconds

R(config-if)#ip ospf hello-interval 10

Dead:-

R(config)#interface gigabitEthernet 0/0

R(config-if)#ip ospf hello-interval <1-65535> Seconds

R(config-if)#ip ospf dead-interval 40

1. R#show ip protocols
2. R#show ip ospf
3. R#show ip ospf interface gigabitEthernet 0/0

2. Type-2 Message Database Descriptor packet (DBDs)

1. In this packet routers only exchange empty DBDs packet with own sequence number to neighbors.
2. Also routers share MTU size in this packet. (MTU Size must be same in packet of the router's interface).
3. Master/ Slave are elected. And that router will become master router whose router-id will be higher than other and master router will start the exchange information and other router (Slave) will give response to master.

```
∨ Open Shortest Path First
  ∨ OSPF Header
      Version: 2
      Message Type: DB Description (2)    DBD PACKET
      Packet Length: 52
      Source OSPF Router: 1.1.1.1
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0x598c [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  ∨ OSPF DB Description
      Interface MTU: 1500        MTU SIZE
    ∨ Options: 0x52, O, (L) LLS Data block, (E) External Routing
        0... .... = DN: Not set
        .1.. .... = O: Set
        ..0. .... = (DC) Demand Circuits: Not supported
        ...1 .... = (L) LLS Data block: Present
        .... 0... = (N) NSSA: Not supported
        .... .0.. = (MC) Multicast: Not capable
        .... ..1. = (E) External Routing: Capable
        .... ...0 = (MT) Multi-Topology Routing: No
    ∨ DB Description: 0x02, (M) More
        .... 0... = (R) OOBResync: Not set
        .... .0.. = (I) Init: Not set
        .... ..1. = (M) More: Set
        .... ...0 = (MS) Master: No
      DD Sequence: 9591
```

Here R1 Router is announing I'm not Master as my Router Id is less than you so I'm not Master router.

In this packet R1 Router has mentioned Sequence no of R2

```
∨ Open Shortest Path First
  ∨ OSPF Header
      Version: 2
      Message Type: DB Description (2)    DBD PACKET
      Packet Length: 32
      Source OSPF Router: 2.2.2.2
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0x7c7f [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  ∨ OSPF DB Description
      Interface MTU: 1500        MTU SIZE
    ∨ Options: 0x52, O, (L) LLS Data block, (E) External Routing
        0... .... = DN: Not set
        .1.. .... = O: Set
        ..0. .... = (DC) Demand Circuits: Not supported
        ...1 .... = (L) LLS Data block: Present
        .... 0... = (N) NSSA: Not supported
        .... .0.. = (MC) Multicast: Not capable
        .... ..1. = (E) External Routing: Capable
        .... ...0 = (MT) Multi-Topology Routing: No
    ∨ DB Description: 0x07, (I) Init, (M) More, (MS) Master
        .... 0... = (R) OOBResync: Not set
        .... .1.. = (I) Init: Set
        .... ..1. = (M) More: Set
        .... ...1 = (MS) Master: Yes
      DD Sequence: 9591
```

I'm Master as My router id heigher than you

Type-3– Link state Request (LSR):-

In this state will request to its neighbors that I am having some LSA header and I need complete information about that ok let me check in my database table, Vice versa.

Type-4 – Link state update (LSU):-

In this packet/message router will share update about own links information to neighbors.

```
>  Internet Protocol Version 4, Src: 10.16.1.1, Dst: 10.16.1.2
v  Open Shortest Path First
   v  OSPF Header
         Version: 2
         Message Type: LS Update (4)
         Packet Length: 64
         Source OSPF Router: 1.1.1.1
         Area ID: 0.0.0.0 (Backbone)
         Checksum: 0xc9be [correct]
         Auth Type: Null (0)
         Auth Data (none): 0000000000000000
   v  LS Update Packet
         Number of LSAs: 1
      v  LSA-type 1 (Router-LSA), len 36
            .000 0000 0010 1100 = LS Age (seconds): 44
            0... .... .... .... = Do Not Age Flag: 0
         v  Options: 0x22, (DC) Demand Circuits, (E) External Routing
               0... .... = DN: Not set
               .0.. .... = O: Not set
               ..1. .... = (DC) Demand Circuits: Supported
               ...0 .... = (L) LLS Data block: Not Present
               .... 0... = (N) NSSA: Not supported
               .... .0.. = (MC) Multicast: Not capable
               .... ..1. = (E) External Routing: Capable
               .... ...0 = (MT) Multi-Topology Routing: No
            LS Type: Router-LSA (1)
            Link State ID: 1.1.1.1
            Advertising Router: 1.1.1.1
            Sequence Number: 0x80000001
            Checksum: 0x7e90
            Length: 36
         v  Flags: 0x00
               .... .0.. = (V) Virtual link endpoint: No
               .... ..0. = (E) AS boundary router: No
               .... ...0 = (B) Area border router: No
            Number of Links: 1                    Links information
         v  Type: Stub      ID: 10.16.1.0        Data: 255.255.255.0    Metric: 1
               Link ID: 10.16.1.0 - IP network/subnet number
               Link Data: 255.255.255.0
               Link Type: 3 - Connection to a stub network
               Number of Metrics: 0 - TOS
               0 Metric: 1
```

R2 router's update-

```
> Internet Protocol Version 4, Src: 10.16.1.2, Dst: 10.16.1.1
∨ Open Shortest Path First
  ∨ OSPF Header
       Version: 2
       Message Type: LS Update (4)          LSU
       Packet Length: 64
       Source OSPF Router: 2.2.2.2
       Area ID: 0.0.0.0 (Backbone)
       Checksum: 0x0f62 [correct]
       Auth Type: Null (0)
       Auth Data (none): 0000000000000000
  ∨ LS Update Packet
       Number of LSAs: 1
     ∨ LSA-type 1 (Router-LSA), len 36
         .000 0000 0011 1111 = LS Age (seconds): 63
         0... .... .... .... = Do Not Age Flag: 0
       ∨ Options: 0x22, (DC) Demand Circuits, (E) External Routing
           0... .... = DN: Not set
           .0.. .... = O: Not set
           ..1. .... = (DC) Demand Circuits: Supported
           ...0 .... = (L) LLS Data block: Not Present
           .... 0... = (N) NSSA: Not supported
           .... .0.. = (MC) Multicast: Not capable
           .... ..1. = (E) External Routing: Capable
           .... ...0 = (MT) Multi-Topology Routing: No
         LS Type: Router-LSA (1)
         Link State ID: 2.2.2.2
         Advertising Router: 2.2.2.2
         Sequence Number: 0x80000001
         Checksum: 0x32d4
         Length: 36
       > Flags: 0x00                  Links information/update
         Number of Links: 1
       ∨ Type: Stub     ID: 10.16.1.0      Data: 255.255.255.0   Metric: 1
           Link ID: 10.16.1.0 - IP network/subnet number
           Link Data: 255.255.255.0
           Link Type: 3 - Connection to a stub network
           Number of Metrics: 0 - TOS
           0 Metric: 1
```

Type -5- link state acknowledgement (LSack)

Then routers will give to each other acknowledgement message.

```
> Internet Protocol Version 4, Src: 10.16.1.2, Dst: 224.0.0.5
∨ Open Shortest Path First
  ∨ OSPF Header
      Version: 2
      Message Type: LS Acknowledge (5)
      Packet Length: 64
      Source OSPF Router: 2.2.2.2
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0x637d [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  ∨ LSA-type 1 (Router-LSA), len 36
      .000 0000 0010 1100 = LS Age (seconds): 44
      0... .... .... .... = Do Not Age Flag: 0
    ∨ Options: 0x22, (DC) Demand Circuits, (E) External Routing
        0... .... = DN: Not set
        .0.. .... = O: Not set
        ..1. .... = (DC) Demand Circuits: Supported
        ...0 .... = (L) LLS Data block: Not Present
        .... 0... = (N) NSSA: Not supported
        .... .0.. = (MC) Multicast: Not capable
        .... ..1. = (E) External Routing: Capable
        .... ...0 = (MT) Multi-Topology Routing: No
      LS Type: Router-LSA (1)
      Link State ID: 1.1.1.1
      Advertising Router: 1.1.1.1
      Sequence Number: 0x80000001
      Checksum: 0x7e90
      Length: 36
  ∨ LSA-type 1 (Router-LSA), len 36
      .000 0000 0000 0001 = LS Age (seconds): 1
      0... .... .... .... = Do Not Age Flag: 0
    ∨ Options: 0x22, (DC) Demand Circuits, (E) External Routing
        0... .... = DN: Not set
        .0.. .... = O: Not set
        ..1. .... = (DC) Demand Circuits: Supported
        ...0 .... = (L) LLS Data block: Not Present
        .... 0... = (N) NSSA: Not supported
        .... .0.. = (MC) Multicast: Not capable
        .... ..1. = (E) External Routing: Capable
        .... ...0 = (MT) Multi-Topology Routing: No
      LS Type: Router-LSA (1)
      Link State ID: 1.1.1.1
      Advertising Router: 1.1.1.1
      Sequence Number: 0x80000002
      Checksum: 0xcb25
      Length: 36
```

```
> Internet Protocol Version 4, Src: 10.16.1.1, Dst: 224.0.0.5
∨ Open Shortest Path First
  ∨ OSPF Header
      Version: 2
      Message Type: LS Acknowledge (5)
      Packet Length: 104
      Source OSPF Router: 1.1.1.1
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0x4ca4 [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  ∨ LSA-type 1 (Router-LSA), len 36
      .000 0000 0011 1111 = LS Age (seconds): 63
      0... .... .... .... = Do Not Age Flag: 0
    ∨ Options: 0x22, (DC) Demand Circuits, (E) External Routing
        0... .... = DN: Not set
        .0.. .... = O: Not set
        ..1. .... = (DC) Demand Circuits: Supported
        ...0 .... = (L) LLS Data block: Not Present
        .... 0... = (N) NSSA: Not supported
        .... .0.. = (MC) Multicast: Not capable
        .... ..1. = (E) External Routing: Capable
        .... ...0 = (MT) Multi-Topology Routing: No
      LS Type: Router-LSA (1)
      Link State ID: 2.2.2.2
      Advertising Router: 2.2.2.2
      Sequence Number: 0x80000001
      Checksum: 0x32d4
      Length: 36
  ∨ LSA-type 1 (Router-LSA), len 36
      .000 0000 0000 0010 = LS Age (seconds): 2
      0... .... .... .... = Do Not Age Flag: 0
    ∨ Options: 0x22, (DC) Demand Circuits, (E) External Routing
        0... .... = DN: Not set
        .0.. .... = O: Not set
        ..1. .... = (DC) Demand Circuits: Supported
        ...0 .... = (L) LLS Data block: Not Present
        .... 0... = (N) NSSA: Not supported
        .... .0.. = (MC) Multicast: Not capable
        .... ..1. = (E) External Routing: Capable
        .... ...0 = (MT) Multi-Topology Routing: No
      LS Type: Router-LSA (1)
      Link State ID: 1.1.1.1
      Advertising Router: 1.1.1.1
      Sequence Number: 0x80000002
      Checksum: 0xcb25
      Length: 36
  ∨ LSA-type 1 (Router-LSA), len 36
      .000 0000 0000 0001 = LS Age (seconds): 1
      0... .... .... .... = Do Not Age Flag: 0
    ∨ Options: 0x22, (DC) Demand Circuits, (E) External Routing
        0... .... = DN: Not set
        .0.. .... = O: Not set

        ..1. .... = (DC) Demand Circuits: Supported
        ...0 .... = (L) LLS Data block: Not Present
        .... 0... = (N) NSSA: Not supported
        .... .0.. = (MC) Multicast: Not capable
        .... ..1. = (E) External Routing: Capable
        .... ...0 = (MT) Multi-Topology Routing: No
      LS Type: Router-LSA (1)
      Link State ID: 2.2.2.2
      Advertising Router: 2.2.2.2
      Sequence Number: 0x80000002
      Checksum: 0x8d5a
      Length: 36
  ∨ LSA-type 2 (Network-LSA), len 32
      .000 0000 0000 0001 = LS Age (seconds): 1
      0... .... .... .... = Do Not Age Flag: 0
    ∨ Options: 0x22, (DC) Demand Circuits, (E) External Routing
        0... .... = DN: Not set
        .0.. .... = O: Not set
        ..1. .... = (DC) Demand Circuits: Supported
        ...0 .... = (L) LLS Data block: Not Present
        .... 0... = (N) NSSA: Not supported
        .... .0.. = (MC) Multicast: Not capable
        .... ..1. = (E) External Routing: Capable
        .... ...0 = (MT) Multi-Topology Routing: No
      LS Type: Network-LSA (2)
      Link State ID: 10.16.1.2
      Advertising Router: 2.2.2.2
      Sequence Number: 0x80000001
      Checksum: 0x7791
      Length: 32
```

Types of OSPF states

1. Down state
2. Init state
3. 2-way state
4. Ex-start state
5. Exchange state
6. Loading state
7. Full state
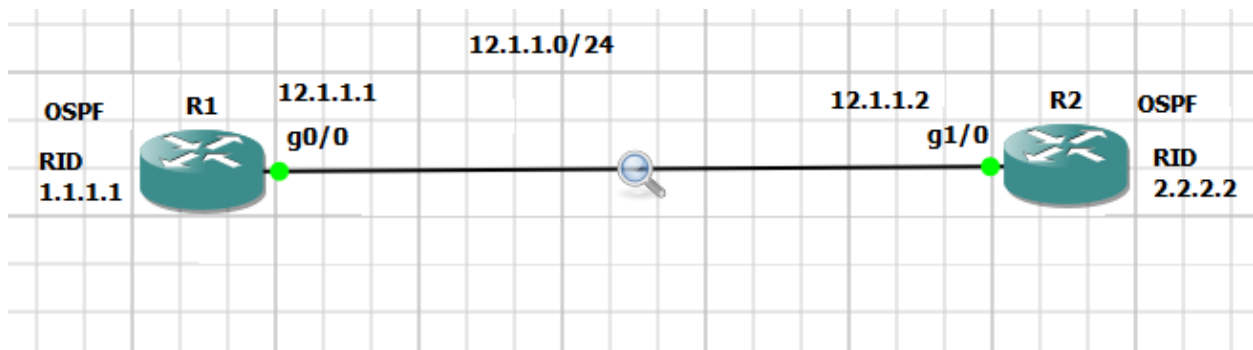
Down state-

This is the first state of OSPF, this state indicates the no information has been received from its neighbor Means Hello packet still did not received from its neighbor.
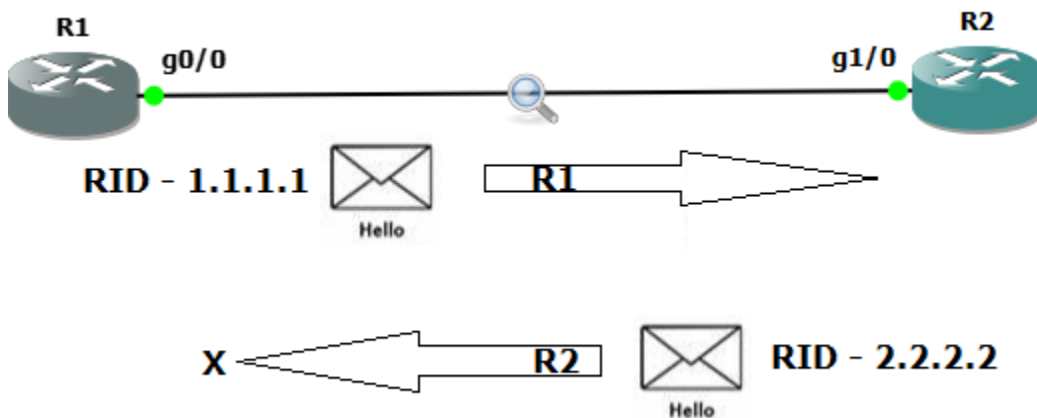
Then router move next state.

2. Init state-

This state designates that hello packet received from its neighbor.
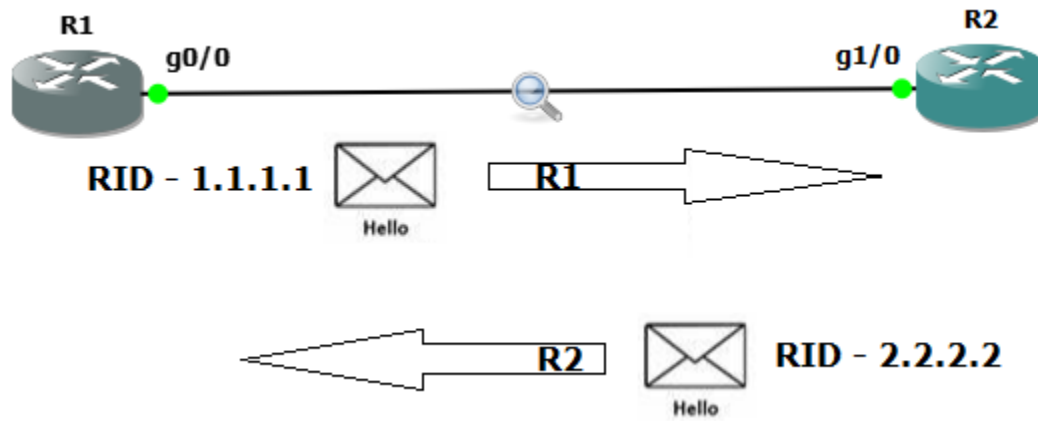
Hello packet content.

1. OSPF version
2. Message Type
3. Packet length
4. Router –id
5. Area Id
6. Checksum value
7. Authentication type
8. Authentication data
9. Subnet mask
10. Hello and dead interval timer
11. Priority
12. DR&BDR IP address
13. Stub area flag

```
∨ Open Shortest Path First
    ∨ OSPF Header
        Version: 2
        Message Type: Hello Packet (1)
        Packet Length: 44
        Source OSPF Router: 1.1.1.1
        Area ID: 0.0.0.0 (Backbone)
        Checksum: 0xea9c [correct]
        Auth Type: Null (0)
        Auth Data (none): 0000000000000000
    ∨ OSPF Hello Packet
        Network Mask: 255.255.255.0
        Hello Interval [sec]: 10
        ∨ Options: 0x12, (L) LLS Data block, (E) External Routing
            0... .... = DN: Not set
            .0.. .... = O: Not set
            ..0. .... = (DC) Demand Circuits: Not supported
            ...1 .... = (L) LLS Data block: Present
            .... 0... = (N) NSSA: Not supported
            .... .0.. = (MC) Multicast: Not capable
            .... ..1. = (E) External Routing: Capable
            .... ...0 = (MT) Multi-Topology Routing: No
        Router Priority: 1
        Router Dead Interval [sec]: 40
        Designated Router: 0.0.0.0
        Backup Designated Router: 0.0.0.0
    ∨ OSPF LLS Data Block
        Checksum: 0xfff6
        LLS Data Length: 12 bytes
        ∨ Extended options TLV
            TLV Type: 1
            TLV Length: 4
            ∨ Options: 0x00000001, (LR) LSDB Resynchronization
                .... .... .... .... .... .... .... ..0. = (RS) Restart Signal: Not set
                .... .... .... .... .... .... .... ...1 = (LR) LSDB Resynchronization: Set
```

Neighbor-ship parameters-

1. Router-id must not match between the Routers
2. Area id must match
3. Authentication type and authentication data must match
4. Subnet mask must match
5. Hello and dead timer must match
6. MTU size must match

7. Stub area flag must match
8. OSPF network type should match

R2 Router Hello packet.

```
∨ Open Shortest Path First
∨ Open Shortest Path First
   ∨ OSPF Header
        Version: 2
        Message Type: Hello Packet (1)
        Packet Length: 44
        Source OSPF Router: 2.2.2.2
        Area ID: 0.0.0.0 (Backbone)
        Checksum: 0xe89a [correct]
        Auth Type: Null (0)
        Auth Data (none): 0000000000000000
   ∨ OSPF Hello Packet
        Network Mask: 255.255.255.0
        Hello Interval [sec]: 10
      ∨ Options: 0x12, (L) LLS Data block, (E) External Routing
             0... .... = DN: Not set
             .0.. .... = O: Not set
             ..0. .... = (DC) Demand Circuits: Not supported
             ...1 .... = (L) LLS Data block: Present
             .... 0... = (N) NSSA: Not supported
             .... .0.. = (MC) Multicast: Not capable
             .... ..1. = (E) External Routing: Capable
             .... ...0 = (MT) Multi-Topology Routing: No
        Router Priority: 1
        Router Dead Interval [sec]: 40
        Designated Router: 0.0.0.0
        Backup Designated Router: 0.0.0.0
   ∨ OSPF LLS Data Block
        Checksum: 0xfff6
        LLS Data Length: 12 bytes
      ∨ Extended options TLV
           TLV Type: 1
           TLV Length: 4
         ∨ Options: 0x00000001, (LR) LSDB Resynchronization
              .... .... .... .... .... .... .... ..0. = (RS) Restart Signal: Not set
              .... .... .... .... .... .... .... ...1 = (LR) LSDB Resynchronization: Set
```

3. Two-state

This is the 3rd state of OSPF, in this state bidirectional communication are established between the routers. Bidirectional means both router send to each other hello packet with neighbor router id as well as self router-id.

And in this state DR&BDR are elect, If we have multi-access network.

Note – DR&BDR are elect on Ethernet link, not an elect on serial link as serial link's priority are 0.

RID– 2.2.2.2 RID – 1.1.1.1

Hello

R1

R1

g0/0

R2

g1/0

Hello

RID – 2.2.2.2 RID – 1.1.1.1

R2
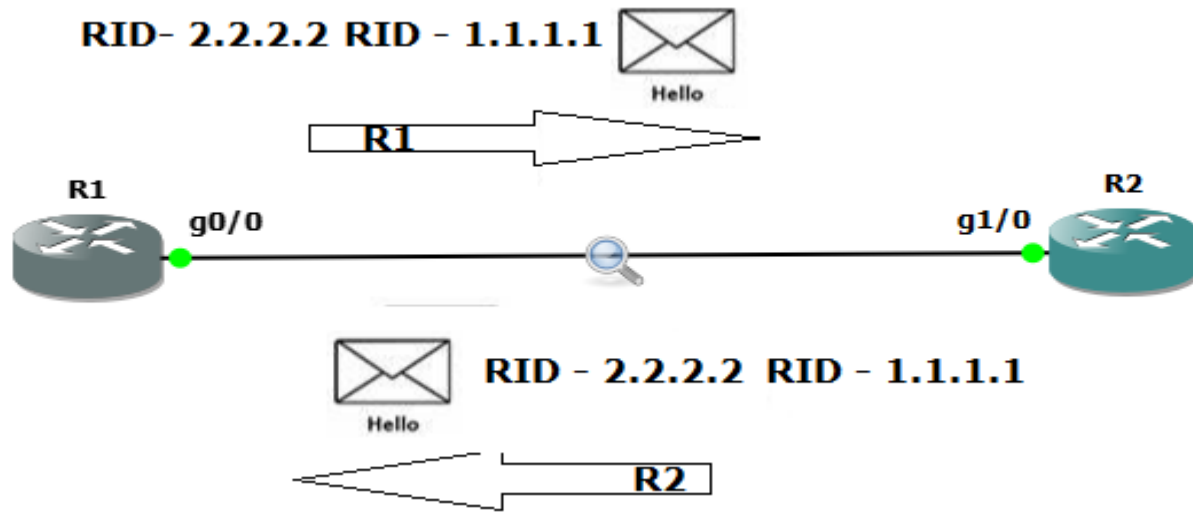
Here as you can see both router share own router id as well as neighbor router-id.

```
∨ Open Shortest Path First
  ∨ OSPF Header
       Version: 2
       Message Type: Hello Packet (1)
       Packet Length: 48
       Source OSPF Router: 1.1.1.1        Router id of R1
       Area ID: 0.0.0.0 (Backbone)
       Checksum: 0xe694 [correct]
       Auth Type: Null (0)
       Auth Data (none): 0000000000000000
  ∨ OSPF Hello Packet
       Network Mask: 255.255.255.0
       Hello Interval [sec]: 10
    ∨ Options: 0x12, (L) LLS Data block, (E) External Routing
          0... .... = DN: Not set
          .0.. .... = O: Not set
          ..0. .... = (DC) Demand Circuits: Not supported
          ...1 .... = (L) LLS Data block: Present
          .... 0... = (N) NSSA: Not supported
          .... .0.. = (MC) Multicast: Not capable
          .... ..1. = (E) External Routing: Capable
          .... ...0 = (MT) Multi-Topology Routing: No
       Router Priority: 1
       Router Dead Interval [sec]: 40
       Designated Router: 0.0.0.0
       Backup Designated Router: 0.0.0.0
       Active Neighbor: 2.2.2.2        Router id of R2
  ∨ OSPF LLS Data Block
       Checksum: 0xfff6
       LLS Data Length: 12 bytes
    ∨ Extended options TLV
         TLV Type: 1
         TLV Length: 4
       ∨ Options: 0x00000001, (LR) LSDB Resynchronization
            .... .... .... .... .... .... .... ..0. = (RS) Restart Signal: Not set
            .... .... .... .... .... .... .... ...1 = (LR) LSDB Resynchronization: Set
```

R2 router's router-ID

```
∨ Open Shortest Path First
   ∨ OSPF Header
        Version: 2
        Message Type: Hello Packet (1)
        Packet Length: 48
        Source OSPF Router: 2.2.2.2     Router id of R2
        Area ID: 0.0.0.0 (Backbone)
        Checksum: 0xe694 [correct]
        Auth Type: Null (0)
        Auth Data (none): 0000000000000000
   ∨ OSPF Hello Packet
        Network Mask: 255.255.255.0
        Hello Interval [sec]: 10
      ∨ Options: 0x12, (L) LLS Data block, (E) External Routing
            0... .... = DN: Not set
            .0.. .... = O: Not set
            ..0. .... = (DC) Demand Circuits: Not supported
            ...1 .... = (L) LLS Data block: Present
            .... 0... = (N) NSSA: Not supported
            .... .0.. = (MC) Multicast: Not capable
            .... ..1. = (E) External Routing: Capable
            .... ...0 = (MT) Multi-Topology Routing: No
        Router Priority: 1
        Router Dead Interval [sec]: 40
        Designated Router: 0.0.0.0
        Backup Designated Router: 0.0.0.0
        Active Neighbor: 1.1.1.1     Router id of R1
   ∨ OSPF LLS Data Block
        Checksum: 0xfff6
        LLS Data Length: 12 bytes
      ∨ Extended options TLV
            TLV Type: 1
            TLV Length: 4
         ∨ Options: 0x00000001, (LR) LSDB Resynchronization
               .... .... .... .... .... .... .... ..0. = (RS) Restart Signal: Not set
               .... .... .... .... .... .... .... ...1 = (LR) LSDB Resynchronization: Set
```

Then router move next state and that state is called Ex-start state.

4. Ex-start state.

In this state routers send to each other empty DBDs packet and in that empty DBDs packet routers also share their sequence number.

MTU size must match between the routers.

In Ex-start state master & slave are elected and highest router will become Master, second heights will become slave and that router will become master will start the exchange information.
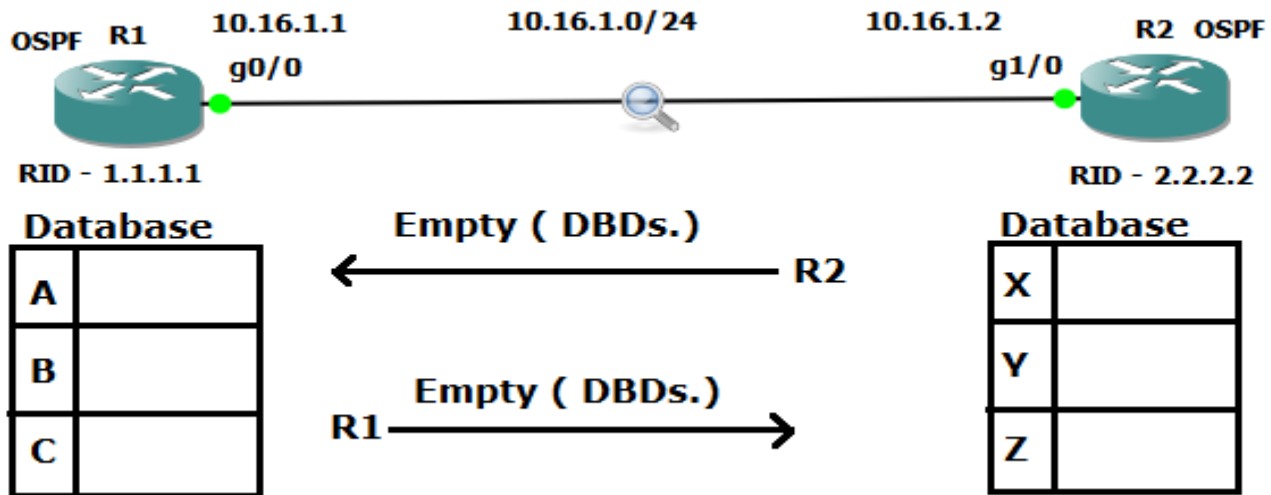
DBDs packet of R1-

```
∨ Open Shortest Path First
  ∨ OSPF Header
      Version: 2
      Message Type: DB Description (2)
      Packet Length: 32
      Source OSPF Router: 1.1.1.1
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0x9e06 [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  ∨ OSPF DB Description
      Interface MTU: 1500
    ∨ Options: 0x52, O, (L) LLS Data block, (E) External Routing
          0... .... = DN: Not set
          .1.. .... = O: Set
          ..0. .... = (DC) Demand Circuits: Not supported
          ...1 .... = (L) LLS Data block: Present
          .... 0... = (N) NSSA: Not supported
          .... .0.. = (MC) Multicast: Not capable
          .... ..1. = (E) External Routing: Capable
          .... ...0 = (MT) Multi-Topology Routing: No
    ∨ DB Description: 0x07, (I) Init, (M) More, (MS) Master
          .... 0... = (R) OOBResync: Not set
          .... .1.. = (I) Init: Set
          .... ..1. = (M) More: Set
          .... ...1 = (MS) Master: Yes
      DD Sequence: 1522
  ∨ OSPF LLS Data Block
      Checksum: 0xfff6
      LLS Data Length: 12 bytes
    ∨ Extended options TLV
        TLV Type: 1
        TLV Length: 4
      ∨ Options: 0x00000001, (LR) LSDB Resynchronization
          .... .... .... .... .... .... .... ..0. = (RS) Restart Signal: Not set
          .... .... .... .... .... .... .... ...1 = (LR) LSDB Resynchronization: Set
```

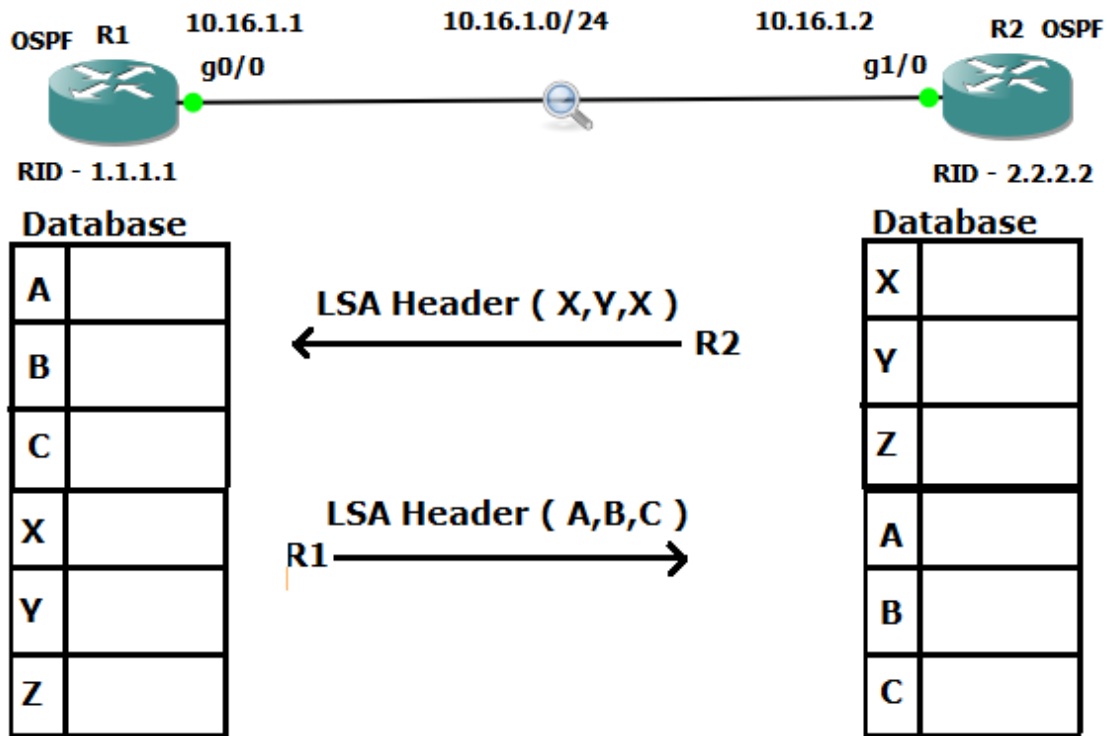**DBDs packet of R2-**

```
∨ Open Shortest Path First
  ∨ OSPF Header
        Version: 2
        Message Type: DB Description (2)
        Packet Length: 32
        Source OSPF Router: 2.2.2.2
        Area ID: 0.0.0.0 (Backbone)
        Checksum: 0x8376 [correct]
        Auth Type: Null (0)
        Auth Data (none): 0000000000000000
  ∨ OSPF DB Description
        Interface MTU: 1500
    ∨ Options: 0x52, O, (L) LLS Data block, (E) External Routing
          0... .... = DN: Not set
          .1.. .... = O: Set
          ..0. .... = (DC) Demand Circuits: Not supported
          ...1 .... = (L) LLS Data block: Present
          .... 0... = (N) NSSA: Not supported
          .... .0.. = (MC) Multicast: Not capable
          .... ..1. = (E) External Routing: Capable
          .... ...0 = (MT) Multi-Topology Routing: No
    ∨ DB Description: 0x07, (I) Init, (M) More, (MS) Master
          .... 0... = (R) OOBResync: Not set
          .... .1.. = (I) Init: Set
          .... ..1. = (M) More: Set
          .... ...1 = (MS) Master: Yes
        DD Sequence: 7808
  ∨ OSPF LLS Data Block
        Checksum: 0xfff6
        LLS Data Length: 12 bytes
    ∨ Extended options TLV
          TLV Type: 1
          TLV Length: 4
      ∨ Options: 0x00000001, (LR) LSDB Resynchronization
            .... .... .... .... .... .... .... ..0. = (RS) Restart Signal: Not set
            .... .... .... .... .... .... .... ...1 = (LR) LSDB Resynchronization: Set
```

Then router move next state that state is called exchange state.
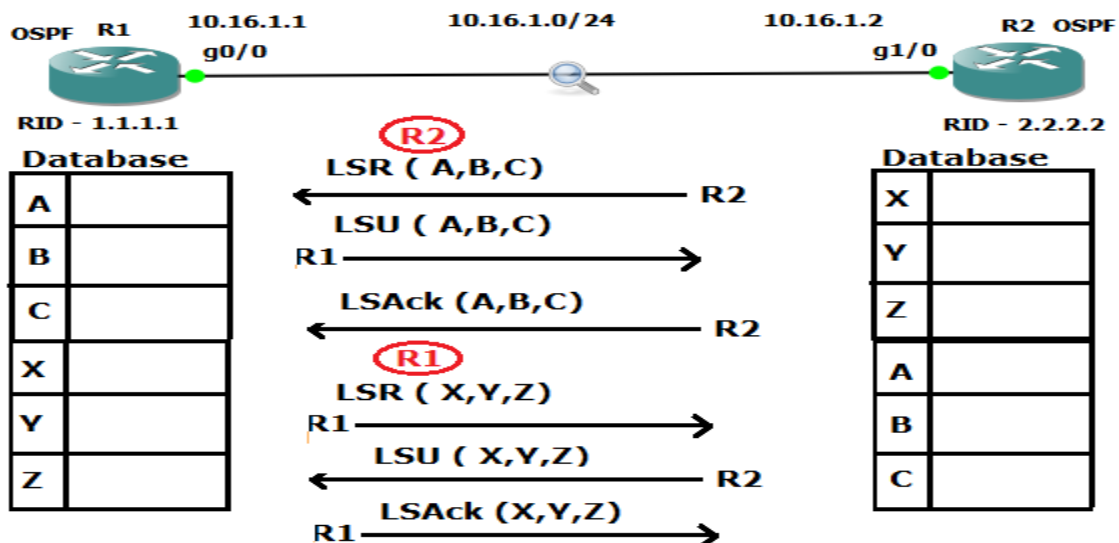
5. Exchange state-

In this state routers only exchange LSA header to each other and do not share complete information.

6. Loading state.

In loading state router will request with its neighbor that I have some LSA header and I need complete information about that.

```
> Frame 46: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface -, id 0
> Ethernet II, Src: ca:01:08:ba:00:08 (ca:01:08:ba:00:08), Dst: ca:02:08:c9:00:1c (ca:02:08:c9:00:1c)
> Internet Protocol Version 4, Src: 10.16.1.1, Dst: 10.16.1.2
✓ Open Shortest Path First
  ✓ OSPF Header
        Version: 2
        Message Type: LS Request (3)    Type -3 msg - LSR
        Packet Length: 36
        Source OSPF Router: 1.1.1.1
        Area ID: 0.0.0.0 (Backbone)
        Checksum: 0xf3cd [correct]
        Auth Type: Null (0)
        Auth Data (none): 0000000000000000
  ✓ Link State Request
        LS Type: Router-LSA (1)
        Link State ID: 2.2.2.2
        Advertising Router: 2.2.2.2
```

Type – 4 message Link state update.

```
✓ Open Shortest Path First
  ✓ OSPF Header
        Version: 2
        Message Type: LS Update (4)    Type – 4 msg
        Packet Length: 64
        Source OSPF Router: 2.2.2.2
        Area ID: 0.0.0.0 (Backbone)
        Checksum: 0x0f79 [correct]
        Auth Type: Null (0)
        Auth Data (none): 0000000000000000
  ✓ LS Update Packet
        Number of LSAs: 1
      ✓ LSA-type 1 (Router-LSA), len 36
            .000 0000 0010 1000 = LS Age (seconds): 40
            0... .... .... .... = Do Not Age Flag: 0
          ✓ Options: 0x22, (DC) Demand Circuits, (E) External Routing
                0... .... = DN: Not set
                .0.. .... = O: Not set
                ..1. .... = (DC) Demand Circuits: Supported
                ...0 .... = (L) LLS Data block: Not Present
                .... 0... = (N) NSSA: Not supported
                .... .0.. = (MC) Multicast: Not capable
                .... ..1. = (E) External Routing: Capable
                .... ...0 = (MT) Multi-Topology Routing: No
            LS Type: Router-LSA (1)
            Link State ID: 2.2.2.2
            Advertising Router: 2.2.2.2
            Sequence Number: 0x80000001
            Checksum: 0x32d4
            Length: 36
          ✓ Flags: 0x00
                .... .0.. = (V) Virtual link endpoint: No
                .... ..0. = (E) AS boundary router: No
                .... ...0 = (B) Area border router: No
            Number of Links: 1
      ✓ Type: Stub      ID: 10.16.1.0      Data: 255.255.255.0    Metric: 1
            Link ID: 10.16.1.0 - IP network/subnet number
            Link Data: 255.255.255.0
            Link Type: 3 - Connection to a stub network
            Number of Metrics: 0 - TOS
            0 Metric: 1
```

Type -5 Message link state Acknowlgement.

```
> Frame 52: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on interface -, id 0
> Ethernet II, Src: ca:01:08:ba:00:08 (ca:01:08:ba:00:08), Dst: ca:02:08:c9:00:1c (ca:02:08:c9:00:1c)
> Internet Protocol Version 4, Src: 10.16.1.1, Dst: 10.16.1.2
v Open Shortest Path First
  v OSPF Header
         Version: 2
         Message Type: LS Acknowledge (5)
         Packet Length: 44
         Source OSPF Router: 1.1.1.1
         Area ID: 0.0.0.0 (Backbone)
         Checksum: 0xd6d1 [correct]
         Auth Type: Null (0)
         Auth Data (none): 0000000000000000
  v LSA-type 1 (Router-LSA), len 36
         .000 0000 0100 0000 = LS Age (seconds): 64
         0... .... .... .... = Do Not Age Flag: 0
       v Options: 0x22, (DC) Demand Circuits, (E) External Routing
              0... .... = DN: Not set
              .0.. .... = O: Not set
              ..1. .... = (DC) Demand Circuits: Supported
              ...0 .... = (L) LLS Data block: Not Present
              .... 0... = (N) NSSA: Not supported
              .... .0.. = (MC) Multicast: Not capable
              .... ..1. = (E) External Routing: Capable
              .... ...0 = (MT) Multi-Topology Routing: No
         LS Type: Router-LSA (1)
         Link State ID: 1.1.1.1
         Advertising Router: 1.1.1.1
         Sequence Number: 0x80000001
         Checksum: 0x7e90
         Length: 36
```

Here R2 router is requesting.

```
> Frame 49: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface -, id 0
> Ethernet II, Src: ca:02:08:c9:00:1c (ca:02:08:c9:00:1c), Dst: ca:01:08:ba:00:08 (ca:01:08:ba:00:08)
> Internet Protocol Version 4, Src: 10.16.1.2, Dst: 10.16.1.1
v Open Shortest Path First
  v OSPF Header
         Version: 2
         Message Type: LS Request (3)    Type -3 msg
         Packet Length: 36
         Source OSPF Router: 2.2.2.2
         Area ID: 0.0.0.0 (Backbone)
         Checksum: 0xf5cf [correct]
         Auth Type: Null (0)
         Auth Data (none): 0000000000000000
  v Link State Request
         LS Type: Router-LSA (1)
         Link State ID: 1.1.1.1
         Advertising Router: 1.1.1.1
```

```
Open Shortest Path First
  OSPF Header
        Version: 2
        Message Type: LS Update (4)   Type -4 Msg
        Packet Length: 64
        Source OSPF Router: 1.1.1.1
        Area ID: 0.0.0.0 (Backbone)
        Checksum: 0xc9ab [correct]
        Auth Type: Null (0)
        Auth Data (none): 0000000000000000
  LS Update Packet
        Number of LSAs: 1
     LSA-type 1 (Router-LSA), len 36
          .000 0000 0011 1111 = LS Age (seconds): 63
          0... .... .... .... = Do Not Age Flag: 0
        Options: 0x22, (DC) Demand Circuits, (E) External Routing
              0... .... = DN: Not set
              .0.. .... = O: Not set
              ..1. .... = (DC) Demand Circuits: Supported
              ...0 .... = (L) LLS Data block: Not Present
              .... 0... = (N) NSSA: Not supported
              .... .0.. = (MC) Multicast: Not capable
              .... ..1. = (E) External Routing: Capable
              .... ...0 = (MT) Multi-Topology Routing: No
        LS Type: Router-LSA (1)
        Link State ID: 1.1.1.1
        Advertising Router: 1.1.1.1
        Sequence Number: 0x80000001
        Checksum: 0x7e90
        Length: 36
        Flags: 0x00
              .... .0.. = (V) Virtual link endpoint: No
              .... ..0. = (E) AS boundary router: No
              .... ...0 = (B) Area border router: No
        Number of Links: 1
     Type: Stub      ID: 10.16.1.0        Data: 255.255.255.0   Metric: 1
          Link ID: 10.16.1.0 - IP network/subnet number
          Link Data: 255.255.255.0
          Link Type: 3 - Connection to a stub network
          Number of Metrics: 0 - TOS
          0 Metric: 1
```
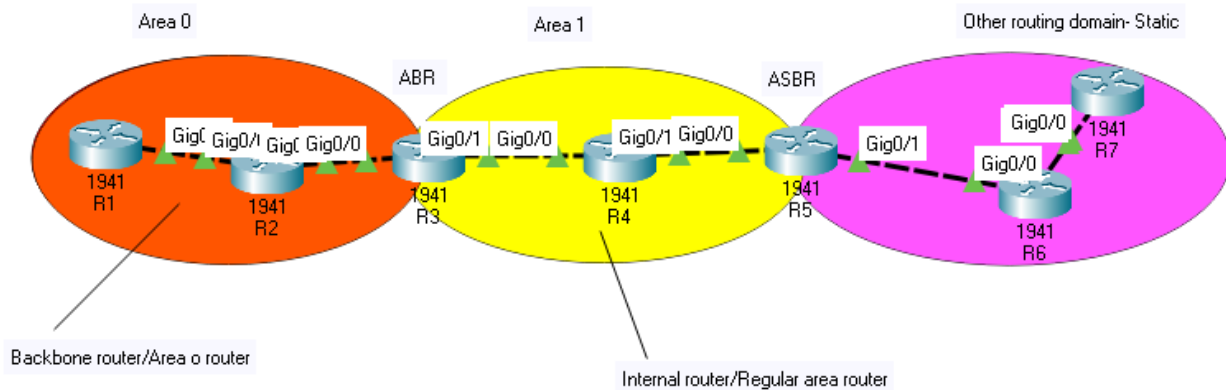
Then router move next state.

7. Full state.

In this state routers assume that we have full adjacency with each **OR** In this state routers are fully adjacent to each other.

Types of router in OSPF:-

1. **Backbone router/ Area 0**
2. **Internal router / Regular area router**
3. **ABR (Area border router)**
4. **ASBR (Autonomous system border router)**

Backbone router:-

➢ All interfaces must be in area 0 / backbone area.
➢ We can call it transit router.

Internal router:-

➢ All interfaces must be in Regular area/ internal area.

Area border router (ABR):-

➢ At least one interface must be connected to area 0 and one interface must be connected to regular area / internal area that router is called ABR router.

Autonomous system boundary router (ASBR router):-

➢ It is used to connect different routing protocol with OSPF or redistribute – RIP, EIGRP, BGP into OSPF.
➢ It is used to exchange routing information in OSPF and different routing protocol.
➢ ASBR router is used to connect different routing protocol with the help of Redistribute process.

LSA (Link state advertisement):-

LSA are used to exchange information about the network topology between the routers. When router receives an LSA then stored in LSDB. Once LSDB synk between the router then OSPF execute SPF algorithm to calculate the best path (route) for each network.

Type-1 LSA: **Router LSA**

Type-2 LSA: **Network LSA**

Type-3 LSA: **Summary LSA**

Type-4 LSA: **ASBR summary LSA**

Type-5 LSA: **External LSA**

Type-6 LSA: **MOSPF LSA (Multicast OSPF LSA)**

Type-7 LSA: **NSSA (Not-so-stubby area LSA)**

Type-8 LSA: **External LSA for BGP**
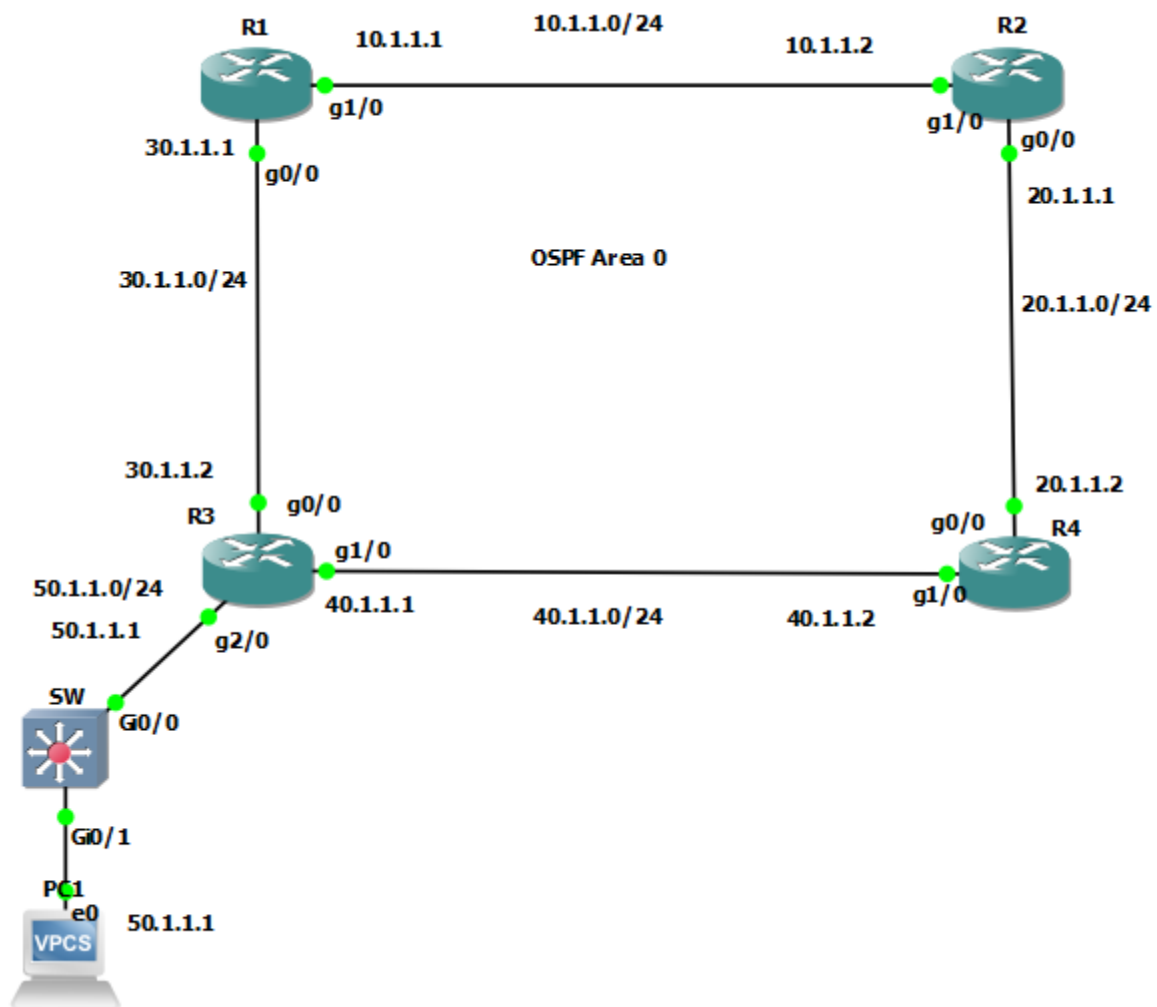
Type-9 LSA:

Type-10 LSA:

Type-11 LSA:

Some points which you see in every LSA:-

Link-id = Router-id/ IP address/ Prefix information means Network information. (Depends of LSA type)

Adv. Router-id = Router-id

Below is the topology for only your reference purpose: about LSA

```
R3#show ip ospf database

        OSPF Router with ID (3.3.3.3) (Process ID 100)

            Router Link States (Area 0)

Link ID          ADV Router       Age         Seq#        Checksum Link count
1.1.1.1          1.1.1.1          400         0x80000003 0x00BEFB 2
2.2.2.2          2.2.2.2          409         0x80000003 0x00D7ED 2
3.3.3.3          3.3.3.3          394         0x80000003 0x00A186 3
4.4.4.4          4.4.4.4          395         0x80000003 0x005C1C 2

            Net Link States (Area 0)

Link ID          ADV Router       Age         Seq#        Checksum
10.1.1.2         2.2.2.2          415         0x80000001 0x002CEB
20.1.1.2         4.4.4.4          410         0x80000001 0x00E316
30.1.1.2         3.3.3.3          399         0x80000001 0x002BD0
40.1.1.2         4.4.4.4          394         0x80000001 0x0011D0
R3#
```

R3# show ip ospf database router 3.3.3.3

```
R3# show ip ospf database router 3.3.3.3

            OSPF Router with ID (3.3.3.3) (Process ID 100)

                Router Link States (Area 0)

  LS age: 654
  Options: (No TOS-capability, DC)
  LS Type: Router Links                    Common OSPF Header in
  Link State ID: 3.3.3.3                    LSA
  Advertising Router: 3.3.3.3
  LS Seq Number: 80000003
  Checksum: 0xA186                          Type -1 LSA
  Length: 60
  Number of Links: 3

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 50.1.1.0
     (Link Data) Network Mask: 255.255.255.0
      Number of TOS metrics: 0
        TOS 0 Metrics: 1        cost

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 40.1.1.2
     (Link Data) Router Interface address: 40.1.1.1
      Number of TOS metrics: 0
        TOS 0 Metrics: 1          cost

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 30.1.1.2
     (Link Data) Router Interface address: 30.1.1.2
      Number of TOS metrics: 0
        TOS 0 Metrics: 1      cost

R3#
```

```
R3# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/24 is subnetted, 1 subnets
C       50.1.1.0 is directly connected, GigabitEthernet2/0
     20.0.0.0/24 is subnetted, 1 subnets
O       20.1.1.0 [110/2] via 40.1.1.2, 00:18:15, GigabitEthernet1/0
     40.0.0.0/24 is subnetted, 1 subnets
C       40.1.1.0 is directly connected, GigabitEthernet1/0
     10.0.0.0/24 is subnetted, 1 subnets
O       10.1.1.0 [110/2] via 30.1.1.1, 00:18:25, GigabitEthernet0/0
     30.0.0.0/24 is subnetted, 1 subnets
C       30.1.1.0 is directly connected, GigabitEthernet0/0
R3#
```

Type – 1 LSA: Router LSA

1. Type 1 LSA Router LSA are generated by the every router within the same area. And types 1 LSA do not cross in the other area.
2. Within an area all routers will have common LSA that LSA is called Router LSA.
3. One router LSA can keep multiple links information.
4. After every 30 minutes router will flood LSA, if any router receive higher sequence number it means SPF algorithm is executed.
5. In type -1 LSA link-id and advertisement-id will be same.
6. Router LSA contains some special bits like 'V' Bit, end point to virtual link, 'E' bit it is ASBR and 'B' bit is ABR.

   ➢ **Link State ID = Router-id of router**
   ➢ **Advertising Router: Router-id of router**

   ➢ R1 Router: - Type 1 LSA (Router LSA)
     ○ **Link State ID: 1.1.1.1**
     ○ **Advertising Router: 1.1.1.1**

```
R1#show ip ospf database router 1.1.1.1

            OSPF Router with ID (1.1.1.1) (Process ID 100)

               Router Link States (Area 0)

  LS age: 1748
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 1.1.1.1
  Advertising Router: 1.1.1.1
  LS Seq Number: 80000003
  Checksum: 0xBEFB
  Length: 48
  Number of Links: 2

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 30.1.1.2
     (Link Data) Router Interface address: 30.1.1.1
      Number of TOS metrics: 0
       TOS 0 Metrics: 1

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 10.1.1.2
     (Link Data) Router Interface address: 10.1.1.1
      Number of TOS metrics: 0
       TOS 0 Metrics: 1


R1#
```

Database table of all routers:- #show ip ospf database

```
R1#show ip ospf database

        OSPF Router with ID (1.1.1.1) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum Link count
1.1.1.1         1.1.1.1         138       0x80000004 0x00BCFC 2
2.2.2.2         2.2.2.2         124       0x80000004 0x00D5EE 2
3.3.3.3         3.3.3.3         105       0x80000004 0x009F87 3
4.4.4.4         4.4.4.4         130       0x80000004 0x005A1D 2

            Net Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum
10.1.1.2        2.2.2.2         124       0x80000002 0x002AEC
20.1.1.2        4.4.4.4         130       0x80000002 0x00E117
30.1.1.2        3.3.3.3         105       0x80000002 0x0029D1
40.1.1.2        4.4.4.4         130       0x80000002 0x000FD1
R1#
```

```
R3#show ip ospf database

        OSPF Router with ID (3.3.3.3) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum Link count
1.1.1.1         1.1.1.1         201       0x80000004 0x00BCFC 2
2.2.2.2         2.2.2.2         187       0x80000004 0x00D5EE 2
3.3.3.3         3.3.3.3         167       0x80000004 0x009F87 3
4.4.4.4         4.4.4.4         192       0x80000004 0x005A1D 2

            Net Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum
10.1.1.2        2.2.2.2         187       0x80000002 0x002AEC
20.1.1.2        4.4.4.4         191       0x80000002 0x00E117
30.1.1.2        3.3.3.3         167       0x80000002 0x0029D1
40.1.1.2        4.4.4.4         191       0x80000002 0x000FD1
R3#
```

```
R2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum Link count
1.1.1.1         1.1.1.1         163       0x80000004 0x00BCFC 2
2.2.2.2         2.2.2.2         148       0x80000004 0x00D5EE 2
3.3.3.3         3.3.3.3         131       0x80000004 0x009F87 3
4.4.4.4         4.4.4.4         154       0x80000004 0x005A1D 2

            Net Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum
10.1.1.2        2.2.2.2         148       0x80000002 0x002AEC
20.1.1.2        4.4.4.4         154       0x80000002 0x00E117
30.1.1.2        3.3.3.3         131       0x80000002 0x0029D1
40.1.1.2        4.4.4.4         154       0x80000002 0x000FD1
R2#
```

```
R4#show ip ospf database

        OSPF Router with ID (4.4.4.4) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum Link count
1.1.1.1         1.1.1.1         230       0x80000004 0x00BCFC 2
2.2.2.2         2.2.2.2         214       0x80000004 0x00D5EE 2
3.3.3.3         3.3.3.3         195       0x80000004 0x009F87 3
4.4.4.4         4.4.4.4         218       0x80000004 0x005A1D 2

            Net Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum
10.1.1.2        2.2.2.2         214       0x80000002 0x002AEC
20.1.1.2        4.4.4.4         218       0x80000002 0x00E117
30.1.1.2        3.3.3.3         195       0x80000002 0x0029D1
40.1.1.2        4.4.4.4         218       0x80000002 0x000FD1
R4#
```

Note – If any router's link goes down or come back then OSPF routers in own sequence increased by 1 and flood to with neighbors and vice versa. Let me show you

Procedure – I'm going to down LAN link (50.1.1.0/24) Router of R3, see the snapshot right now sequence number 4 in R3 router as well as every router in this area.

1. It means it will be proved that whenever any link goes down or come up then router would increment in sequence number by 1 and flood to neighbors.
2. If any link goes down or come up then ospf also execute SPF algorithm. You can verify using

   #Show ip ospf

#show ip ospf

```
R1#show ip ospf database

        OSPF Router with ID (1.1.1.1) (Process ID 100)

        Router Link States (Area 0)

Link ID      ADV Router      Age      Seq#        Checksum Link count
1.1.1.1      1.1.1.1         702      0x80000004 0x00BCFC 2
2.2.2.2      2.2.2.2         689      0x80000004 0x00D5EE 2
3.3.3.3      3.3.3.3         23       0x80000005 0x003C2F 2
4.4.4.4      4.4.4.4         695      0x80000004 0x005A1D 2

        Net Link States (Area 0)

Link ID      ADV Router      Age      Seq#        Checksum
10.1.1.2     2.2.2.2         689      0x80000002 0x002AEC
20.1.1.2     4.4.4.4         695      0x80000002 0x00E117
30.1.1.2     3.3.3.3         670      0x80000002 0x0029D1
40.1.1.2     4.4.4.4         695      0x80000002 0x000FD1
R1#
```

```
R3#show ip ospf database

        OSPF Router with ID (3.3.3.3) (Process ID 100)

        Router Link States (Area 0)

Link ID      ADV Router      Age      Seq#        Checksum Link count
1.1.1.1      1.1.1.1         686      0x80000004 0x00BCFC 2
2.2.2.2      2.2.2.2         672      0x80000004 0x00D5EE 2
3.3.3.3      3.3.3.3         4        0x80000005 0x003C2F 2
4.4.4.4      4.4.4.4         677      0x80000004 0x005A1D 2

        Net Link States (Area 0)

Link ID      ADV Router      Age      Seq#        Checksum
10.1.1.2     2.2.2.2         672      0x80000002 0x002AEC
20.1.1.2     4.4.4.4         676      0x80000002 0x00E117
30.1.1.2     3.3.3.3         652      0x80000002 0x0029D1
40.1.1.2     4.4.4.4         676      0x80000002 0x000FD1
R3#
```

```
R2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

        Router Link States (Area 0)

Link ID      ADV Router      Age      Seq#        Checksum Link count
1.1.1.1      1.1.1.1         694      0x80000004 0x00BCFC 2
2.2.2.2      2.2.2.2         679      0x80000004 0x00D5EE 2
3.3.3.3      3.3.3.3         15       0x80000005 0x003C2F 2
4.4.4.4      4.4.4.4         685      0x80000004 0x005A1D 2

        Net Link States (Area 0)

Link ID      ADV Router      Age      Seq#        Checksum
10.1.1.2     2.2.2.2         679      0x80000002 0x002AEC
20.1.1.2     4.4.4.4         685      0x80000002 0x00E117
30.1.1.2     3.3.3.3         662      0x80000002 0x0029D1
40.1.1.2     4.4.4.4         685      0x80000002 0x000FD1
R2#
```

```
R4#show ip ospf database

        OSPF Router with ID (4.4.4.4) (Process ID 100)

        Router Link States (Area 0)

Link ID      ADV Router      Age      Seq#        Checksum Link count
1.1.1.1      1.1.1.1         710      0x80000004 0x00BCFC 2
2.2.2.2      2.2.2.2         695      0x80000004 0x00D5EE 2
3.3.3.3      3.3.3.3         29       0x80000005 0x003C2F 2
4.4.4.4      4.4.4.4         699      0x80000004 0x005A1D 2

        Net Link States (Area 0)

Link ID      ADV Router      Age      Seq#        Checksum
10.1.1.2     2.2.2.2         695      0x80000002 0x002AEC
20.1.1.2     4.4.4.4         699      0x80000002 0x00E117
30.1.1.2     3.3.3.3         676      0x80000002 0x0029D1
40.1.1.2     4.4.4.4         699      0x80000002 0x000FD1
R4#
```

```
R3# show ip ospf
 Routing Process "ospf 100" with ID 3.3.3.3
 Start time: 00:00:21.004, Time elapsed: 00:51:42.156
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Link-local Signaling (LLS)
 Supports area transit capability
 Router is not originating router-LSAs with maximum metric
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 Number of areas transit capable is 0
 External flood list length 0
 IETF NSF helper support enabled
 Cisco NSF helper support enabled
    Area BACKBONE(0)
        Number of interfaces in this area is 3
        Area has no authentication
        SPF algorithm last executed 00:00:59.544 ago
        SPF algorithm executed 5 times
        Area ranges are                SPF algorithm executed.
        Number of LSA 8. Checksum Sum 0x03CE35
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0

R3#
```

Type -2 LSA: Network LSA

1. Types 2 LSA are generated by the DR router to describe that all routers are connected to its segment directly and type -2 LSA packets are flood between the neighbors within the same area of origin and remain within that area.
2. It is also having information that how many networks are connected in that multi-access network in the form of router-id.
3. It will also having information of DR router's ip address.
4. It send to all attached router between the same area.

Link-id = ip address of DR (Interface address).
Adv.-id = Router id of DR
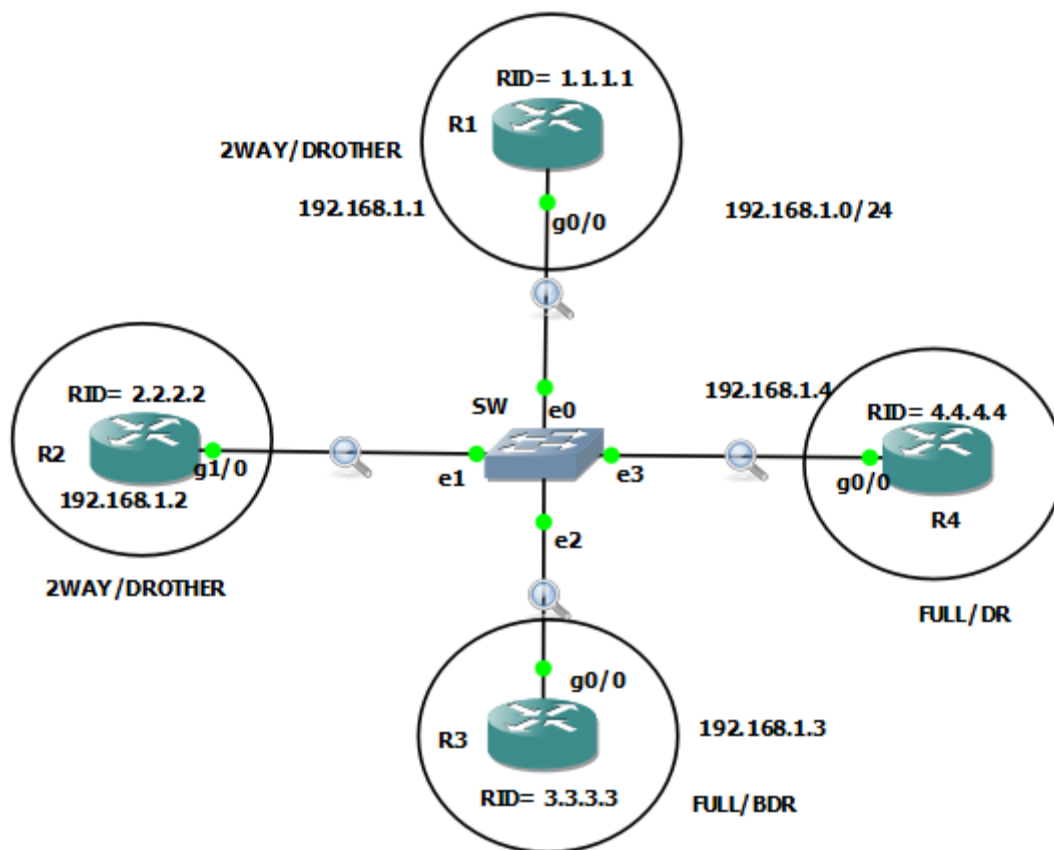
Note- In this topology every router have 3 neighbors, it means total number of adjacency will be 12.

R1 Router has neighbors=

```
R1#show ip ospf neighbor

Neighbor ID     Pri    State           Dead Time    Address          Interface
2.2.2.2          1     2WAY/DROTHER    00:00:37     192.168.1.2      GigabitEthernet0/0
3.3.3.3          1     FULL/BDR        00:00:35     192.168.1.3      GigabitEthernet0/0
4.4.4.4          1     FULL/DR         00:00:32     192.168.1.4      GigabitEthernet0/0
R1#
```

R2 Router has neighbors=

```
R2#show ip ospf neighbor

Neighbor ID     Pri    State           Dead Time    Address          Interface
1.1.1.1          1     2WAY/DROTHER    00:00:31     192.168.1.1      GigabitEthernet1/0
3.3.3.3          1     FULL/BDR        00:00:38     192.168.1.3      GigabitEthernet1/0
4.4.4.4          1     FULL/DR         00:00:35     192.168.1.4      GigabitEthernet1/0
R2#
```

R3 Router has neighbors=

```
R3#show ip ospf neighbor

Neighbor ID     Pri    State           Dead Time    Address          Interface
1.1.1.1          1     FULL/DROTHER    00:00:33     192.168.1.1      GigabitEthernet0/0
2.2.2.2          1     FULL/DROTHER    00:00:34     192.168.1.2      GigabitEthernet0/0
4.4.4.4          1     FULL/DR         00:00:38     192.168.1.4      GigabitEthernet0/0
R3#
```

R4 Router has neighbors=

```
R4#show ip ospf neighbor

Neighbor ID     Pri    State           Dead Time    Address          Interface
1.1.1.1          1     FULL/DROTHER    00:00:33     192.168.1.1      GigabitEthernet0/0
2.2.2.2          1     FULL/DROTHER    00:00:33     192.168.1.2      GigabitEthernet0/0
3.3.3.3          1     FULL/BDR        00:00:31     192.168.1.3      GigabitEthernet0/0
R4#
```

All router's database table=

```
R1#show ip ospf database

            OSPF Router with ID (1.1.1.1) (Process ID 100)

                Router Link States (Area 0)

Link ID          ADV Router       Age         Seq#         Checksum Link count
1.1.1.1          1.1.1.1          349         0x80000002 0x00A4AB 1
2.2.2.2          2.2.2.2          350         0x80000002 0x0066E0 1
3.3.3.3          3.3.3.3          350         0x80000002 0x002816 1
4.4.4.4          4.4.4.4          350         0x80000002 0x00E94B 1

                Net Link States (Area 0)

Link ID          ADV Router       Age         Seq#         Checksum
192.168.1.4      4.4.4.4          350         0x80000001 0x008803
R1#
```

```
R2#show ip ospf database

            OSPF Router with ID (2.2.2.2) (Process ID 100)

                Router Link States (Area 0)

Link ID          ADV Router       Age         Seq#         Checksum Link count
1.1.1.1          1.1.1.1          419         0x80000002 0x00A4AB 1
2.2.2.2          2.2.2.2          418         0x80000002 0x0066E0 1
3.3.3.3          3.3.3.3          419         0x80000002 0x002816 1
4.4.4.4          4.4.4.4          419         0x80000002 0x00E94B 1

                Net Link States (Area 0)

Link ID          ADV Router       Age         Seq#         Checksum
192.168.1.4      4.4.4.4          419         0x80000001 0x008803
R2#
```

```
R3#show ip ospf database

            OSPF Router with ID (3.3.3.3) (Process ID 100)

                Router Link States (Area 0)

Link ID          ADV Router       Age         Seq#         Checksum Link count
1.1.1.1          1.1.1.1          444         0x80000002 0x00A4AB 1
2.2.2.2          2.2.2.2          444         0x80000002 0x0066E0 1
3.3.3.3          3.3.3.3          443         0x80000002 0x002816 1
4.4.4.4          4.4.4.4          444         0x80000002 0x00E94B 1

                Net Link States (Area 0)

Link ID          ADV Router       Age         Seq#         Checksum
192.168.1.4      4.4.4.4          444         0x80000001 0x008803
R3#
```

```
R4#show ip ospf database

            OSPF Router with ID (4.4.4.4) (Process ID 100)

                Router Link States (Area 0)

Link ID          ADV Router       Age         Seq#         Checksum Link count
1.1.1.1          1.1.1.1          371         0x80000002 0x00A4AB 1
2.2.2.2          2.2.2.2          371         0x80000002 0x0066E0 1
3.3.3.3          3.3.3.3          371         0x80000002 0x002816 1
4.4.4.4          4.4.4.4          370         0x80000002 0x00E94B 1

                Net Link States (Area 0)

Link ID          ADV Router       Age         Seq#         Checksum
192.168.1.4      4.4.4.4          370         0x80000001 0x008803
R4#
```

Note -

➢ **DRO router will be full adjacent with DR/BDR Router.**
➢ **DRO router will be without adjacent with DRO router in 2 way state.**
➢ **DR router will be full adjacent with BDR router.**

```
R1#show ip ospf neighbor

Neighbor ID     Pri   State         Dead Time   Address        Interface
2.2.2.2           1   2WAY/DROTHER  00:00:31    192.168.1.2    GigabitEthernet0/0
3.3.3.3           1   FULL/BDR      00:00:38    192.168.1.3    GigabitEthernet0/0
4.4.4.4           1   FULL/DR       00:00:32    192.168.1.4    GigabitEthernet0/0
R1#

R2#show ip ospf neighbor

Neighbor ID     Pri   State         Dead Time   Address        Interface
1.1.1.1           1   2WAY/DROTHER  00:00:33    192.168.1.1    GigabitEthernet1/0
3.3.3.3           1   FULL/BDR      00:00:31    192.168.1.3    GigabitEthernet1/0
4.4.4.4           1   FULL/DR       00:00:36    192.168.1.4    GigabitEthernet1/0
R2#

R3#show ip ospf ne

Neighbor ID     Pri   State         Dead Time   Address        Interface
1.1.1.1           1   FULL/DROTHER  00:00:36    192.168.1.1    GigabitEthernet0/0
2.2.2.2           1   FULL/DROTHER  00:00:36    192.168.1.2    GigabitEthernet0/0
4.4.4.4           1   FULL/DR       00:00:39    192.168.1.4    GigabitEthernet0/0
R3#

R4#show ip ospf neighbor

Neighbor ID     Pri   State         Dead Time   Address        Interface
1.1.1.1           1   FULL/DROTHER  00:00:38    192.168.1.1    GigabitEthernet0/0
2.2.2.2           1   FULL/DROTHER  00:00:30    192.168.1.2    GigabitEthernet0/0
3.3.3.3           1   FULL/BDR      00:00:37    192.168.1.3    GigabitEthernet0/0
R4#
```

DR BDR election process=

DR/BDR

Highest priority (0-255)

Bydefaul priority are 1.

Router-id

1. Highest manual configured router-id.
2. Highest active loopback ip address.
3. Highest active physical interface ip address.

Note – DR/BDR are used to reduce the LSA flooding.
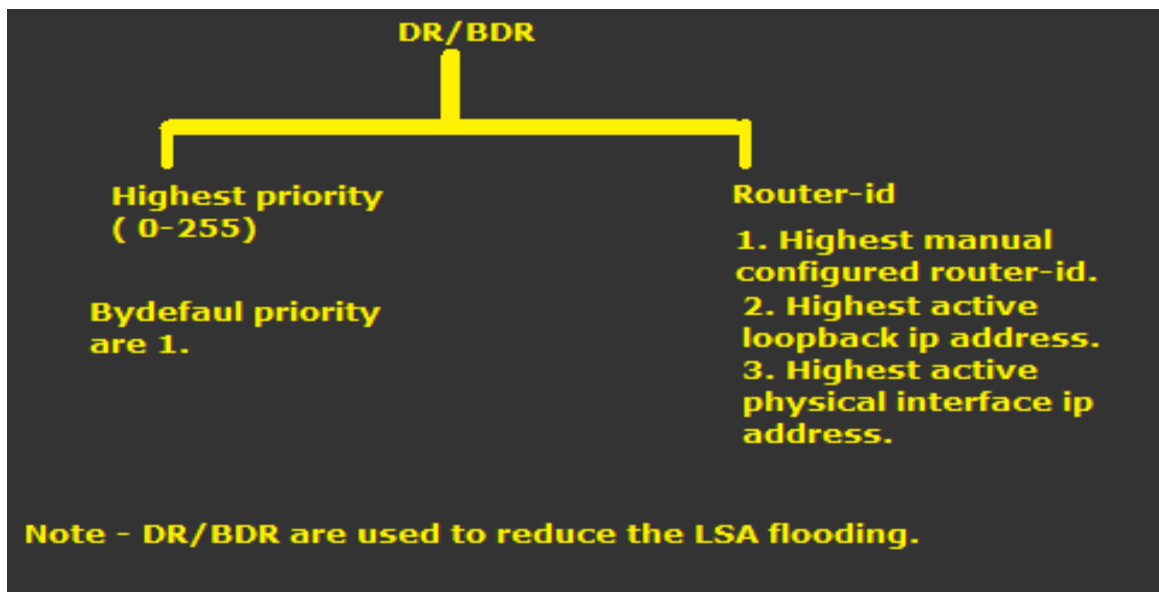
Note –

➢ If priority will be of any interface that mean router will never participate in DR/BDR election.
➢ Suppose If DR router goes down then BDR router will become DR and second highest router-id will become BDR router. And in case of DR again will come up then DR will never become DR router means will become DR other router whether Router –id highest why not ?
➢ If you enable ospf configuration on the router within 40 second (means within wait timer) that router will become DR router otherwise another router will become DR router. Means ospf enable get started wait timer on the router.

OSPF Hello, Dead, Wait timer


```
R4#show ip ospf interface gigabitEthernet 0/0
GigabitEthernet0/0 is up, line protocol is up
  Internet Address 192.168.1.4/24, Area 0
  Process ID 100, Router ID 4.4.4.4, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 4.4.4.4, Interface address 192.168.1.4
  Backup Designated router (ID) 3.3.3.3, Interface address 192.168.1.3
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:02                    Hello, Dead, Wait timer
  Supports Link-local Signaling (LLS)
  Cisco NSF helper support enabled
  IETF NSF helper support enabled
  Index 1/1, flood queue length 0
  Next 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 3, Adjacent neighbor count is 3
    Adjacent with neighbor 1.1.1.1
    Adjacent with neighbor 2.2.2.2
    Adjacent with neighbor 3.3.3.3  (Backup Designated Router)
  Suppress hello for 0 neighbor(s)
R4#
```

Type-2 LSA Network LSA:-

```
R4#show ip ospf database

            OSPF Router with ID (4.4.4.4) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#         Checksum Link count
1.1.1.1         1.1.1.1         1418        0x80000003 0x00A2AC 1
2.2.2.2         2.2.2.2         1504        0x80000003 0x0064E1 1
3.3.3.3         3.3.3.3         1441        0x80000003 0x002617 1
4.4.4.4         4.4.4.4         1423        0x80000003 0x00E74C 1

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
192.168.1.4     4.4.4.4         1423        0x80000002 0x008604
R4#
                Type-2 LSA network LSA
```

Link-id = 192.168.1.4   IP address of DR router's interface
ADV. Router-id = 4.4.4.4 Router-id of DR router

#Show ip ospf database network

```
R4# show ip ospf database network

            OSPF Router with ID (4.4.4.4) (Process ID 100)

                Net Link States (Area 0)

  Routing Bit Set on this LSA
  LS age: 566
  Options: (No TOS-capability, DC)
  LS Type: Network Links
  Link State ID: 192.168.1.4 (address of Designated Router)
  Advertising Router: 4.4.4.4
  LS Seq Number: 80000003
  Checksum: 0x8405
  Length: 40
  Network Mask: /24
        Attached Router: 4.4.4.4
        Attached Router: 1.1.1.1
        Attached Router: 2.2.2.2
        Attached Router: 3.3.3.3

R4#
```

In starting when you enable ospf then router will send hello packet with own neighbors on multicast address – 224.0.0.5
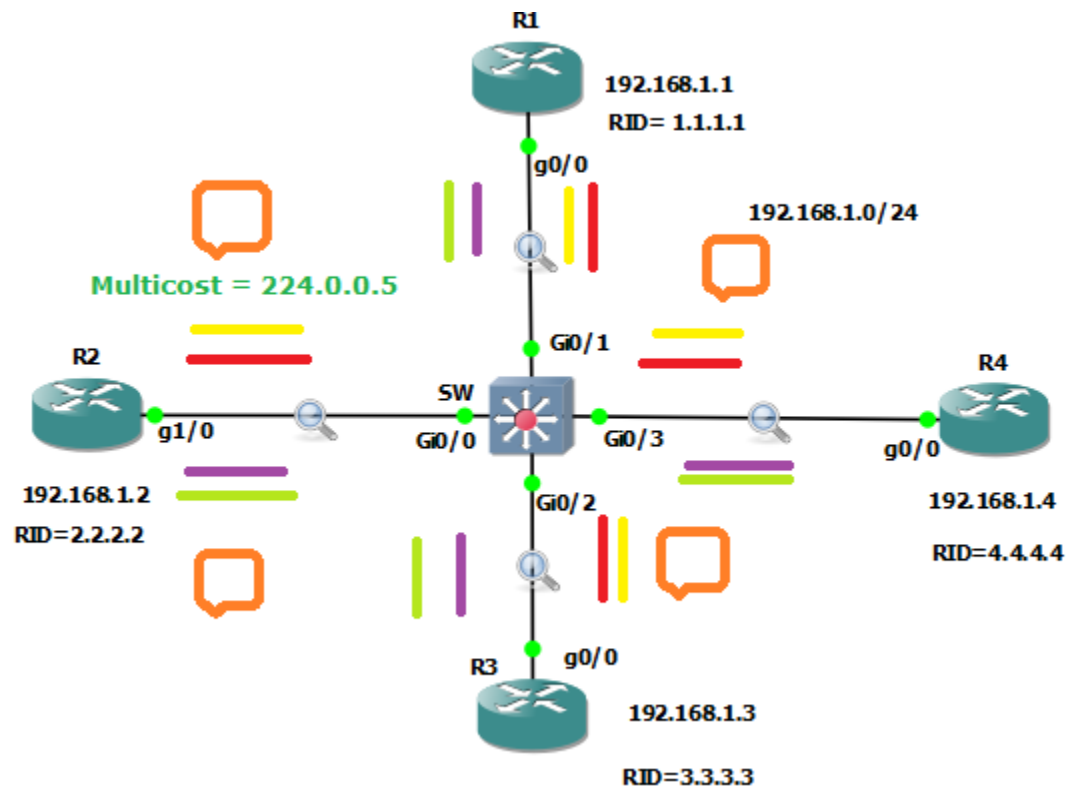
Note – If new link came up on the R2 router then it will send update message to its neighbors on 224.0.0.6 address on all routers but 224.0.0.04 listen DR router and other router will discard of this message's.
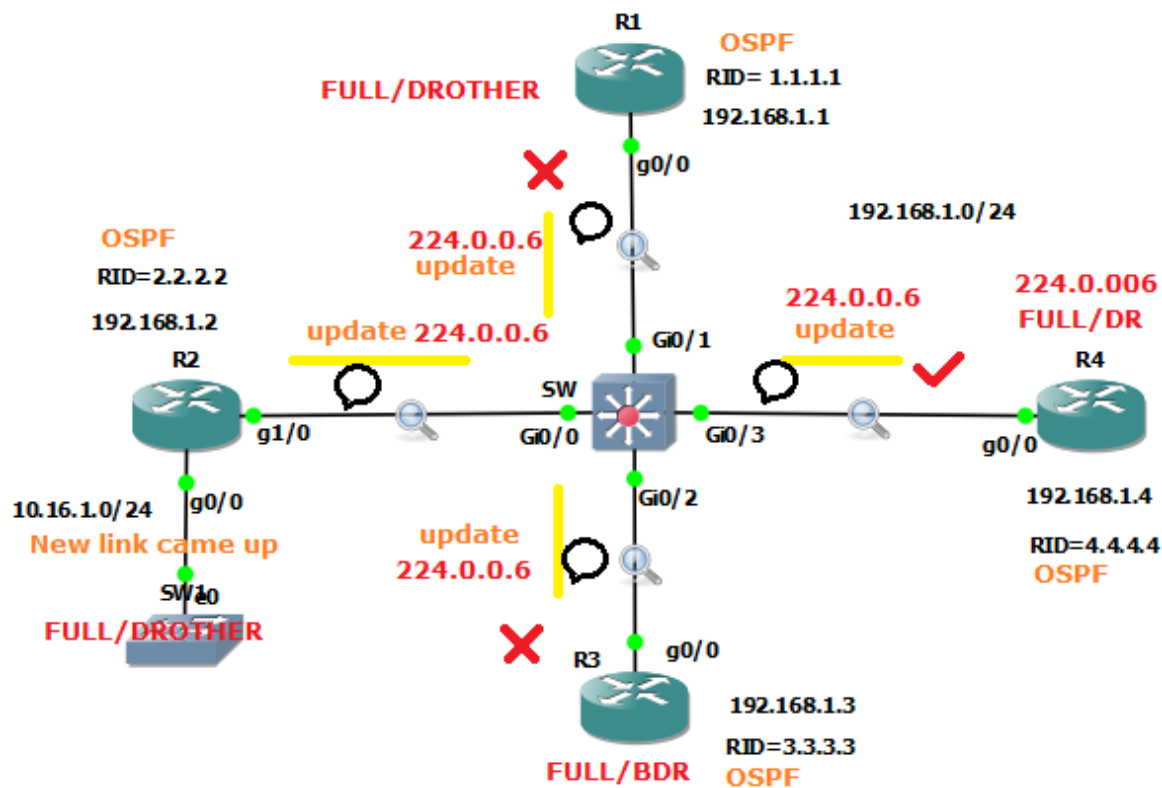
Router's captured packet.

R1 router captured packet

6981 6282.214628	192.168.1.2	224.0.0.6	OSPF	110 LS Update
6982 6282.236414	192.168.1.4	224.0.0.5	OSPF	110 LS Update
6983 6282.767043	192.168.1.1	224.0.0.5	OSPF	102 Hello Packet
6984 6283.885609	0c:80:c4:0d:9e:01	Spanning-tree-(for-…	STP	60 RST. Root = 3276
6985 6284.737650	192.168.1.1	224.0.0.6	OSPF	78 LS Acknowledge
6986 6284.754907	192.168.1.3	224.0.0.5	OSPF	78 LS Acknowledge

R2 router captured packet

6960 6254.724836	192.168.1.2	224.0.0.6	OSPF	110 LS Update
6961 6254.759586	192.168.1.4	224.0.0.5	OSPF	110 LS Update
6962 6255.297707	192.168.1.1	224.0.0.5	OSPF	102 Hello Packet
6963 6256.401136	0c:80:c4:0d:9e:00	Spanning-tree-(for-…	STP	60 RST. Root = 32768/
6964 6257.271081	192.168.1.1	224.0.0.6	OSPF	78 LS Acknowledge
6965 6257.278068	192.168.1.3	224.0.0.5	OSPF	78 LS Acknowledge

R3 router captured packet

6968 6252.105624	192.168.1.2	224.0.0.6	OSPF	110 LS Update
6969 6252.127854	192.168.1.4	224.0.0.5	OSPF	110 LS Update
6970 6252.665760	192.168.1.1	224.0.0.5	OSPF	102 Hello Packet
6971 6253.784263	0c:80:c4:0d:9e:02	Spanning-tree-(for-…	STP	60 RST. Root = 32768/
6972 6254.639287	192.168.1.1	224.0.0.6	OSPF	78 LS Acknowledge
6973 6254.640680	192.168.1.3	224.0.0.5	OSPF	78 LS Acknowledge

R4 router captured packet

6982 6245.110262	192.168.1.2	224.0.0.6	OSPF	110 LS Update
6983 6245.125242	192.168.1.4	224.0.0.5	OSPF	110 LS Update
6984 6245.321410	ca:04:06:4e:00:08	CDP/VTP/DTP/PAgP/UD…	CDP	353 Device ID: R4 Port
6985 6245.669541	192.168.1.1	224.0.0.5	OSPF	102 Hello Packet
6986 6246.794692	0c:80:c4:0d:9e:03	Spanning-tree-(for-…	STP	60 RST. Root = 32768/1/
6987 6247.646283	192.168.1.1	224.0.0.6	OSPF	78 LS Acknowledge
6988 6247.652602	192.168.1.3	224.0.0.5	OSPF	78 LS Acknowledge

➢ In this packet if you see R2 sending update to it's neighbors on multicast address 224.0.0.6 but other router will discard of this packet as 224.0.0.5 address's only DR .

➢ Other will discard to packet.

➢ Then DR router will send update to its neighbors on multicast address 224.0.0.5, R1 and R3 will accept of this packet and R2 will discard as he has already on same sequence no information.

➢ Then R1 and R3 give ACK to DR router (R4 router).

```
R1#show ip ospf database

            OSPF Router with ID (1.1.1.1) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum Link count
1.1.1.1         1.1.1.1         1874        0x80000005 0x009EAE 1
2.2.2.2         2.2.2.2         1744        0x80000006 0x00F125 2
3.3.3.3         3.3.3.3         1886        0x80000005 0x002219 1
4.4.4.4         4.4.4.4         1839        0x80000005 0x00E34E 1

                Net Link States (Area 0)              Added new link

Link ID         ADV Router      Age         Seq#        Checksum
192.168.1.4     4.4.4.4         1839        0x80000004 0x008206
R1#
```

> Internet Protocol Version 4, Src: 192.168.1.2, Dst: 224.0.0.6
∨ Open Shortest Path First
  > OSPF Header
  ∨ LS Update Packet
      Number of LSAs: 1
    ∨ LSA-type 1 (Router-LSA), len 48
        .000 0000 0000 0001 = LS Age (seconds): 1
        0... .... = Do Not Age Flag: 0
      > Options: 0x22, (DC) Demand Circuits, (E) External Routing
        LS Type: Router-LSA (1)
        Link State ID: 2.2.2.2
        Advertising Router: 2.2.2.2
        Sequence Number: 0x80000006
        Checksum: 0xf125
        Length: 48
      > Flags: 0x00
        Number of Links: 2
      > Type: Stub   ID: 10.16.1.0   Data: 255.255.255.0   Metric: 1
      > Type: Transit ID: 192.168.1.4   Data: 192.168.1.2   Metric: 1

New link added in type -1 LSA
10.16.1.0/24

> Internet Protocol Version 4, Src: 192.168.1.4, Dst: 224.0.0.5
∕ Open Shortest Path First
  > OSPF Header
  ∨ LS Update Packet
      Number of LSAs: 1
    ∨ LSA-type 1 (Router-LSA), len 48
        .000 0000 0000 0010 = LS Age (seconds): 2
        0... .... = Do Not Age Flag: 0
      > Options: 0x22, (DC) Demand Circuits, (E) External Routing
        LS Type: Router-LSA (1)
        Link State ID: 2.2.2.2
        Advertising Router: 2.2.2.2
        Sequence Number: 0x80000006
        Checksum: 0xf125
        Length: 48
      > Flags: 0x00
        Number of Links: 2
      > Type: Stub   ID: 10.16.1.0   Data: 255.255.255.0   Metric: 1
      > Type: Transit ID: 192.168.1.4   Data: 192.168.1.2   Metric: 1

DR router is sending update in which it mentioned that link 10.16.1.0/24

Type -3 LSA: Summary LSA

1. Type-3 LSA are generated by the ABR router for sending routing information from one are to another area.
2. It contains information about all inter area routes.
3. Link-id = Network-id/ Prefix-id
   Adv. Router-id = router-id of ABR

Note –

1. A router which has at least one interface in backbone area and one interface in regular area that router is called ABR.
2. We create ABR for divide database in different area.
3. An ABR will keep multiple areas' database in database table.
4. ABR routers send routing information from one area to different area not a database table in one area to other area.
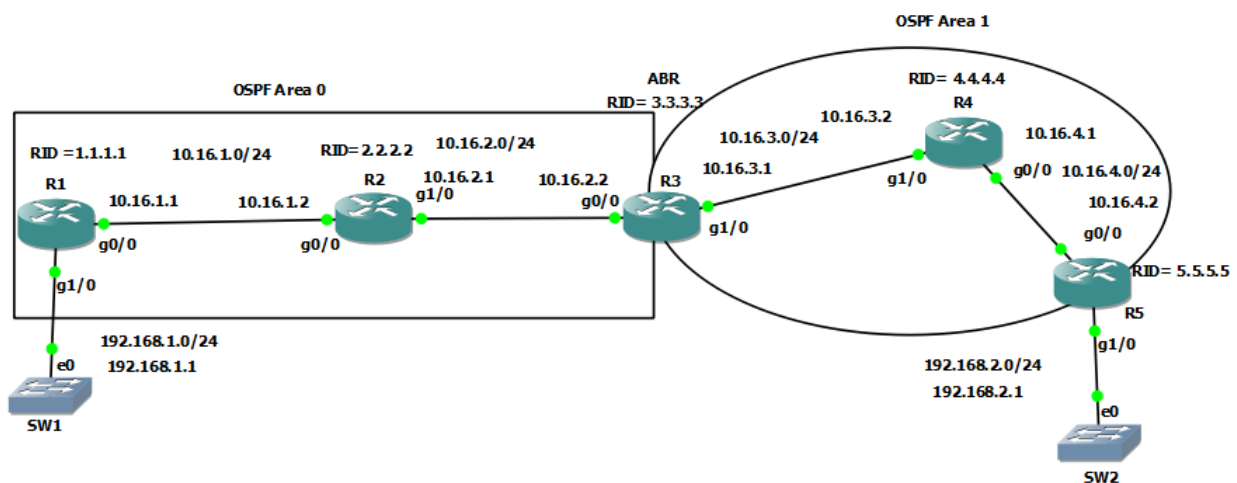
```
> Internet Protocol Version 4, Src: 10.16.2.2, Dst: 224.0.0.5
∨ Open Shortest Path First
   ∨ OSPF Header
        Version: 2
        Message Type: LS Update (4)
        Packet Length: 64
        Source OSPF Router: 3.3.3.3
        Area ID: 0.0.0.0 (Backbone)
        Checksum: 0xebbf [correct]
        Auth Type: Null (0)
        Auth Data (none): 0000000000000000
   ∨ LS Update Packet
        Number of LSAs: 1
      ∨ LSA-type 1 (Router-LSA), len 36
           .000 0000 0000 0001 = LS Age (seconds): 1
           0... .... .... .... = Do Not Age Flag: 0
         ∨ Options: 0x22, (DC) Demand Circuits, (E) External Routing
              0... .... = DN: Not set
              .0.. .... = O: Not set
              ..1. .... = (DC) Demand Circuits: Supported
              ...0 .... = (L) LLS Data block: Not Present
              .... 0... = (N) NSSA: Not supported
              .... .0.. = (MC) Multicast: Not capable
              .... ..1. = (E) External Routing: Capable
              .... ...0 = (MT) Multi-Topology Routing: No
```

LS Type: Router-LSA (1)
Link State ID: 3.3.3.3
Advertising Router: 3.3.3.3   **Type -1 LSA**
Sequence Number: 0x80000009
Checksum: 0x4294
Length: 36

```
         ∨ Flags: 0x01, (B) Area border router
              .... .0.. = (V) Virtual link endpoint: No
              .... ..0. = (E) AS boundary router: No
              .... ...1 = (B) Area border router: Yes     B bit truned on
           Number of Links: 1
         ∨ Type: Transit   ID: 10.16.2.1        Data: 10.16.2.2        Metric: 1
              Link ID: 10.16.2.1 - IP address of Designated Router
              Link Data: 10.16.2.2
              Link Type: 2 - Connection to a transit network
              Number of Metrics: 0 - TOS
              0 Metric: 1
```

```
>  Internet Protocol Version 4, Src: 10.16.3.1, Dst: 224.0.0.5
∨  Open Shortest Path First
   ∨  OSPF Header
         Version: 2
         Message Type: LS Update (4)
         Packet Length: 64
         Source OSPF Router: 3.3.3.3
         Area ID: 0.0.0.1
         Checksum: 0xd1d8 [correct]
         Auth Type: Null (0)
         Auth Data (none): 0000000000000000
   ∨  LS Update Packet
         Number of LSAs: 1
      ∨  LSA-type 1 (Router-LSA), len 36
            .000 0000 0000 0001 = LS Age (seconds): 1
            0... .... .... .... = Do Not Age Flag: 0
         ∨  Options: 0x22, (DC) Demand Circuits, (E) External Routing
               0... .... = DN: Not set
               .0.. .... = O: Not set
               ..1. .... = (DC) Demand Circuits: Supported
               ...0 .... = (L) LLS Data block: Not Present
               .... 0... = (N) NSSA: Not supported
               .... .0.. = (MC) Multicast: Not capable
               .... ..1. = (E) External Routing: Capable
               .... ...0 = (MT) Multi-Topology Routing: No
            LS Type: Router-LSA (1)
            Link State ID: 3.3.3.3
            Advertising Router: 3.3.3.3          Type -1 LSA
            Sequence Number: 0x80000006
            Checksum: 0x5a7d
            Length: 36
         ∨  Flags: 0x01, (B) Area border router
               .... .0.. = (V) Virtual link endpoint: No
               .... ..0. = (E) AS boundary router: No
               .... ...1 = (B) Area border router: Yes          B bit truned on
            Number of Links: 1
         ∨  Type: Transit  ID: 10.16.3.2      Data: 10.16.3.1      Metric: 1
               Link ID: 10.16.3.2 - IP address of Designated Router
               Link Data: 10.16.3.1
               Link Type: 2 - Connection to a transit network
               Number of Metrics: 0 - TOS
               0 Metric: 1
```

ABR router database – in which you can see it is maintaining multiple area's database.

```
R3#show ip ospf database

            OSPF Router with ID (3.3.3.3) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum Link count
1.1.1.1         1.1.1.1         1003        0x80000004 0x0075FE 2
2.2.2.2         2.2.2.2         833         0x8000000B 0x00CCC8 2
3.3.3.3         3.3.3.3         830         0x80000009 0x004294 1

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.1.1       1.1.1.1         1003        0x80000003 0x00AB60
10.16.2.1       2.2.2.2         833         0x80000001 0x00DA26

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.3.0       3.3.3.3         837         0x80000001 0x00D43E
10.16.4.0       3.3.3.3         837         0x80000001 0x00D33D
192.168.2.0     3.3.3.3         837         0x80000001 0x00853D

                Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum Link count
3.3.3.3         3.3.3.3         835         0x80000006 0x005A7D 1
4.4.4.4         4.4.4.4         841         0x80000005 0x00E898 2
5.5.5.5         5.5.5.5         1068        0x80000002 0x000C41 2

                Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.3.2       4.4.4.4         841         0x80000003 0x00C923
10.16.4.2       5.5.5.5         1068        0x80000001 0x00F8E8

                Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.1.0       3.3.3.3         823         0x80000001 0x00F41F
10.16.2.0       3.3.3.3         833         0x80000001 0x00DF34
192.168.1.0     3.3.3.3         823         0x80000001 0x009033
R3#
R3#
```

```
R1#show ip ospf database

            OSPF Router with ID (1.1.1.1) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum Link count
1.1.1.1         1.1.1.1         1441        0x80000004 0x0075FE 2
2.2.2.2         2.2.2.2         1272        0x8000000B 0x00CCC8 2
3.3.3.3         3.3.3.3         1271        0x80000009 0x004294 1

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.1.1       1.1.1.1         1441        0x80000003 0x00AB60
10.16.2.1       2.2.2.2         1272        0x80000001 0x00DA26

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.3.0       3.3.3.3         1279        0x80000001 0x00D43E
10.16.4.0       3.3.3.3         1279        0x80000001 0x00D33D
192.168.2.0     3.3.3.3         1279        0x80000001 0x00853D
R1#
```

```
R2#show ip ospf database

            OSPF Router with ID (2.2.2.2) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum Link count
1.1.1.1         1.1.1.1         1420        0x80000004 0x0075FE 2
2.2.2.2         2.2.2.2         1249        0x8000000B 0x00CCC8 2
3.3.3.3         3.3.3.3         1248        0x80000009 0x004294 1

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.1.1       1.1.1.1         1420        0x80000003 0x00AB60
10.16.2.1       2.2.2.2         1249        0x80000001 0x00DA26

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.3.0       3.3.3.3         1256        0x80000001 0x00D43E
10.16.4.0       3.3.3.3         1256        0x80000001 0x00D33D
192.168.2.0     3.3.3.3         1256        0x80000001 0x00853D
R2#
```

```
            OSPF Router with ID (3.3.3.3) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum Link count
1.1.1.1         1.1.1.1         1448        0x80000004 0x0075FE 2
2.2.2.2         2.2.2.2         1278        0x8000000B 0x00CCC8 2
3.3.3.3         3.3.3.3         1275        0x80000009 0x004294 1

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.1.1       1.1.1.1         1449        0x80000003 0x00AB60
10.16.2.1       2.2.2.2         1278        0x80000001 0x00DA26

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.3.0       3.3.3.3         1282        0x80000001 0x00D43E
10.16.4.0       3.3.3.3         1282        0x80000001 0x00D33D
192.168.2.0     3.3.3.3         1282        0x80000001 0x00853D

                Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum Link count
3.3.3.3         3.3.3.3         1280        0x80000006 0x005A7D 1
4.4.4.4         4.4.4.4         1286        0x80000005 0x00E898 2
5.5.5.5         5.5.5.5         1513        0x80000002 0x000C41 2

                Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.3.2       4.4.4.4         1286        0x80000003 0x00C923
10.16.4.2       5.5.5.5         1513        0x80000001 0x00F8E8

                Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.1.0       3.3.3.3         1268        0x80000001 0x00F41F
10.16.2.0       3.3.3.3         1278        0x80000001 0x00DF34
192.168.1.0     3.3.3.3         1268        0x80000001 0x009033
R3#
```

summary LSA

```
R4#show ip ospf database

            OSPF Router with ID (4.4.4.4) (Process ID 100)

                Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum Link count
3.3.3.3         3.3.3.3         1299        0x80000006 0x005A7D 1
4.4.4.4         4.4.4.4         1303        0x80000005 0x00E898 2
5.5.5.5         5.5.5.5         1531        0x80000002 0x000C41 2

                Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.3.2       4.4.4.4         1303        0x80000003 0x00C923
10.16.4.2       5.5.5.5         1531        0x80000001 0x00F8E8

                Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.1.0       3.3.3.3         1287        0x80000001 0x00F41F
10.16.2.0       3.3.3.3         1297        0x80000001 0x00DF34
192.168.1.0     3.3.3.3         1287        0x80000001 0x009033
R4#
```

```
R5#show ip ospf database

            OSPF Router with ID (5.5.5.5) (Process ID 100)

                Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum Link count
3.3.3.3         3.3.3.3         1437        0x80000006 0x005A7D 1
4.4.4.4         4.4.4.4         1442        0x80000005 0x00E898 2
5.5.5.5         5.5.5.5         1668        0x80000002 0x000C41 2

                Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.3.2       4.4.4.4         1442        0x80000003 0x00C923
10.16.4.2       5.5.5.5         1668        0x80000001 0x00F8E8

                Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.16.1.0       3.3.3.3         1426        0x80000001 0x00F41F
10.16.2.0       3.3.3.3         1436        0x80000001 0x00DF34
192.168.1.0     3.3.3.3         1426        0x80000001 0x009033
R5#
```

summary LSA

Open summary LSA – Type 3 LSA:-

```
R5# show ip ospf database summary 192.168.1.0

            OSPF Router with ID (5.5.5.5) (Process ID 100)

               Summary Net Link States (Area 1)

  Routing Bit Set on this LSA
  LS age: 1835
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.1.0 (summary Network Number)
  Advertising Router: 3.3.3.3
  LS Seq Number: 80000001
  Checksum: 0x9033
  Length: 28
  Network Mask: /24
        TOS: 0  Metric: 3              Matric calculation
                                       in routing table

R5#
```

```
R5#show ip ospf border-routers

OSPF Process 100 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 3.3.3.3 [2] via 10.16.4.1, GigabitEthernet0/0, ABR, Area 1, SPF 5
R5#
```

```
R5#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 4 subnets
O IA    10.16.2.0 [110/3] via 10.16.4.1, 00:31:55, GigabitEthernet0/0
O       10.16.3.0 [110/2] via 10.16.4.1, 00:31:55, GigabitEthernet0/0
O IA    10.16.1.0 [110/4] via 10.16.4.1, 00:31:48, GigabitEthernet0/0
C       10.16.4.0 is directly connected, GigabitEthernet0/0
O IA 192.168.1.0/24 [110/5] via 10.16.4.1, 00:31:48, GigabitEthernet0/0
C    192.168.2.0/24 is directly connected, GigabitEthernet1/0
R5#
```

Useful commands:-

1. R#show ip ospf database summary 192.168.2.0
2. R#show ip ospf border-routers
3. R#show ip ospf border-routers detail

Routing table described-

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set    ┌─────────────────────────────────────────────┐
                                      │ OIA = inter area route means other area's route│
                                      │ O= same area's route                           │
                                      └─────────────────────────────────────────────┘
     10.0.0.0/24 is subnetted, 4 subnets
O       10.16.2.0 [110/2] via 10.16.1.2, 00:38:30, GigabitEthernet0/0
O IA    10.16.3.0 [110/3] via 10.16.1.2, 00:38:20, GigabitEthernet0/0
C       10.16.1.0 is directly connected, GigabitEthernet0/0
O IA    10.16.4.0 [110/4] via 10.16.1.2, 00:38:20, GigabitEthernet0/0
C    192.168.1.0/24 is directly connected, GigabitEthernet1/0
O IA 192.168.2.0/24 [110/5] via 10.16.1.2, 00:38:20, GigabitEthernet0/0
R1#
```

Type – 4 LSA – ASBR Summary LSA –

1. Type -4 LSA ASBR Summary LSA are generated by the ABR router.
2. Describe that who is doing redistribution means ASBR information.
3. Cost to reach an ASBR from ABR.

➤ **Link-id – router-id of ASBR**
➤ **Adv.router-id = router id of ABR**
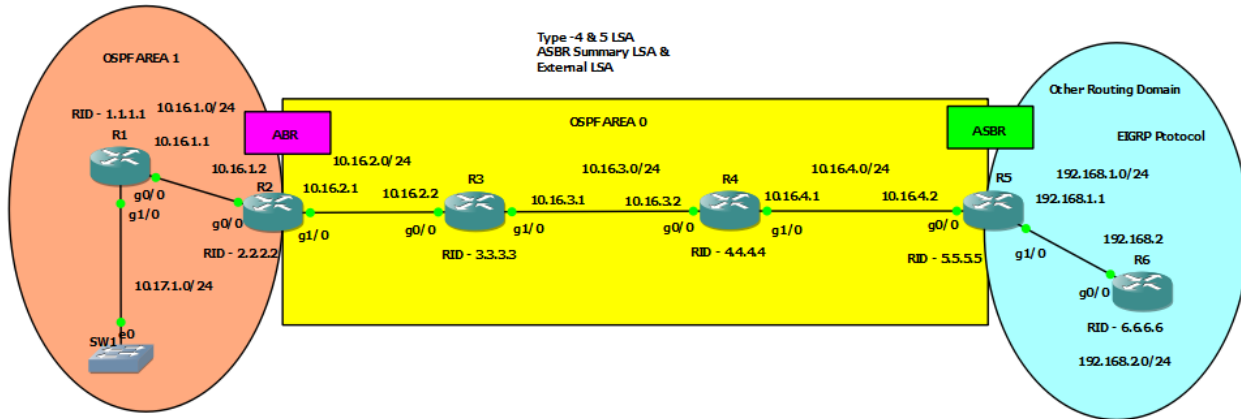

```
R2#show ip protocols
Routing Protocol is "ospf 100"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 2.2.2.2
  It is an area border router          As you can see that this router is ABR router
  Number of areas in this router is 2. 2 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    10.16.1.0 0.0.0.255 area 1
    10.16.2.0 0.0.0.255 area 0
  Reference bandwidth unit is 100 mbps
  Routing Information Sources:
    Gateway         Distance      Last Update
    5.5.5.5              110      00:16:49
    4.4.4.4              110      00:16:59
    3.3.3.3              110      00:17:47
    1.1.1.1              110      00:17:57
  Distance: (default is 110)

R2#show ip os
R2#show ip ospf ne
R2#show ip ospf neighbor

Neighbor ID     Pri   State          Dead Time    Address         Interface
3.3.3.3           1   FULL/BDR       00:00:31     10.16.2.2       GigabitEthernet1/0
1.1.1.1           1   FULL/BDR       00:00:38     10.16.1.1       GigabitEthernet0/0
R2#show ip os
R2#
```

#R2#show ip ospf border-routers

```
R2#show ip ospf border-routers

OSPF Process 100 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 5.5.5.5 [3] via 10.16.2.2, GigabitEthernet1/0, ASBR, Area 0, SPF 13
R2#
```

This router know that who is ASBR

Note –

1. **In that area types -4 LSA are never generated in that area ASBR directly connected.**

```
R3#  show ip ospf database

            OSPF Router with ID (3.3.3.3) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum Link count
2.2.2.2         2.2.2.2         1616      0x80000008 0x00825E 1
3.3.3.3         3.3.3.3         1295      0x80000004 0x00DCB2 2
4.4.4.4         4.4.4.4         1272      0x80000004 0x00EA97 2
5.5.5.5         5.5.5.5         1349      0x80000003 0x00EED7 1

                Net Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum
10.16.2.1       2.2.2.2         1341      0x80000002 0x00D827
10.16.3.2       4.4.4.4         1272      0x80000002 0x00CB22
10.16.4.2       5.5.5.5         1349      0x80000002 0x00F6E9

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age       Seq#        Checksum
10.16.1.0       2.2.2.2         1615      0x80000001 0x000910
10.17.1.0       2.2.2.2         1605      0x80000001 0x000710

                Type-5 AS External Link States

Link ID         ADV Router      Age       Seq#        Checksum Tag
192.168.1.0     5.5.5.5         1349      0x80000002 0x00928E 0
192.168.2.0     5.5.5.5         1350      0x80000002 0x008798 0
R3#
```

#show ip ospf database

```
R1#show ip ospf database

           OSPF Router with ID (1.1.1.1) (Process ID 100)

                Router Link States (Area 1)

Link ID          ADV Router      Age        Seq#        Checksum Link count
1.1.1.1          1.1.1.1         1485        0x80000008 0x00B10D 2
2.2.2.2          2.2.2.2         1483        0x8000000B 0x00746A 1

                Net Link States (Area 1)

Link ID          ADV Router      Age        Seq#        Checksum
10.16.1.1        1.1.1.1         1485        0x80000005 0x00A762

                Summary Net Link States (Area 1)

Link ID          ADV Router      Age        Seq#        Checksum
10.16.2.0        2.2.2.2         1491        0x80000002 0x00FB1B
10.16.3.0        2.2.2.2         1491        0x80000002 0x00FA1A
10.16.4.0        2.2.2.2         1491        0x80000002 0x00F919

                Summary ASB Link States (Area 1)            Type - LSA
                                                            ASBR
Link ID          ADV Router      Age        Seq#  Checksum  summary
5.5.5.5          2.2.2.2         1491        0x80000002 0x0074A7  LSA

                Type-5 AS External Link States

Link ID          ADV Router      Age        Seq#        Checksum Tag
192.168.1.0      5.5.5.5         1224        0x80000002 0x00928E 0
192.168.2.0      5.5.5.5         1224        0x80000002 0x008798 0
R1#
R1#
```

R1#show ip ospf database asbr-summary (To check type – 4 LSA)

```
R1#show ip ospf database asbr-summary

              OSPF Router with ID (1.1.1.1) (Process ID 100)

                  Summary ASB Link States (Area 1)

  Routing Bit Set on this LSA
  LS age: 130
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(AS Boundary Router)
  Link State ID: 5.5.5.5 (AS Boundary Router address)
  Advertising Router: 2.2.2.2
  LS Seq Number: 80000003
  Checksum: 0x72A8
  Length: 28
  Network Mask: /0
        TOS: 0  Metric: 3
R1# show ip ospf border-routers

OSPF Process 100 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

I 5.5.5.5 [4] via 10.16.1.2, GigabitEthernet0/0, ASBR, Area 1, SPF 8
i 2.2.2.2 [1] via 10.16.1.2, GigabitEthernet0/0, ABR, Area 1, SPF 8
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 5 subnets
O IA    10.16.2.0 [110/2] via 10.16.1.2, 00:33:19, GigabitEthernet0/0
O IA    10.16.3.0 [110/3] via 10.16.1.2, 00:33:19, GigabitEthernet0/0
C       10.17.1.0 is directly connected, GigabitEthernet1/0
C       10.16.1.0 is directly connected, GigabitEthernet0/0
O IA    10.16.4.0 [110/4] via 10.16.1.2, 00:33:19, GigabitEthernet0/0
O E2 192.168.1.0/24 [110/20] via 10.16.1.2, 00:33:19, GigabitEthernet0/0
O E2 192.168.2.0/24 [110/20] via 10.16.1.2, 00:33:19, GigabitEthernet0/0
R1#
```

Type – 5 LSA External LSA –

1. Type – 5 LSA are generated by the ASBR router.
2. This LSA will keep information of all routes of other routing domain.
➢ **Link –id = External routes**
➢ **Adv. Router-id =router-id of ASBR**
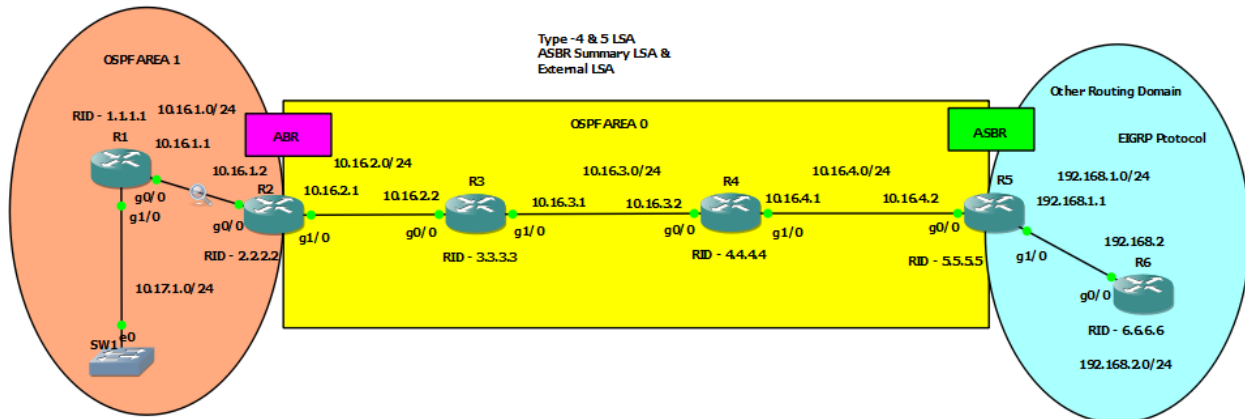
Note –

1. If you will see in the type -1 LSA , ASBR router E bit turned on to send.
2. Type -5 LSA are crossed in the other area in the form of Type -5 LSA.

Lets see whether E bit turned on or not. Right now I'm going to down g0/0 of ASBR router.

```
> Internet Protocol Version 4, Src: 10.16.4.2, Dst: 10.16.4.1
v Open Shortest Path First
  > OSPF Header
  v LS Update Packet
      Number of LSAs: 1
    v LSA-type 1 (Router-LSA), len 36
        .000 0000 0000 0101 = LS Age (seconds): 5
        0... .... .... .... = Do Not Age Flag: 0
      > Options: 0x22, (DC) Demand Circuits, (E) External Routing
        LS Type: Router-LSA (1)
        Link State ID: 5.5.5.5
        Advertising Router: 5.5.5.5
        Sequence Number: 0x80000006
        Checksum: 0x6480
        Length: 36
      v Flags: 0x02, (E) AS boundary router
          .... .0.. = (V) Virtual link endpoint: No
          .... ..1. = (E) AS boundary router: Yes        E bit turned on
          .... ...0 = (B) Area border router: No
        Number of Links: 1
      v Type: Stub      ID: 10.16.4.0        Data: 255.255.255.0    Metric: 1
          Link ID: 10.16.4.0 - IP network/subnet number
          Link Data: 255.255.255.0
          Link Type: 3 - Connection to a stub network
          Number of Metrics: 0 - TOS
          0 Metric: 1
```

- **As shown - Type – 5 LSA**

```
R3#show ip ospf database

        OSPF Router with ID (3.3.3.3) (Process ID 100)

            Router Link States (Area 0)

Link ID          ADV Router       Age        Seq#         Checksum Link count
2.2.2.2          2.2.2.2          1169       0x80000009 0x00805F 1
3.3.3.3          3.3.3.3          869        0x80000005 0x00DAB3 2
4.4.4.4          4.4.4.4          238        0x80000007 0x00DAA5 2
5.5.5.5          5.5.5.5          238        0x80000007 0x00DCE6 1

            Net Link States (Area 0)

Link ID          ADV Router       Age        Seq#         Checksum
10.16.2.1        2.2.2.2          927        0x80000003 0x00D628
10.16.3.2        4.4.4.4          854        0x80000003 0x00C923
10.16.4.1        4.4.4.4          238        0x80000001 0x0031B5

            Summary Net Link States (Area 0)

Link ID          ADV Router       Age        Seq#         Checksum
10.16.1.0        2.2.2.2          1169       0x80000002 0x000711
10.17.1.0        2.2.2.2          1169       0x80000002 0x000511

            Type-5 AS External Link States

Link ID          ADV Router       Age        Seq#         Checksum Tag
192.168.1.0      5.5.5.5          938        0x80000003 0x00908F 0
192.168.2.0      5.5.5.5          938        0x80000003 0x008599 0
R3#
```

External routes it means that this route are coming from other routing domain.

```
R1#show ip ospf database

        OSPF Router with ID (1.1.1.1) (Process ID 100)

            Router Link States (Area 1)

Link ID          ADV Router       Age        Seq#         Checksum Link count
1.1.1.1          1.1.1.1          1223       0x80000009 0x00AF0E 2
2.2.2.2          2.2.2.2          1176       0x8000000C 0x00726B 1

            Net Link States (Area 1)

Link ID          ADV Router       Age        Seq#         Checksum
10.16.1.1        1.1.1.1          1223       0x80000006 0x00A563

            Summary Net Link States (Area 1)

Link ID          ADV Router       Age        Seq#         Checksum
10.16.2.0        2.2.2.2          1431       0x80000003 0x00F91C
10.16.3.0        2.2.2.2          1431       0x80000003 0x00F81B
10.16.4.0        2.2.2.2          1431       0x80000003 0x00F71A

            Summary ASB Link States (Area 1)

Link ID          ADV Router       Age        Seq#         Checksum
5.5.5.5          2.2.2.2          229        0x80000006 0x006CAB

            Type-5 AS External Link States          Type - 5 LSA external LSA

Link ID          ADV Router       Age        Seq#         Checksum Tag
192.168.1.0      5.5.5.5          947        0x80000003 0x00908F 0
192.168.2.0      5.5.5.5          947        0x80000003 0x008599 0
R1#
```

- **Routing table of R5 router –**

```
R5#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 5 subnets
O        10.16.2.0 [110/3] via 10.16.4.1, 00:11:36, GigabitEthernet0/0
O        10.16.3.0 [110/2] via 10.16.4.1, 00:11:36, GigabitEthernet0/0
O IA     10.17.1.0 [110/5] via 10.16.4.1, 00:11:36, GigabitEthernet0/0
O IA     10.16.1.0 [110/4] via 10.16.4.1, 00:11:36, GigabitEthernet0/0
C        10.16.4.0 is directly connected, GigabitEthernet0/0
C     192.168.1.0/24 is directly connected, GigabitEthernet1/0
D     192.168.2.0/24 [90/3072] via 192.168.1.2, 01:29:13, GigabitEthernet1/0
R5#
```

- **Routing table of R1 router which is in other ospf's area.**

```
R1# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 5 subnets
O IA     10.16.2.0 [110/2] via 10.16.1.2, 01:02:07, GigabitEthernet0/0
O IA     10.16.3.0 [110/3] via 10.16.1.2, 01:02:07, GigabitEthernet0/0
C        10.17.1.0 is directly connected, GigabitEthernet1/0
C        10.16.1.0 is directly connected, GigabitEthernet0/0
O IA     10.16.4.0 [110/4] via 10.16.1.2, 01:02:07, GigabitEthernet0/0
O E2 192.168.1.0/24 [110/20] via 10.16.1.2, 00:12:17, GigabitEthernet0/0
O E2 192.168.2.0/24 [110/20] via 10.16.1.2, 00:12:17, GigabitEthernet0/0
R1#
```

> **router eigrp 1**
>
> redistribute ospf 100 metric 1 1 1 1 1
>
> no auto-summary
>
> exit
>
> !
>
> **router ospf 100**
>
> redistribute eigrp 1 subnets
>
> network 10.16.4.0 0.0.0.255 area 0
>
> exit

Type -7 LSA - NSSA (Not-so stubby area LSA) –

1. It is generated by ASBR within NSSA area.
2. It remains within the NSSA area.
3. Type – 7 LSA gets translate back into type -5 LSA by the NSSA, ABR router.
➢ **Link –id = external routes**
➢ **Adv.router-id = router id of ASBR**

Before understanding Type – 7 LSA we need to understand type of area in ospf .

Types of area in ospf –

1. **Standard area** (By default all areas will be standard area in ospf)
2. **Stub area**
3. **Totally stub area**
4. **NSSA area** (Not-so-stubby area)
5. **Totally NSSA area**

Note –

➢ We used types of area to filter LSA. Or
➢ Types of area are used to reduce the size of database table.
1. **Standard Area –**

By default are areas are standard area.

2. Stub Area: -

1. It is used to filter type -4LSA & Type-5 LSA or to filter external routes.
2. After filtering type-4 & type-5 LSA. it automatically generate default route.
3. Default route is advertised by ABR router (Type-3 LSA).
4. Stub area run on both sides means ABR and all other router of this area.
5. We can't configure as stub area.
6. Stub area are not allowed virtual link.
7. Stub area is not allowed ASBR router so we can't configure stub area near ASBR router.
8. We can make stub to that area which is attached with ASBR because it can't do redistribution.

Stub area configuration –

Router (config)# router ospf 100
            #area 1 stub

3. Totally stub area –

1. It filters LSA 3, 4, 5 or external as well as inter-area routes.
2. It automatically generate default route.
3. Implement only on ABR router.

Router(conifg)# router ospf 100
          #Area 1 stub no-summary

4. NSSA area (Not-so-stubby-area) –

NSSA stands for Not-so-stubby-area.

It is used to allow an ASBR to send external routes through stub area with using Type-7 LSA.

Filter LSA 4, 5 but redistribution is not allowed.

ASBR router will generate type-7 LSA after that ABR will convert type-7 LSA back to type-5 LSA.

Default route will be manually configured. (ABR router)

Run on both side like – stub router.

Router(config)#router ospf 100
          #Area 1 nssa
          # Area 1 nssa default-information originate

5. Totally NSSA area –

1. It filter LSA 3, 4, 5 .
2. Default route will be automatically generated.
3. Implemented only on ABR router.
4. Allow redistribution
5. Default route originate by ABR.

Router(config)#router ospf 100
               #Area 1 nssa no-summary
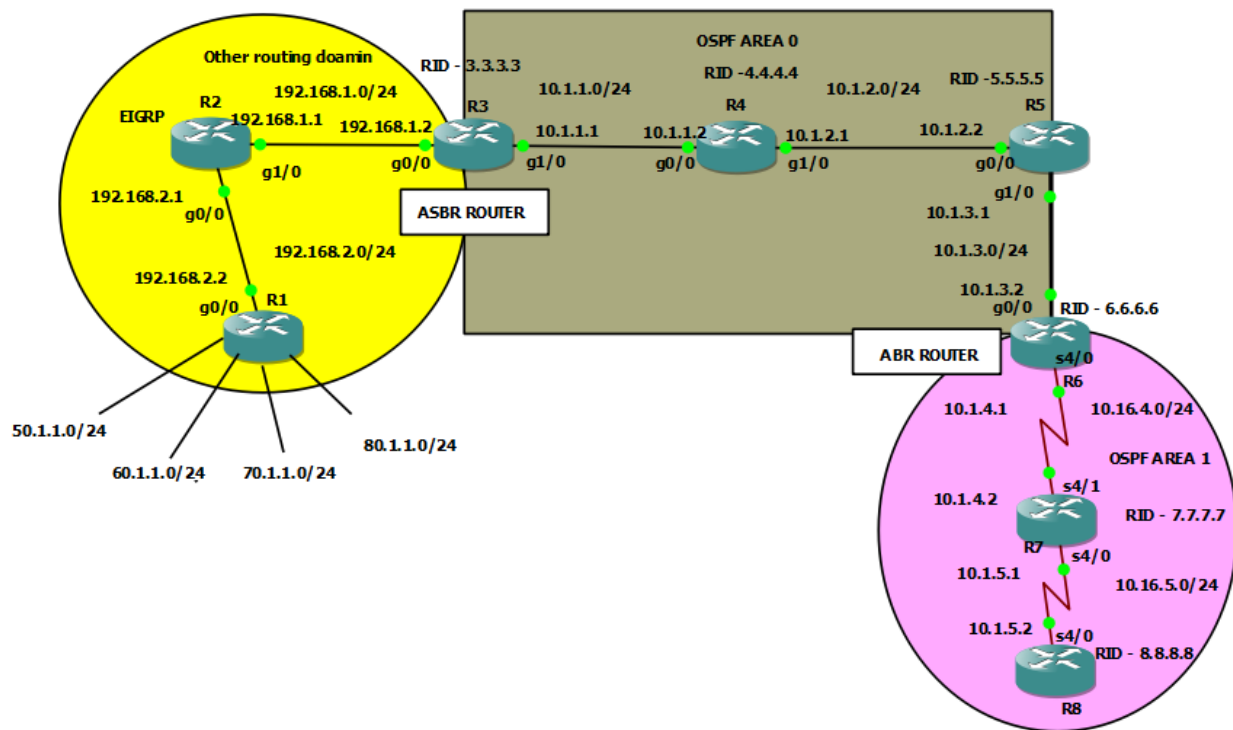
Redistribution Configuration on R3 Router -

➢ R3(config)#router eigrp 1
➢ R3(config-router)#redistribute ospf 100 metric 1 1 1 1 1

➢ R3(config)# router ospf 100
➢ R3(config-router)# redistribute ospf 100 subnets metric-type 1

```
R3# show ip ospf database          [ASBR Router]

        OSPF Router with ID (1.1.1.1) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum Link count
1.1.1.1         1.1.1.1         612         0x80000003 0x00A269 1
2.2.2.2         2.2.2.2         984         0x80000003 0x002FA9 2
3.3.3.3         3.3.3.3         938         0x80000002 0x001DB0 2
4.4.4.4         4.4.4.4         938         0x80000004 0x00F2FB 1

            Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.1.2        2.2.2.2         992         0x80000001 0x002CEB
10.1.2.1        2.2.2.2         984         0x80000001 0x008F80
10.1.3.2        4.4.4.4         939         0x80000001 0x00827B

            Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.4.0        4.4.4.4         945         0x80000001 0x00D805
10.1.5.0        4.4.4.4         63          0x80000001 0x00504C

            Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#        Checksum Tag
50.1.1.0        1.1.1.1         611         0x80000001 0x00A246 0
60.1.1.0        1.1.1.1         612         0x80000001 0x0020BE 0
70.1.1.0        1.1.1.1         612         0x80000001 0x009D37 0
80.1.1.0        1.1.1.1         612         0x80000001 0x001BAF 0
192.168.1.0     1.1.1.1         612         0x80000001 0x008929 0
192.168.2.0     1.1.1.1         612         0x80000001 0x007E33 0
R3#
```

```
R4#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum Link count
1.1.1.1         1.1.1.1         659         0x80000003 0x00A269 1
2.2.2.2         2.2.2.2         1029        0x80000003 0x002FA9 2
3.3.3.3         3.3.3.3         984         0x80000002 0x001DB0 2
4.4.4.4         4.4.4.4         984         0x80000004 0x00F2FB 1

            Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.1.2        2.2.2.2         1038        0x80000001 0x002CEB
10.1.2.1        2.2.2.2         1029        0x80000001 0x008F80
10.1.3.2        4.4.4.4         985         0x80000001 0x00827B

            Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.4.0        4.4.4.4         990         0x80000001 0x00D805
10.1.5.0        4.4.4.4         108         0x80000001 0x00504C

            Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#        Checksum Tag
50.1.1.0        1.1.1.1         659         0x80000001 0x00A246 0
60.1.1.0        1.1.1.1         659         0x80000001 0x0020BE 0
70.1.1.0        1.1.1.1         659         0x80000001 0x009D37 0
80.1.1.0        1.1.1.1         659         0x80000001 0x001BAF 0
192.168.1.0     1.1.1.1         659         0x80000001 0x008929 0
192.168.2.0     1.1.1.1         659         0x80000001 0x007E33 0
R4#
```

```
R5#show ip ospf database

        OSPF Router with ID (3.3.3.3) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum Link count
1.1.1.1         1.1.1.1         691         0x80000003 0x00A269 1
2.2.2.2         2.2.2.2         1061        0x80000003 0x002FA9 2
3.3.3.3         3.3.3.3         1013        0x80000002 0x001DB0 2
4.4.4.4         4.4.4.4         1014        0x80000004 0x00F2FB 1

            Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.1.2        2.2.2.2         1069        0x80000001 0x002CEB
10.1.2.1        2.2.2.2         1061        0x80000001 0x008F80
10.1.3.2        4.4.4.4         1014        0x80000001 0x00827B

            Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.4.0        4.4.4.4         1020        0x80000001 0x00D805
10.1.5.0        4.4.4.4         137         0x80000001 0x00504C

            Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#        Checksum Tag
50.1.1.0        1.1.1.1         690         0x80000001 0x00A246 0
60.1.1.0        1.1.1.1         690         0x80000001 0x0020BE 0
70.1.1.0        1.1.1.1         690         0x80000001 0x009D37 0
80.1.1.0        1.1.1.1         690         0x80000001 0x001BAF 0
192.168.1.0     1.1.1.1         690         0x80000001 0x008929 0
192.168.2.0     1.1.1.1         690         0x80000001 0x007E33 0
R5#
```

```
R6#show ip ospf database          [ABR Router]

        OSPF Router with ID (4.4.4.4) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum Link count
1.1.1.1         1.1.1.1         730         0x80000003 0x00A269 1
2.2.2.2         2.2.2.2         1099        0x80000003 0x002FA9 2
3.3.3.3         3.3.3.3         1052        0x80000002 0x001DB0 2
4.4.4.4         4.4.4.4         1051        0x80000004 0x00F2FB 1

            Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.1.2        2.2.2.2         1108        0x80000001 0x002CEB
10.1.2.1        2.2.2.2         1099        0x80000001 0x008F80
10.1.3.2        4.4.4.4         1051        0x80000001 0x00827B

            Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.4.0        4.4.4.4         1057        0x80000001 0x00D805
10.1.5.0        4.4.4.4         175         0x80000001 0x00504C

            Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum Link count
4.4.4.4         4.4.4.4         184         0x80000007 0x009AAF 2
5.5.5.5         5.5.5.5         189         0x80000008 0x00A1CB 4
6.6.6.6         6.6.6.6         201         0x80000005 0x003307 2

            Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.1.0        4.4.4.4         190         0x80000003 0x00918A
10.1.2.0        4.4.4.4         190         0x80000003 0x007C9F
10.1.3.0        4.4.4.4         190         0x80000004 0x0065B5

            Summary ASB Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
1.1.1.1         4.4.4.4         190         0x80000001 0x00F232

            Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#        Checksum Tag
50.1.1.0        1.1.1.1         729         0x80000001 0x00A246 0
60.1.1.0        1.1.1.1         730         0x80000001 0x0020BE 0
70.1.1.0        1.1.1.1         730         0x80000001 0x009D37 0
80.1.1.0        1.1.1.1         730         0x80000001 0x001BAF 0
192.168.1.0     1.1.1.1         730         0x80000001 0x008929 0
192.168.2.0     1.1.1.1         730         0x80000001 0x007E33 0
R6#
```

```
R7#show ip ospf database

        OSPF Router with ID (5.5.5.5) (Process ID 100)

            Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum Link count
4.4.4.4         4.4.4.4         459         0x80000007 0x009AAF 2
5.5.5.5         5.5.5.5         462         0x80000008 0x00A1CB 4
6.6.6.6         6.6.6.6         474         0x80000005 0x003307 2

            Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.1.0        4.4.4.4         464         0x80000003 0x00918A
10.1.2.0        4.4.4.4         464         0x80000003 0x007C9F
10.1.3.0        4.4.4.4         464         0x80000004 0x0065B5

            Summary ASB Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
1.1.1.1         4.4.4.4         464         0x80000001 0x00F232

            Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#        Checksum Tag
50.1.1.0        1.1.1.1         1003        0x80000001 0x00A246 0
60.1.1.0        1.1.1.1         1004        0x80000001 0x0020BE 0
70.1.1.0        1.1.1.1         1004        0x80000001 0x009D37 0
80.1.1.0        1.1.1.1         1004        0x80000001 0x001BAF 0
192.168.1.0     1.1.1.1         1004        0x80000001 0x008929 0
192.168.2.0     1.1.1.1         1004        0x80000001 0x007E33 0
R7#
```

```
R8#show ip ospf database

        OSPF Router with ID (6.6.6.6) (Process ID 100)

            Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum Link count
4.4.4.4         4.4.4.4         484         0x80000007 0x009AAF 2
5.5.5.5         5.5.5.5         487         0x80000008 0x00A1CB 4
6.6.6.6         6.6.6.6         497         0x80000005 0x003307 2

            Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.1.0        4.4.4.4         490         0x80000003 0x00918A
10.1.2.0        4.4.4.4         490         0x80000003 0x007C9F
10.1.3.0        4.4.4.4         490         0x80000004 0x0065B5

            Summary ASB Link States (Area 1)

Link ID         ADV Router      Age         Seq#        Checksum
1.1.1.1         4.4.4.4         490         0x80000001 0x00F232

            Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#        Checksum Tag
50.1.1.0        1.1.1.1         1029        0x80000001 0x00A246 0
60.1.1.0        1.1.1.1         1029        0x80000001 0x0020BE 0
70.1.1.0        1.1.1.1         1029        0x80000001 0x009D37 0
80.1.1.0        1.1.1.1         1029        0x80000001 0x001BAF 0
192.168.1.0     1.1.1.1         1029        0x80000001 0x008929 0
192.168.2.0     1.1.1.1         1029        0x80000001 0x007E33 0
R8#
```

Routing table –

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/24 is subnetted, 1 subnets
C       50.1.1.0 is directly connected, Loopback1
     70.0.0.0/24 is subnetted, 1 subnets
C       70.1.1.0 is directly connected, Loopback3
     80.0.0.0/24 is subnetted, 1 subnets
C       80.1.1.0 is directly connected, Loopback4
     10.0.0.0/24 is subnetted, 5 subnets
D EX    10.1.3.0
           [170/2560000768] via 192.168.2.1, 00:19:19, GigabitEthernet0/0
D EX    10.1.2.0
           [170/2560000768] via 192.168.2.1, 00:19:19, GigabitEthernet0/0
D EX    10.1.1.0
           [170/2560000768] via 192.168.2.1, 00:19:19, GigabitEthernet0/0
D EX    10.1.5.0
           [170/2560000768] via 192.168.2.1, 00:12:24, GigabitEthernet0/0
D EX    10.1.4.0
           [170/2560000768] via 192.168.2.1, 00:19:19, GigabitEthernet0/0
D    192.168.1.0/24 [90/3072] via 192.168.2.1, 00:23:31, GigabitEthernet0/0
C    192.168.2.0/24 is directly connected, GigabitEthernet0/0
     60.0.0.0/24 is subnetted, 1 subnets
C       60.1.1.0 is directly connected, Loopback2
R1#
```

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/24 is subnetted, 1 subnets
D       50.1.1.0 [90/130816] via 192.168.2.2, 00:20:33, GigabitEthernet0/0
     70.0.0.0/24 is subnetted, 1 subnets
D       70.1.1.0 [90/130816] via 192.168.2.2, 00:20:33, GigabitEthernet0/0
     80.0.0.0/24 is subnetted, 1 subnets
D       80.1.1.0 [90/130816] via 192.168.2.2, 00:20:33, GigabitEthernet0/0
     10.0.0.0/24 is subnetted, 5 subnets
D EX    10.1.3.0
           [170/2560000512] via 192.168.1.2, 00:16:21, GigabitEthernet1/0
D EX    10.1.2.0
           [170/2560000512] via 192.168.1.2, 00:16:21, GigabitEthernet1/0
D EX    10.1.1.0
           [170/2560000512] via 192.168.1.2, 00:16:21, GigabitEthernet1/0
D EX    10.1.5.0
           [170/2560000512] via 192.168.1.2, 00:09:24, GigabitEthernet1/0
D EX    10.1.4.0
           [170/2560000512] via 192.168.1.2, 00:16:22, GigabitEthernet1/0
C    192.168.1.0/24 is directly connected, GigabitEthernet1/0
C    192.168.2.0/24 is directly connected, GigabitEthernet0/0
     60.0.0.0/24 is subnetted, 1 subnets
D       60.1.1.0 [90/130816] via 192.168.2.2, 00:20:33, GigabitEthernet0/0
R2#
```

```
R3# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

      50.0.0.0/24 is subnetted, 1 subnets
D        50.1.1.0 [90/131072] via 192.168.1.1, 00:30:20, GigabitEthernet0/0
      70.0.0.0/24 is subnetted, 1 subnets
D        70.1.1.0 [90/131072] via 192.168.1.1, 00:30:20, GigabitEthernet0/0
      80.0.0.0/24 is subnetted, 1 subnets
D        80.1.1.0 [90/131072] via 192.168.1.1, 00:30:20, GigabitEthernet0/0
      10.0.0.0/24 is subnetted, 5 subnets
O        10.1.3.0 [110/3] via 10.1.1.2, 00:29:34, GigabitEthernet1/0
O        10.1.2.0 [110/2] via 10.1.1.2, 00:30:28, GigabitEthernet1/0
C        10.1.1.0 is directly connected, GigabitEthernet1/0
O IA     10.1.5.0 [110/131] via 10.1.1.2, 00:15:01, GigabitEthernet1/0
O IA     10.1.4.0 [110/67] via 10.1.1.2, 00:29:24, GigabitEthernet1/0
C     192.168.1.0/24 is directly connected, GigabitEthernet0/0
D     192.168.2.0/24 [90/3072] via 192.168.1.1, 00:31:17, GigabitEthernet0/0
      60.0.0.0/24 is subnetted, 1 subnets
D        60.1.1.0 [90/131072] via 192.168.1.1, 00:30:20, GigabitEthernet0/0
R3# 
```

```
R4# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

      50.0.0.0/24 is subnetted, 1 subnets
O E1     50.1.1.0 [110/21] via 10.1.1.1, 00:24:32, GigabitEthernet0/0
      70.0.0.0/24 is subnetted, 1 subnets
O E1     70.1.1.0 [110/21] via 10.1.1.1, 00:24:32, GigabitEthernet0/0
      80.0.0.0/24 is subnetted, 1 subnets
O E1     80.1.1.0 [110/21] via 10.1.1.1, 00:24:32, GigabitEthernet0/0
      10.0.0.0/24 is subnetted, 5 subnets
O        10.1.3.0 [110/2] via 10.1.2.2, 00:29:57, GigabitEthernet1/0
C        10.1.2.0 is directly connected, GigabitEthernet1/0
C        10.1.1.0 is directly connected, GigabitEthernet0/0
O IA     10.1.5.0 [110/130] via 10.1.2.2, 00:15:25, GigabitEthernet1/0
O IA     10.1.4.0 [110/66] via 10.1.2.2, 00:29:47, GigabitEthernet1/0
O E1  192.168.1.0/24 [110/21] via 10.1.1.1, 00:24:32, GigabitEthernet0/0
O E1  192.168.2.0/24 [110/21] via 10.1.1.1, 00:24:33, GigabitEthernet0/0
      60.0.0.0/24 is subnetted, 1 subnets
O E1     60.1.1.0 [110/21] via 10.1.1.1, 00:24:33, GigabitEthernet0/0
R4# 
```

```
R5# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

      50.0.0.0/24 is subnetted, 1 subnets
O E1     50.1.1.0 [110/22] via 10.1.2.1, 00:25:07, GigabitEthernet0/0
      70.0.0.0/24 is subnetted, 1 subnets
O E1     70.1.1.0 [110/22] via 10.1.2.1, 00:25:07, GigabitEthernet0/0
      80.0.0.0/24 is subnetted, 1 subnets
O E1     80.1.1.0 [110/22] via 10.1.2.1, 00:25:07, GigabitEthernet0/0
      10.0.0.0/24 is subnetted, 5 subnets
C        10.1.3.0 is directly connected, GigabitEthernet1/0
C        10.1.2.0 is directly connected, GigabitEthernet0/0
O        10.1.1.0 [110/2] via 10.1.2.1, 00:31:19, GigabitEthernet0/0
O IA     10.1.5.0 [110/129] via 10.1.3.2, 00:16:00, GigabitEthernet1/0
O IA     10.1.4.0 [110/65] via 10.1.3.2, 00:30:32, GigabitEthernet1/0
O E1  192.168.1.0/24 [110/22] via 10.1.2.1, 00:25:07, GigabitEthernet0/0
O E1  192.168.2.0/24 [110/22] via 10.1.2.1, 00:25:07, GigabitEthernet0/0
      60.0.0.0/24 is subnetted, 1 subnets
O E1     60.1.1.0 [110/22] via 10.1.2.1, 00:25:07, GigabitEthernet0/0
R5# 
```

```
R6# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

      50.0.0.0/24 is subnetted, 1 subnets
O E1     50.1.1.0 [110/23] via 10.1.3.1, 00:16:42, GigabitEthernet0/0
      70.0.0.0/24 is subnetted, 1 subnets
O E1     70.1.1.0 [110/23] via 10.1.3.1, 00:16:42, GigabitEthernet0/0
      80.0.0.0/24 is subnetted, 1 subnets
O E1     80.1.1.0 [110/23] via 10.1.3.1, 00:16:42, GigabitEthernet0/0
      10.0.0.0/24 is subnetted, 5 subnets
C        10.1.3.0 is directly connected, GigabitEthernet0/0
O        10.1.2.0 [110/2] via 10.1.3.1, 00:16:42, GigabitEthernet0/0
O        10.1.1.0 [110/3] via 10.1.3.1, 00:16:42, GigabitEthernet0/0
O        10.1.5.0 [110/128] via 10.1.4.2, 00:16:27, Serial4/0
C        10.1.4.0 is directly connected, Serial4/0
O E1  192.168.1.0/24 [110/23] via 10.1.3.1, 00:16:42, GigabitEthernet0/0
O E1  192.168.2.0/24 [110/23] via 10.1.3.1, 00:16:42, GigabitEthernet0/0
      60.0.0.0/24 is subnetted, 1 subnets
O E1     60.1.1.0 [110/23] via 10.1.3.1, 00:16:42, GigabitEthernet0/0
R6# 
```

```
R7# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

      50.0.0.0/24 is subnetted, 1 subnets
O E1     50.1.1.0 [110/87] via 10.1.4.1, 00:18:49, Serial4/1
      70.0.0.0/24 is subnetted, 1 subnets
O E1     70.1.1.0 [110/87] via 10.1.4.1, 00:18:49, Serial4/1
      80.0.0.0/24 is subnetted, 1 subnets
O E1     80.1.1.0 [110/87] via 10.1.4.1, 00:18:49, Serial4/1
      10.0.0.0/24 is subnetted, 5 subnets
O IA     10.1.3.0 [110/65] via 10.1.4.1, 00:18:49, Serial4/1
O IA     10.1.2.0 [110/66] via 10.1.4.1, 00:18:49, Serial4/1
O IA     10.1.1.0 [110/67] via 10.1.4.1, 00:18:49, Serial4/1
C        10.1.5.0 is directly connected, Serial4/0
C        10.1.4.0 is directly connected, Serial4/1
O E1  192.168.1.0/24 [110/87] via 10.1.4.1, 00:18:49, Serial4/1
O E1  192.168.2.0/24 [110/87] via 10.1.4.1, 00:18:49, Serial4/1
      60.0.0.0/24 is subnetted, 1 subnets
O E1     60.1.1.0 [110/87] via 10.1.4.1, 00:18:49, Serial4/1
R7# 
```

```
R8# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

      50.0.0.0/24 is subnetted, 1 subnets
O E1     50.1.1.0 [110/151] via 10.1.5.1, 00:19:22, Serial4/0
      70.0.0.0/24 is subnetted, 1 subnets
O E1     70.1.1.0 [110/151] via 10.1.5.1, 00:19:22, Serial4/0
      80.0.0.0/24 is subnetted, 1 subnets
O E1     80.1.1.0 [110/151] via 10.1.5.1, 00:19:22, Serial4/0
      10.0.0.0/24 is subnetted, 5 subnets
O IA     10.1.3.0 [110/129] via 10.1.5.1, 00:19:22, Serial4/0
O IA     10.1.2.0 [110/130] via 10.1.5.1, 00:19:22, Serial4/0
O IA     10.1.1.0 [110/131] via 10.1.5.1, 00:19:22, Serial4/0
C        10.1.5.0 is directly connected, Serial4/0
O        10.1.4.0 [110/128] via 10.1.5.1, 00:19:32, Serial4/0
O E1  192.168.1.0/24 [110/151] via 10.1.5.1, 00:19:22, Serial4/0
O E1  192.168.2.0/24 [110/151] via 10.1.5.1, 00:19:23, Serial4/0
      60.0.0.0/24 is subnetted, 1 subnets
O E1     60.1.1.0 [110/151] via 10.1.5.1, 00:19:23, Serial4/0
R8# 
```

1. Stub area configuration – ABR router (R6), R7, R8

➢ R6(config)#router ospf 100
➢ R6(config-router)#area 1 stub

➢ R7(config)#router ospf 100
➢ R7(config-router)#area 1 stub

➢ R8(config)#router ospf 100
➢ R8(config-router)#area 1 stub

After configuring stub area below see the database table of R6, R7, R8 and Routing table –

You can see the database size has been reduced of router R7 & R8.

```
R6#show ip ospf database

        OSPF Router with ID (4.4.4.4) (Process ID 100)

            Router Link States (Area 0)

Link ID       ADV Router      Age       Seq#       Checksum Link count
1.1.1.1       1.1.1.1         267       0x80000004 0x00A06A 1
2.2.2.2       2.2.2.2         557       0x80000004 0x002DAA 2
3.3.3.3       3.3.3.3         522       0x80000003 0x001BB1 2
4.4.4.4       4.4.4.4         483       0x80000005 0x00F0FC 1

            Net Link States (Area 0)

Link ID       ADV Router      Age       Seq#       Checksum
10.1.1.2      2.2.2.2         557       0x80000002 0x002AEC
10.1.2.1      2.2.2.2         557       0x80000002 0x008D81
10.1.3.2      4.4.4.4         483       0x80000002 0x00807C

            Summary Net Link States (Area 0)

Link ID       ADV Router      Age       Seq#       Checksum
10.1.4.0      4.4.4.4         483       0x80000002 0x00D606
10.1.5.0      4.4.4.4         199       0x80000001 0x00504C

            Router Link States (Area 1)

Link ID       ADV Router      Age       Seq#       Checksum Link count
4.4.4.4       4.4.4.4         207       0x80000009 0x00B495 2
5.5.5.5       5.5.5.5         209       0x8000000B 0x00B9B2 4
6.6.6.6       6.6.6.6         220       0x80000007 0x004DEC 2

            Summary Net Link States (Area 1)

Link ID       ADV Router      Age       Seq#       Checksum
0.0.0.0       4.4.4.4         214       0x80000001 0x0039F4
10.1.1.0      4.4.4.4         214       0x80000004 0x00AD6F
10.1.2.0      4.4.4.4         214       0x80000004 0x009884
10.1.3.0      4.4.4.4         214       0x80000005 0x00819A

            Type-5 AS External Link States

Link ID       ADV Router      Age       Seq#       Checksum Tag
50.1.1.0      1.1.1.1         267       0x80000002 0x00A047 0
60.1.1.0      1.1.1.1         267       0x80000002 0x001EBF 0
70.1.1.0      1.1.1.1         267       0x80000002 0x009B38 0
80.1.1.0      1.1.1.1         267       0x80000002 0x0019B0 0
192.168.1.0   1.1.1.1         267       0x80000002 0x00872A 0
192.168.2.0   1.1.1.1         268       0x80000002 0x007C34 0
R6#
```

```
R7#show ip ospf database

        OSPF Router with ID (5.5.5.5) (Process ID 100)

            Router Link States (Area 1)

Link ID       ADV Router      Age       Seq#       Checksum Link count
4.4.4.4       4.4.4.4         273       0x80000009 0x00B495 2
5.5.5.5       5.5.5.5         272       0x8000000B 0x00B9B2 4
6.6.6.6       6.6.6.6         284       0x80000007 0x004DEC 2

            Summary Net Link States (Area 1)

Link ID       ADV Router      Age       Seq#       Checksum
0.0.0.0       4.4.4.4         279       0x80000001 0x0039F4
10.1.1.0      4.4.4.4         279       0x80000004 0x00AD6F
10.1.2.0      4.4.4.4         279       0x80000004 0x009884
10.1.3.0      4.4.4.4         279       0x80000005 0x00819A
R7#
```

```
R8#show ip ospf database

        OSPF Router with ID (6.6.6.6) (Process ID 100)

            Router Link States (Area 1)

Link ID       ADV Router      Age       Seq#       Checksum Link count
4.4.4.4       4.4.4.4         306       0x80000009 0x00B495 2
5.5.5.5       5.5.5.5         306       0x8000000B 0x00B9B2 4
6.6.6.6       6.6.6.6         316       0x80000007 0x004DEC 2

            Summary Net Link States (Area 1)

Link ID       ADV Router      Age       Seq#       Checksum
0.0.0.0       4.4.4.4         312       0x80000001 0x0039F4
10.1.1.0      4.4.4.4         312       0x80000004 0x00AD6F
10.1.2.0      4.4.4.4         312       0x80000004 0x009884
10.1.3.0      4.4.4.4         312       0x80000005 0x00819A
R8#
```

```
R6# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/24 is subnetted, 1 subnets
O E1    50.1.1.0 [110/23] via 10.1.3.1, 00:08:27, GigabitEthernet0/0
     70.0.0.0/24 is subnetted, 1 subnets
O E1    70.1.1.0 [110/23] via 10.1.3.1, 00:08:27, GigabitEthernet0/0
     80.0.0.0/24 is subnetted, 1 subnets
O E1    80.1.1.0 [110/23] via 10.1.3.1, 00:08:27, GigabitEthernet0/0
     10.0.0.0/24 is subnetted, 5 subnets
C       10.1.3.0 is directly connected, GigabitEthernet0/0
O       10.1.2.0 [110/2] via 10.1.3.1, 00:08:27, GigabitEthernet0/0
O       10.1.1.0 [110/3] via 10.1.3.1, 00:08:27, GigabitEthernet0/0
O       10.1.5.0 [110/128] via 10.1.4.2, 00:08:12, Serial4/0
C       10.1.4.0 is directly connected, Serial4/0
O E1 192.168.1.0/24 [110/23] via 10.1.3.1, 00:08:27, GigabitEthernet0/0
O E1 192.168.2.0/24 [110/23] via 10.1.3.1, 00:08:28, GigabitEthernet0/0
     60.0.0.0/24 is subnetted, 1 subnets
O E1    60.1.1.0 [110/23] via 10.1.3.1, 00:08:28, GigabitEthernet0/0
R6#

R8#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 = 112/122/128 ms
R8#
```

```
R7#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.1.4.1 to network 0.0.0.0

     10.0.0.0/24 is subnetted, 5 subnets
O IA    10.1.3.0 [110/65] via 10.1.4.1, 00:08:40, Serial4/1
O IA    10.1.2.0 [110/66] via 10.1.4.1, 00:08:40, Serial4/1
O IA    10.1.1.0 [110/67] via 10.1.4.1, 00:08:40, Serial4/1
C       10.1.5.0 is directly connected, Serial4/0
C       10.1.4.0 is directly connected, Serial4/1
O*IA 0.0.0.0/0 [110/65] via 10.1.4.1, 00:08:40, Serial4/1
R7#

R8#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.1.5.1 to network 0.0.0.0

     10.0.0.0/24 is subnetted, 5 subnets
O IA    10.1.3.0 [110/129] via 10.1.5.1, 00:08:58, Serial4/0
O IA    10.1.2.0 [110/130] via 10.1.5.1, 00:08:58, Serial4/0
O IA    10.1.1.0 [110/131] via 10.1.5.1, 00:08:58, Serial4/0
C       10.1.5.0 is directly connected, Serial4/0
O       10.1.4.0 [110/128] via 10.1.5.1, 00:09:18, Serial4/0
O*IA 0.0.0.0/0 [110/129] via 10.1.5.1, 00:08:58, Serial4/0
R8#
```

As you can see the ABR routing router sending default route towards R7 & R8 Router and also I'm getting reply from R8 router when I reach the other routing domain.

2. Totally Stub area configuration –

R6(config-router)#area 1 stub no-summary


```
R6#show ip ospf database

            OSPF Router with ID (4.4.4.4) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
1.1.1.1         1.1.1.1         1346        0x80000004 0x00A06A 1
2.2.2.2         2.2.2.2         1636        0x80000004 0x002DAA 2
3.3.3.3         3.3.3.3         1601        0x80000003 0x001BB1 2
4.4.4.4         4.4.4.4         1562        0x80000005 0x00F0FC 1

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.2        2.2.2.2         1636        0x80000002 0x002AEC
10.1.2.1        2.2.2.2         1636        0x80000002 0x008D81
10.1.3.2        4.4.4.4         1562        0x80000002 0x00807C

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.4.0        4.4.4.4         1562        0x80000002 0x00D606
10.1.5.0        4.4.4.4         1278        0x80000001 0x00504C

                Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum Link count
4.4.4.4         4.4.4.4         812         0x8000000A 0x00B296 2
5.5.5.5         5.5.5.5         1288        0x8000000B 0x00B9B2 4
6.6.6.6         6.6.6.6         1299        0x80000007 0x004DEC 2

                Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum
0.0.0.0         4.4.4.4         58          0x80000002 0x0037F5

                Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#       Checksum Tag
50.1.1.0        1.1.1.1         1347        0x80000002 0x00A047 0
60.1.1.0        1.1.1.1         1347        0x80000002 0x001EBF 0
70.1.1.0        1.1.1.1         1347        0x80000002 0x009B38 0
80.1.1.0        1.1.1.1         1347        0x80000002 0x0019B0 0
192.168.1.0     1.1.1.1         1347        0x80000002 0x00872A 0
192.168.2.0     1.1.1.1         1347        0x80000002 0x007C34 0
R6#
```

```
R7# show ip os
R7# show ip dat
R7# show ip ospf database

            OSPF Router with ID (5.5.5.5) (Process ID 100)

                Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum Link count
4.4.4.4         4.4.4.4         889         0x8000000A 0x00B296 2
5.5.5.5         5.5.5.5         1362        0x8000000B 0x00B9B2 4
6.6.6.6         6.6.6.6         1374        0x80000007 0x004DEC 2

                Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum
0.0.0.0         4.4.4.4         133         0x80000002 0x0037F5
R7#

R8#show ip ospf database

            OSPF Router with ID (6.6.6.6) (Process ID 100)

                Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum Link count
4.4.4.4         4.4.4.4         970         0x8000000A 0x00B296 2
5.5.5.5         5.5.5.5         1444        0x8000000B 0x00B9B2 4
6.6.6.6         6.6.6.6         1454        0x80000007 0x004DEC 2

                Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum
0.0.0.0         4.4.4.4         215         0x80000002 0x0037F5
R8#
```

After configuration totally stub area as you can see above screenshot LSA 3, LSA 4, LSA 5 have been filtered by ABR router.

Let's see routing table of router –

```
R6#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/24 is subnetted, 1 subnets
O E1    50.1.1.0 [110/23] via 10.1.3.1, 00:09:00, GigabitEthernet0/0
     70.0.0.0/24 is subnetted, 1 subnets
O E1    70.1.1.0 [110/23] via 10.1.3.1, 00:09:00, GigabitEthernet0/0
     80.0.0.0/24 is subnetted, 1 subnets
O E1    80.1.1.0 [110/23] via 10.1.3.1, 00:09:00, GigabitEthernet0/0
     10.0.0.0/24 is subnetted, 5 subnets
C       10.1.3.0 is directly connected, GigabitEthernet0/0
O       10.1.2.0 [110/2] via 10.1.3.1, 00:09:00, GigabitEthernet0/0
O       10.1.1.0 [110/3] via 10.1.3.1, 00:09:00, GigabitEthernet0/0
O       10.1.5.0 [110/128] via 10.1.4.2, 00:09:00, Serial4/0
C       10.1.4.0 is directly connected, Serial4/0
O E1 192.168.1.0/24 [110/23] via 10.1.3.1, 00:09:00, GigabitEthernet0/0
O E1 192.168.2.0/24 [110/23] via 10.1.3.1, 00:09:00, GigabitEthernet0/0
     60.0.0.0/24 is subnetted, 1 subnets
O E1    60.1.1.0 [110/23] via 10.1.3.1, 00:09:00, GigabitEthernet0/0
R6#

R8#ping 70.1.1.1          getting reply from the Router 8

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 = 68/100/140 ms
R8#
```

```
R7#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.1.4.1 to network 0.0.0.0

     10.0.0.0/24 is subnetted, 2 subnets       Routing table
C       10.1.5.0 is directly connected, Serial4/0   have been
C       10.1.4.0 is directly connected, Serial4/1   reduced
O*IA 0.0.0.0/0 [110/65] via 10.1.4.1, 00:09:18, Serial4/1
R7#
```

```
R8# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.1.5.1 to network 0.0.0.0
                                                  Routing table
     10.0.0.0/24 is subnetted, 2 subnets         have been
C       10.1.5.0 is directly connected, Serial4/0   reduced
O       10.1.4.0 [110/128] via 10.1.5.1, 00:30:21, Serial4/0
O*IA 0.0.0.0/0 [110/129] via 10.1.5.1, 00:09:40, Serial4/0
R8#
```

3. NSSA Area (Not-so-stubby area) configuration –

R8(config)#router ospf 100
     #area 1 nssa
     # area 1 nssa default-information originate
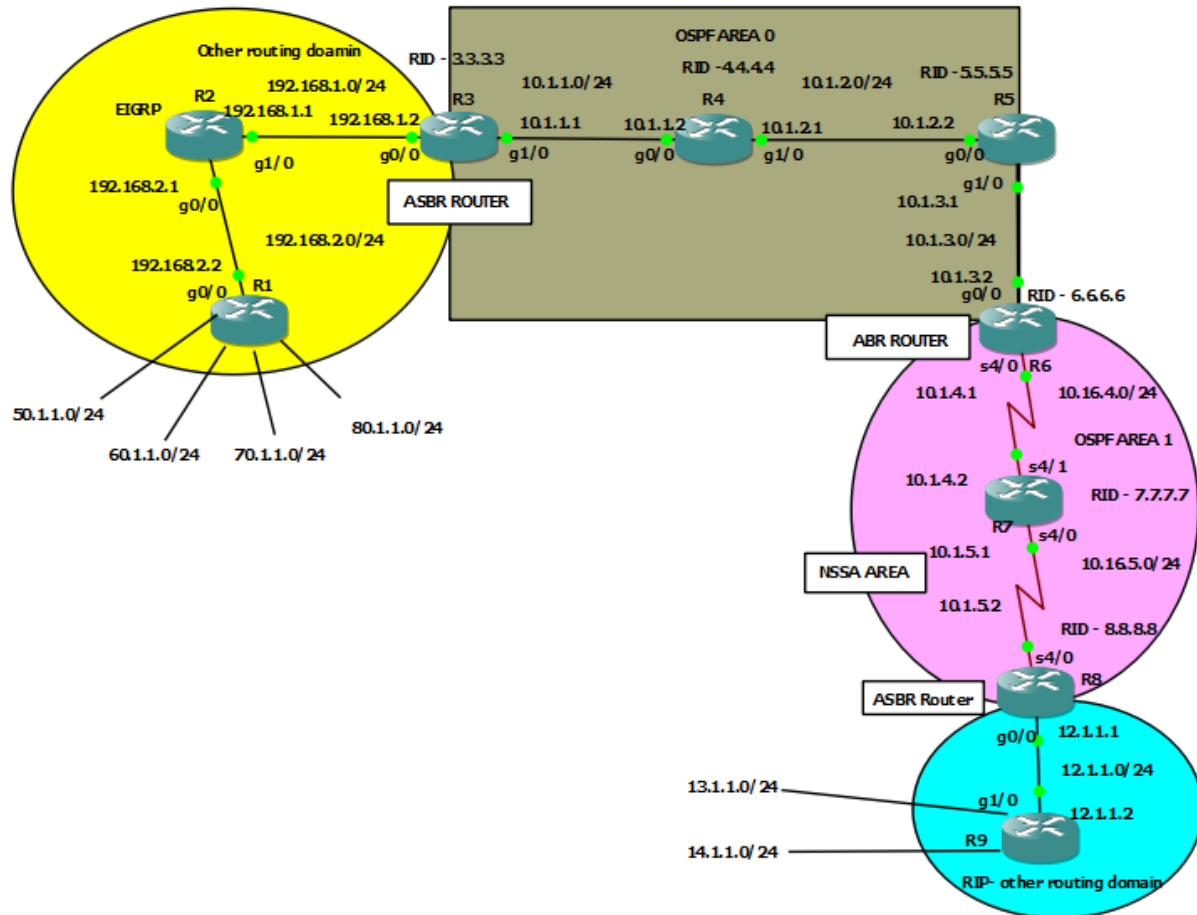
Redistribution configuration on Router - R8

➢ R8(config)#router rip
➢ R8(config-router)#redistribute ospf 100 metric 1

➢ R8(config)#router ospf 100
➢ R8(config-router)#redistribute rip subnets metric-type 1

Routing table –

```
R8#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set                    ┌─────────────────────┐
                                                     │ ASBR router where   │
                                                     │ redistribution are  │
      50.0.0.0/24 is subnetted, 1 subnets            │ configured          │
O E1    50.1.1.0 [110/1649] via 10.1.5.1, 00:15:24, Serial4/0
      70.0.0.0/24 is subnetted, 1 subnets
O E1    70.1.1.0 [110/1649] via 10.1.5.1, 00:15:24, Serial4/0
      80.0.0.0/24 is subnetted, 1 subnets
O E1    80.1.1.0 [110/1649] via 10.1.5.1, 00:15:24, Serial4/0
      10.0.0.0/24 is subnetted, 5 subnets
O IA    10.1.3.0 [110/1627] via 10.1.5.1, 00:15:24, Serial4/0
O IA    10.1.2.0 [110/1628] via 10.1.5.1, 00:15:24, Serial4/0
O IA    10.1.1.0 [110/1629] via 10.1.5.1, 00:15:24, Serial4/0
C       10.1.5.0 is directly connected, Serial4/0
O       10.1.4.0 [110/1626] via 10.1.5.1, 00:15:24, Serial4/0
      12.0.0.0/24 is subnetted, 1 subnets
C       12.1.1.0 is directly connected, GigabitEthernet0/0
O E1 192.168.1.0/24 [110/1649] via 10.1.5.1, 00:15:25, Serial4/0
      13.0.0.0/24 is subnetted, 1 subnets
R       13.1.1.0 [120/1] via 12.1.1.2, 00:00:08, GigabitEthernet0/0
O E1 192.168.2.0/24 [110/1649] via 10.1.5.1, 00:15:25, Serial4/0
      14.0.0.0/24 is subnetted, 1 subnets
R       14.1.1.0 [120/1] via 12.1.1.2, 00:00:08, GigabitEthernet0/0
      60.0.0.0/24 is subnetted, 1 subnets
O E1    60.1.1.0 [110/1649] via 10.1.5.1, 00:15:25, Serial4/0
R8#
```

```
R9#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set                    ┌──────────────┐
                                                     │ Other routing │
                                                     │ domain's      │
      50.0.0.0/24 is subnetted, 1 subnets            │ router        │
R       50.1.1.0 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
      70.0.0.0/24 is subnetted, 1 subnets
R       70.1.1.0 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
      80.0.0.0/24 is subnetted, 1 subnets
R       80.1.1.0 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
      10.0.0.0/24 is subnetted, 5 subnets
R       10.1.3.0 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
R       10.1.2.0 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
R       10.1.1.0 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
R       10.1.5.0 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
R       10.1.4.0 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
      12.0.0.0/24 is subnetted, 1 subnets
C       12.1.1.0 is directly connected, GigabitEthernet1/0
R    192.168.1.0/24 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
      13.0.0.0/24 is subnetted, 1 subnets
C       13.1.1.0 is directly connected, GigabitEthernet0/0
R    192.168.2.0/24 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
      14.0.0.0/24 is subnetted, 1 subnets
C       14.1.1.0 is directly connected, GigabitEthernet2/0
      60.0.0.0/24 is subnetted, 1 subnets
R       60.1.1.0 [120/1] via 12.1.1.1, 00:00:17, GigabitEthernet1/0
R9#
```

Database table of Router –R7

```
R7#show ip ospf database

            OSPF Router with ID (5.5.5.5) (Process ID 100)

                Router Link States (Area 1)

Link ID           ADV Router        Age        Seq#          Checksum Link count
4.4.4.4           4.4.4.4           897        0x80000005 0x009EAD 2
5.5.5.5           5.5.5.5           913        0x80000006 0x00A5C9 4
6.6.6.6           6.6.6.6           541        0x80000008 0x002154 2

                Summary Net Link States (Area 1)

Link ID           ADV Router        Age        Seq#          Checksum
10.1.1.0          4.4.4.4           897        0x80000002 0x009389
10.1.2.0          4.4.4.4           897        0x80000002 0x007E9E
10.1.3.0          4.4.4.4           897        0x80000002 0x0069B3

                Summary ASB Link States (Area 1)

Link ID           ADV Router        Age        Seq#          Checksum
1.1.1.1           4.4.4.4           897        0x80000002 0x00F033

                Type-5 AS External Link States      ┌─────────────┐
                                                    │ Type 5 LSA  │
                                                    └─────────────┘
Link ID           ADV Router        Age        Seq#          Checksum Tag
12.1.1.0          6.6.6.6           1022       0x80000001 0x00FBFE 0
13.1.1.0          6.6.6.6           1023       0x80000001 0x00EE0B 0
14.1.1.0          6.6.6.6           1023       0x80000001 0x00E117 0
50.1.1.0          1.1.1.1           994        0x80000002 0x00A047 0
60.1.1.0          1.1.1.1           994        0x80000002 0x001EBF 0
70.1.1.0          1.1.1.1           994        0x80000002 0x009B38 0
80.1.1.0          1.1.1.1           994        0x80000002 0x0019B0 0
192.168.1.0       1.1.1.1           994        0x80000002 0x00872A 0
192.168.2.0       1.1.1.1           994        0x80000002 0x007C34 0
R7#
```

Type -7 LSA – NSSA

```
R7#show ip ospf database                              R6#show ip ospf database

        OSPF Router with ID (5.5.5.5) (Process ID 100)        OSPF Router with ID (4.4.4.4) (Process ID 100)

            Router Link States (Area 1)                           Router Link States (Area 0)

Link ID      ADV Router    Age      Seq#     Checksum Link count  Link ID      ADV Router    Age      Seq#     Checksum Link count
4.4.4.4      4.4.4.4       21       0x80000007 0x0046FB 2         1.1.1.1      1.1.1.1       1795     0x80000003 0x00A269 1
5.5.5.5      5.5.5.5       20       0x80000009 0x004521 4         2.2.2.2      2.2.2.2       1813     0x80000004 0x00379F 2
6.6.6.6      6.6.6.6       56       0x8000000A 0x00C2AA 2         3.3.3.3      3.3.3.3       1904     0x80000004 0x002F9B 2
                                                                  4.4.4.4      4.4.4.4       48       0x80000004 0x00F8F3 1
            Summary Net Link States (Area 1)
                                                                      Net Link States (Area 0)
Link ID      ADV Router    Age      Seq#     Checksum
10.1.1.0     4.4.4.4       21       0x80000003 0x0037DE           Link ID      ADV Router    Age      Seq#     Checksum
10.1.2.0     4.4.4.4       21       0x80000003 0x0022F3           10.1.1.2     2.2.2.2       1813     0x80000002 0x002AEC
10.1.3.0     4.4.4.4       21       0x80000003 0x000D09           10.1.2.2     3.3.3.3       1904     0x80000002 0x0055B4
                                                                  10.1.3.2     4.4.4.4       1944     0x80000002 0x00807C
            Type-7 AS External Link States (Area 1)
                                                                      Summary Net Link States (Area 0)
Link ID      ADV Router    Age      Seq#     Checksum Tag
12.1.1.0     6.6.6.6       60       0x80000001 0x003F9F 0         Link ID      ADV Router    Age      Seq#     Checksum
13.1.1.0     6.6.6.6       60       0x80000001 0x0032AB 0         10.1.4.0     4.4.4.4       1944     0x80000002 0x00D606
14.1.1.0     6.6.6.6       60       0x80000001 0x0025B7 0         10.1.5.0     4.4.4.4       44       0x80000001 0x00504C
R7#
R8#show ip ospf database              Type -7 LSA                     Router Link States (Area 1)

        OSPF Router with ID (6.6.6.6) (Process ID 100)        Link ID      ADV Router    Age      Seq#     Checksum Link count
                                                                  4.4.4.4      4.4.4.4       48       0x80000007 0x0046FB 2
            Router Link States (Area 1)                           5.5.5.5      5.5.5.5       50       0x80000009 0x004521 4
                                                                  6.6.6.6      6.6.6.6       86       0x8000000A 0x00C2AA 2
Link ID      ADV Router    Age      Seq#     Checksum Link count
4.4.4.4      4.4.4.4       43       0x80000007 0x0046FB 2             Summary Net Link States (Area 1)
5.5.5.5      5.5.5.5       43       0x80000009 0x004521 4
6.6.6.6      6.6.6.6       77       0x8000000A 0x00C2AA 2         Link ID      ADV Router    Age      Seq#     Checksum
                                                                  10.1.1.0     4.4.4.4       49       0x80000003 0x0037DE
            Summary Net Link States (Area 1)                      10.1.2.0     4.4.4.4       49       0x80000003 0x0022F3
                                                                  10.1.3.0     4.4.4.4       49       0x80000003 0x000D09
Link ID      ADV Router    Age      Seq#     Checksum
10.1.1.0     4.4.4.4       44       0x80000003 0x0037DE               Type-7 AS External Link States (Area 1)
10.1.2.0     4.4.4.4       44       0x80000003 0x0022F3
10.1.3.0     4.4.4.4       44       0x80000003 0x000D09           Link ID      ADV Router    Age      Seq#     Checksum Tag
                                                                  12.1.1.0     6.6.6.6       89       0x80000001 0x003F9F 0
            Type-7 AS External Link States (Area 1)               13.1.1.0     6.6.6.6       89       0x80000001 0x0032AB 0
                                                                  14.1.1.0     6.6.6.6       89       0x80000001 0x0025B7 0
Link ID      ADV Router    Age      Seq#     Checksum Tag
12.1.1.0     6.6.6.6       82       0x80000001 0x003F9F 0             Type-5 AS External Link States
13.1.1.0     6.6.6.6       82       0x80000001 0x0032AB 0
14.1.1.0     6.6.6.6       82       0x80000001 0x0025B7 0         Link ID      ADV Router    Age      Seq#     Checksum Tag
R8#                                                               12.1.1.0     4.4.4.4       38       0x80000001 0x0010E0 0
                                                                  13.1.1.0     4.4.4.4       39       0x80000001 0x0003EC 0
                                                                  14.1.1.0     4.4.4.4       39       0x80000001 0x00F5F8 0
                                                                  50.1.1.0     1.1.1.1       1797     0x80000002 0x00A047 0
                                                                  60.1.1.0     1.1.1.1       1797     0x80000002 0x001EBF 0
                                                                  70.1.1.0     1.1.1.1       1797     0x80000002 0x009B38 0
                                                                  80.1.1.0     1.1.1.1       1797     0x80000002 0x0019B0 0
                                                                  192.168.1.0  1.1.1.1       1797     0x80000002 0x00872A 0
                                                                  192.168.2.0  1.1.1.1       1797     0x80000002 0x007C34 0
                                                                  R6#
```

Type – 7 LSA :-

This is a type 7 LSA that is generated by an NSSA ASBR. Type 5 LSAs are not allowed in NSSA areas, so the NSSA ASBR generates a type 7 LSA instead, which remains within the NSSA. This type 7 LSA gets translated back into a type 5 by the NSSA ABR.

In area 0 database table of Router – R5

```
R5#show ip ospf database

            OSPF Router with ID (3.3.3.3) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum Link count
1.1.1.1         1.1.1.1         218         0x80000004 0x00A06A 1
2.2.2.2         2.2.2.2         232         0x80000005 0x0035A0 2
3.3.3.3         3.3.3.3         331         0x80000005 0x002D9C 2
4.4.4.4         4.4.4.4         409         0x80000005 0x00F6F4 1

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.1.2        2.2.2.2         232         0x80000003 0x0028ED
10.1.2.2        3.3.3.3         331         0x80000003 0x0053B5
10.1.3.2        4.4.4.4         409         0x80000003 0x007E7D

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#        Checksum
10.1.4.0        4.4.4.4         409         0x80000003 0x00D407
10.1.5.0        4.4.4.4         503         0x80000001 0x00504C
                                                    ┌──────────────────────┐
                                                    │ In this area type 7 LSA│
                Type-5 AS External Link States      │ ara filered by ABR     │
                                                    └──────────────────────┘
Link ID         ADV Router      Age         Seq#        Checksum Tag
12.1.1.0        4.4.4.4         497         0x80000001 0x0010E0 0
13.1.1.0        4.4.4.4         497         0x80000001 0x0003EC 0
14.1.1.0        4.4.4.4         497         0x80000001 0x00F5F8 0
50.1.1.0        1.1.1.1         218         0x80000003 0x009E48 0
60.1.1.0        1.1.1.1         218         0x80000003 0x001CC0 0
70.1.1.0        1.1.1.1         218         0x80000003 0x009939 0
80.1.1.0        1.1.1.1         218         0x80000003 0x0017B1 0
192.168.1.0     1.1.1.1         218         0x80000003 0x00852B 0
192.168.2.0     1.1.1.1         218         0x80000003 0x007A35 0
R5#
```

If you will see in the routing table of R9 router in the below screenshot there is no route of EIGRP domain so we need configure manually default route on the ABR router (R6).

➢ **R6(config)#router ospf 100**
➢ **R6(config-router)#area 1 nssa default-information-originate**

Routing table of Router R9 where is running RIP routing protocol.

After configure default route on ABR router (R6) it will propagate default route –

> **R6(config)#router ospf 100**
> **R6(config-router)#area 1 nssa default-information-originate**

Default route generated by ABR router –

```
R7# show ip ospf database                              R8#show ip ospf database

        OSPF Router with ID (5.5.5.5) (Process ID 100)         OSPF Router with ID (6.6.6.6) (Process ID 100)

            Router Link States (Area 1)                            Router Link States (Area 1)

Link ID      ADV Router    Age     Seq#       Checksum Link count   Link ID      ADV Router    Age     Seq#       Checksum Link count
4.4.4.4      4.4.4.4       1344    0x80000008 0x0044FC 2            4.4.4.4      4.4.4.4       1331    0x80000008 0x0044FC 2
5.5.5.5      5.5.5.5       1339    0x8000000A 0x004322 4            5.5.5.5      5.5.5.5       1327    0x8000000A 0x004322 4
6.6.6.6      6.6.6.6       1721    0x8000000A 0x00C2AA 2            6.6.6.6      6.6.6.6       1706    0x8000000A 0x00C2AA 2

            Summary Net Link States (Area 1)                       Summary Net Link States (Area 1)

Link ID      ADV Router    Age     Seq#       Checksum             Link ID      ADV Router    Age     Seq#       Checksum
10.1.1.0     4.4.4.4       1344    0x80000004 0x0035DF             10.1.1.0     4.4.4.4       1331    0x80000004 0x0035DF
10.1.2.0     4.4.4.4       1344    0x80000004 0x0020F4             10.1.2.0     4.4.4.4       1331    0x80000004 0x0020F4
10.1.3.0     4.4.4.4       1344    0x80000004 0x000B0A             10.1.3.0     4.4.4.4       1331    0x80000004 0x000B0A

            Type-7 AS External Link States (Area 1)  ┌─────────────────────┐   Type-7 AS External Link States (Area 1)
                                                     │ Default route is    │
                                                     │ generated by ABR    │
                                                     │ router  RID - 4.4.4.4│
Link ID      ADV Router    Age     Seq#       Checksum Tag   Link ID      ADV Router    Age     Seq#       Checksum Tag
0.0.0.0      4.4.4.4       654     0x80000001 0x00940D 0            0.0.0.0      4.4.4.4       641     0x80000001 0x00940D 0
12.1.1.0     6.6.6.6       1725    0x80000001 0x003F9F 0            12.1.1.0     6.6.6.6       1711    0x80000001 0x003F9F 0
13.1.1.0     6.6.6.6       1725    0x80000001 0x0032AB 0            13.1.1.0     6.6.6.6       1711    0x80000001 0x0032AB 0
14.1.1.0     6.6.6.6       1725    0x80000001 0x0025B7 0            14.1.1.0     6.6.6.6       1711    0x80000001 0x0025B7 0
R7#                                                               R8#
```

4. **Totally NSSA Area –**

   - R6(config)#router ospf 100
   - R6(config-router)#area 1 nssa no-summary

After configuring these command LSA are filtered.

```
R7# show ip ospf database                              R8#show ip ospf database

        OSPF Router with ID (5.5.5.5) (Process ID 100)         OSPF Router with ID (6.6.6.6) (Process ID 100)

            Router Link States (Area 1)                            Router Link States (Area 1)

Link ID      ADV Router    Age     Seq#       Checksum Link count   Link ID      ADV Router    Age     Seq#       Checksum Link count
4.4.4.4      4.4.4.4       1884    0x80000008 0x0044FC 2            4.4.4.4      4.4.4.4       1912    0x80000008 0x0044FC 2
5.5.5.5      5.5.5.5       1880    0x8000000A 0x004322 4            5.5.5.5      5.5.5.5       1908    0x8000000A 0x004322 4
6.6.6.6      6.6.6.6       265     0x8000000B 0x00C0AB 2            6.6.6.6      6.6.6.6       291     0x8000000B 0x00C0AB 2

            Summary Net Link States (Area 1)       ┌──────────┐      Summary Net Link States (Area 1)
                                                   │ LSA-3 are│
                                                   │ filtered │
Link ID      ADV Router    Age     Seq#       Checksum   Link ID      ADV Router    Age     Seq#       Checksum
0.0.0.0      4.4.4.4       124     0x80000001 0x00C065             0.0.0.0      4.4.4.4       152     0x80000001 0x00C065

            Type-7 AS External Link States (Area 1)                Type-7 AS External Link States (Area 1)

Link ID      ADV Router    Age     Seq#       Checksum Tag   Link ID      ADV Router    Age     Seq#       Checksum Tag
0.0.0.0      4.4.4.4       1194    0x80000001 0x00940D 0            0.0.0.0      4.4.4.4       1222    0x80000001 0x00940D 0
12.1.1.0     6.6.6.6       265     0x80000002 0x003DA0 0            12.1.1.0     6.6.6.6       291     0x80000002 0x003DA0 0
13.1.1.0     6.6.6.6       265     0x80000002 0x0030AC 0            13.1.1.0     6.6.6.6       291     0x80000002 0x0030AC 0
14.1.1.0     6.6.6.6       265     0x80000002 0x0023B8 0            14.1.1.0     6.6.6.6       291     0x80000002 0x0023B8 0
R7#                                                               R8#
```

Routing table –

```
R7#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.1.4.1 to network 0.0.0.0

     10.0.0.0/24 is subnetted, 2 subnets
C       10.1.5.0 is directly connected, Serial4/0
C       10.1.4.0 is directly connected, Serial4/1
     12.0.0.0/24 is subnetted, 1 subnets
O N1    12.1.1.0 [110/84] via 10.1.5.2, 00:38:42, Serial4/0
     13.0.0.0/24 is subnetted, 1 subnets
O N1    13.1.1.0 [110/84] via 10.1.5.2, 00:38:42, Serial4/0
     14.0.0.0/24 is subnetted, 1 subnets
O N1    14.1.1.0 [110/84] via 10.1.5.2, 00:38:42, Serial4/0
O*IA 0.0.0.0/0 [110/65] via 10.1.4.1, 00:03:08, Serial4/1
R7#
```

```
R8#show ip route
R8#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.1.5.1 to network 0.0.0.0

     10.0.0.0/24 is subnetted, 2 subnets
C       10.1.5.0 is directly connected, Serial4/0
O       10.1.4.0 [110/1626] via 10.1.5.1, 00:39:36, Serial4/0
     12.0.0.0/24 is subnetted, 1 subnets
C       12.1.1.0 is directly connected, GigabitEthernet0/0
     13.0.0.0/24 is subnetted, 1 subnets
R       13.1.1.0 [120/1] via 12.1.1.2, 00:00:24, GigabitEthernet0/0
     14.0.0.0/24 is subnetted, 1 subnets
R       14.1.1.0 [120/1] via 12.1.1.2, 00:00:24, GigabitEthernet0/0
O*IA 0.0.0.0/0 [110/1627] via 10.1.5.1, 00:04:08, Serial4/0
R8#
```

```
R6# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/24 is subnetted, 1 subnets
O E1    50.1.1.0 [110/23] via 10.1.3.1, 00:04:35, GigabitEthernet0/0
     70.0.0.0/24 is subnetted, 1 subnets
O E1    70.1.1.0 [110/23] via 10.1.3.1, 00:04:35, GigabitEthernet0/0
     80.0.0.0/24 is subnetted, 1 subnets
O E1    80.1.1.0 [110/23] via 10.1.3.1, 00:04:35, GigabitEthernet0/0
     10.0.0.0/24 is subnetted, 5 subnets
C       10.1.3.0 is directly connected, GigabitEthernet0/0
O       10.1.2.0 [110/2] via 10.1.3.1, 00:04:35, GigabitEthernet0/0
O       10.1.1.0 [110/3] via 10.1.3.1, 00:04:35, GigabitEthernet0/0
O       10.1.5.0 [110/128] via 10.1.4.2, 00:04:35, Serial4/0
C       10.1.4.0 is directly connected, Serial4/0
     12.0.0.0/24 is subnetted, 1 subnets
O N1    12.1.1.0 [110/148] via 10.1.4.2, 00:04:36, Serial4/0
O E1 192.168.1.0/24 [110/23] via 10.1.3.1, 00:04:36, GigabitEthernet0/0
     13.0.0.0/24 is subnetted, 1 subnets
O N1    13.1.1.0 [110/148] via 10.1.4.2, 00:04:36, Serial4/0
O E1 192.168.2.0/24 [110/23] via 10.1.3.1, 00:04:36, GigabitEthernet0/0
     14.0.0.0/24 is subnetted, 1 subnets
O N1    14.1.1.0 [110/148] via 10.1.4.2, 00:04:36, Serial4/0
     60.0.0.0/24 is subnetted, 1 subnets
O E1    60.1.1.0 [110/23] via 10.1.3.1, 00:04:36, GigabitEthernet0/0
R6#
```

Getting Reply from R9-

```
R9#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 = 80/86/104 ms
R9#tr
R9#traceroute 60.1.1.1

Type escape sequence to abort.
Tracing the route to 60.1.1.1

  1 12.1.1.1 4 msec 20 msec 12 msec
  2 10.1.5.1 16 msec 20 msec 12 msec
  3 10.1.4.1 24 msec 48 msec 48 msec
  4 10.1.3.1 52 msec 60 msec 60 msec
  5 10.1.2.1 64 msec 104 msec 84 msec
  6 10.1.1.1 116 msec 84 msec 128 msec
  7 192.168.1.1 116 msec 124 msec 124 msec
  8 192.168.2.2 128 msec 132 msec 132 msec
R9#
```

Routing table of R1 which are running EIGRP domain –

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

      50.0.0.0/24 is subnetted, 1 subnets
C        50.1.1.0 is directly connected, Loopback1
      70.0.0.0/24 is subnetted, 1 subnets
C        70.1.1.0 is directly connected, Loopback3
      80.0.0.0/24 is subnetted, 1 subnets
C        80.1.1.0 is directly connected, Loopback4
      10.0.0.0/24 is subnetted, 5 subnets
D EX     10.1.3.0
           [170/2560000768] via 192.168.2.1, 01:20:08, GigabitEthernet0/0
D EX     10.1.2.0
           [170/2560000768] via 192.168.2.1, 01:20:08, GigabitEthernet0/0
D EX     10.1.1.0
           [170/2560000768] via 192.168.2.1, 01:20:08, GigabitEthernet0/0
D EX     10.1.5.0
           [170/2560000768] via 192.168.2.1, 00:36:15, GigabitEthernet0/0
D EX     10.1.4.0
           [170/2560000768] via 192.168.2.1, 01:20:08, GigabitEthernet0/0
      12.0.0.0/24 is subnetted, 1 subnets
D EX     12.1.1.0
           [170/2560000768] via 192.168.2.1, 00:36:11, GigabitEthernet0/0
D     192.168.1.0/24 [90/3072] via 192.168.2.1, 01:20:08, GigabitEthernet0/0
      13.0.0.0/24 is subnetted, 1 subnets
D EX     13.1.1.0
           [170/2560000768] via 192.168.2.1, 00:36:11, GigabitEthernet0/0
C     192.168.2.0/24 is directly connected, GigabitEthernet0/0
      14.0.0.0/24 is subnetted, 1 subnets
D EX     14.1.1.0
           [170/2560000768] via 192.168.2.1, 00:36:11, GigabitEthernet0/0
      60.0.0.0/24 is subnetted, 1 subnets
```

Area in OSPF –

- ➢ Area is a logical group of devices within a single administration.
- ➢ Cisco recommended that in a single area should not have more than 50 router.
- ➢ Area-id is a 32 bit long ID.
- ➢ Area-id can be represent in decimal number or IPv4 format.

OSPF Path selection criteria – (OSPF route type)

1. AD value (First check AD value)
2. Route type => O > OIA >E1> E2 > N1> N2
3. Metric type = cost
4. Load balancing

   ➢ = Intra area route (Same area's route)
   ➢ OIA= Inter area route (this route is coming from different area)
   ➢ E1= External type -1 (**Redistribution- route will come in the form of LSA -5**)
   ➢ E2= External type-2 **(Redistribution- route will come in the form of LSA -5)**
   ➢ N1= NSSA type-1
   ➢ N2= NSSA type-2

Redistribution concept in OSPF – Route type – E1 & E2

Redistribution on Router 3

- **router eigrp 1**
- redistribute ospf 100 metric 1 1 1 1 1
- **router ospf 100**
- redistribute eigrp 1 subnets
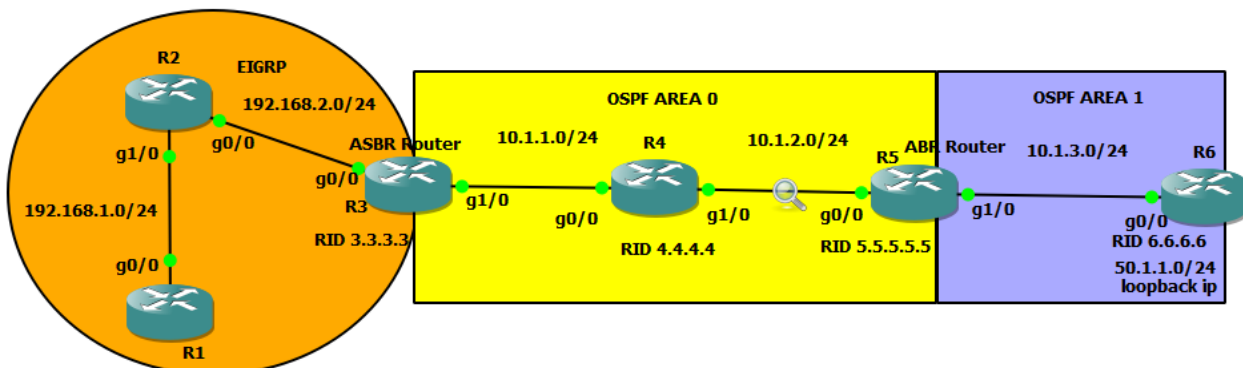
E2 Route -

```
R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/32 is subnetted, 1 subnets
O IA    50.1.1.1 [110/3] via 10.1.2.2, 00:59:04, GigabitEthernet1/0
     10.0.0.0/24 is subnetted, 3 subnets
O IA    10.1.3.0 [110/2] via 10.1.2.2, 01:00:58, GigabitEthernet1/0
C       10.1.2.0 is directly connected, GigabitEthernet1/0
C       10.1.1.0 is directly connected, GigabitEthernet0/0
O E2 192.168.1.0/24 [110/20] via 10.1.1.1, 00:08:11, GigabitEthernet0/0
O E2 192.168.2.0/24 [110/20] via 10.1.1.1, 00:08:11, GigabitEthernet0/0
R4#
```
Bydefault this route is comming E2 with sead metric 20

```
R5#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/32 is subnetted, 1 subnets
O       50.1.1.1 [110/2] via 10.1.3.2, 00:29:35, GigabitEthernet1/0
     10.0.0.0/24 is subnetted, 3 subnets
C       10.1.3.0 is directly connected, GigabitEthernet1/0
C       10.1.2.0 is directly connected, GigabitEthernet0/0
O       10.1.1.0 [110/2] via 10.1.2.1, 00:29:20, GigabitEthernet0/0
O E2 192.168.1.0/24 [110/20] via 10.1.2.1, 00:00:30, GigabitEthernet0/0
O E2 192.168.2.0/24 [110/20] via 10.1.2.1, 00:00:30, GigabitEthernet0/0
R5#
```

```
R6#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/24 is subnetted, 1 subnets
C       50.1.1.0 is directly connected, Loopback1
     10.0.0.0/24 is subnetted, 3 subnets
C       10.1.3.0 is directly connected, GigabitEthernet0/0
O IA    10.1.2.0 [110/2] via 10.1.3.1, 00:38:07, GigabitEthernet0/0
O IA    10.1.1.0 [110/3] via 10.1.3.1, 00:37:57, GigabitEthernet0/0
O E2 192.168.1.0/24 [110/20] via 10.1.3.1, 00:09:02, GigabitEthernet0/0
O E2 192.168.2.0/24 [110/20] via 10.1.3.1, 00:09:02, GigabitEthernet0/0
R6#
```

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set                    ASBR Router

     50.0.0.0/32 is subnetted, 1 subnets
O IA    50.1.1.1 [110/4] via 10.1.1.2, 00:38:54, GigabitEthernet1/0
     10.0.0.0/24 is subnetted, 3 subnets
O IA    10.1.3.0 [110/3] via 10.1.1.2, 00:38:54, GigabitEthernet1/0
O       10.1.2.0 [110/2] via 10.1.1.2, 01:04:07, GigabitEthernet1/0
C       10.1.1.0 is directly connected, GigabitEthernet1/0
D    192.168.1.0/24 [90/3072] via 192.168.2.1, 01:06:45, GigabitEthernet0/0
C    192.168.2.0/24 is directly connected, GigabitEthernet0/0
R3#
```

Note – If you not configure **metric-type 1** then it will share by default **E2** in which you can see above screenshot seed metric from 20.

➢ **R3(config)#router ospf 100**
➢ **R3(config-router)#redistribute eigrp 1 subnets metric-type 1**

See the below snapshot in which you can see router are calculating total path from ASBR router.

E1 Route - It will calculate total path from ASBR.

```
R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/32 is subnetted, 1 subnets
O IA    50.1.1.1 [110/3] via 10.1.2.2, 01:09:19, GigabitEthernet1/0
     10.0.0.0/24 is subnetted, 3 subnets
O IA    10.1.3.0 [110/2] via 10.1.2.2, 01:11:13, GigabitEthernet1/0
C       10.1.2.0 is directly connected, GigabitEthernet1/0
C       10.1.1.0 is directly connected, GigabitEthernet0/0
O E1 192.168.1.0/24 [110/21] via 10.1.1.1, 00:00:43, GigabitEthernet0/0
O E1 192.168.2.0/24 [110/21] via 10.1.1.1, 00:00:43, GigabitEthernet0/0
R4#
```

```
R5#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/32 is subnetted, 1 subnets
O       50.1.1.1 [110/2] via 10.1.3.2, 00:47:57, GigabitEthernet1/0
     10.0.0.0/24 is subnetted, 3 subnets
C       10.1.3.0 is directly connected, GigabitEthernet1/0
C       10.1.2.0 is directly connected, GigabitEthernet0/0
O       10.1.1.0 [110/2] via 10.1.2.1, 00:47:42, GigabitEthernet0/0
O E1 192.168.1.0/24 [110/22] via 10.1.2.1, 00:01:10, GigabitEthernet0/0
O E1 192.168.2.0/24 [110/22] via 10.1.2.1, 00:01:10, GigabitEthernet0/0
R5#
```

```
R6#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set  [E1 Route - It calculating total path]

     50.0.0.0/24 is subnetted, 1 subnets
C       50.1.1.0 is directly connected, Loopback1
     10.0.0.0/24 is subnetted, 3 subnets
C       10.1.3.0 is directly connected, GigabitEthernet0/0
O IA    10.1.2.0 [110/2] via 10.1.3.1, 00:02:35, GigabitEthernet0/0
O IA    10.1.1.0 [110/3] via 10.1.3.1, 00:02:35, GigabitEthernet0/0
O E1 192.168.1.0/24 [110/23] via 10.1.3.1, 00:01:34, GigabitEthernet0/0
O E1 192.168.2.0/24 [110/23] via 10.1.3.1, 00:01:34, GigabitEthernet0/0
R6#
```

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set          ASBR Router

     50.0.0.0/32 is subnetted, 1 subnets
O IA    50.1.1.1 [110/4] via 10.1.1.2, 00:48:39, GigabitEthernet1/0
     10.0.0.0/24 is subnetted, 3 subnets
O IA    10.1.3.0 [110/3] via 10.1.1.2, 00:48:39, GigabitEthernet1/0
O       10.1.2.0 [110/2] via 10.1.1.2, 01:13:52, GigabitEthernet1/0
C       10.1.1.0 is directly connected, GigabitEthernet1/0
D    192.168.1.0/24 [90/3072] via 192.168.2.1, 01:16:31, GigabitEthernet0/0
C    192.168.2.0/24 is directly connected, GigabitEthernet0/0
R3#
```