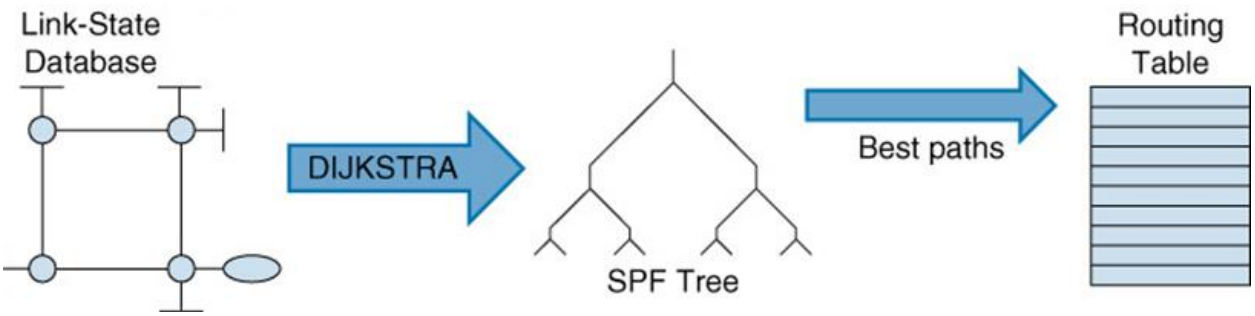
OSPF (Open Shortest Path First) protocol:

- OSPF is term which stands for Open Shortest Path First.
- Link State protocol sends update based in state of the link.
- When a link comes up and goes down it sends the updates.
- OSPF protocols is a dynamic open standard Routing Protocol.
- OSPF protocols is the Link-State dynamic routing protocol.
- OSPF protocols uses the Shortest Path First (SPF) algorithm.
- OSPF protocols uses IP protocol type 89 (not TCP or UDP).
- OSPF External and Internal Administrative Distance is 110.
- OSPF is a classless Routing protocol and OSPF metric is Cost.
- OSPF use multicast address 224.0.0.5 to send the hello packet.
- OSPF use multicast address 224.0.0.6 for all designated routers.
- OSPF default Hello time is 10 seconds and dead time is 40 seconds.
- OSPF protocols supports both the VLSM and route summarization.
- OSPF use wildcard mask, which is the reciprocal of subnet mask.
- OSPF protocols supports both MD5 and clear text authentication.
- OSPF protocols supports the summarization at ABRs router only.
- OSPF are requires more memory and CPU processing to run.
- OSPF work on area, Area 0 is the backbone of OSPF technology.
- OSPF have Neighbor table, Topology table and Routing table.
- OSPF packets are only sends to the neighbor of own Area.
- OSPF protocols supports both IPv4 and IPv6 routed protocols.
- OSPF load balancing with equal cost routes for same destination.
- OSPF dynamic routing protocols supports unlimited hop counts.
- OSPF protocols supports trigger updates for fast convergence.
- OSPF sends update with a sequence number of 0x80000001.
- The sequence number ends with 0x7FFFFFFF and start again.
- The sequence number will increment by one in every updates.
- OSPF protocol is more complex to setup and hard to troubleshoot.



OSPF Terminologies:

Area:

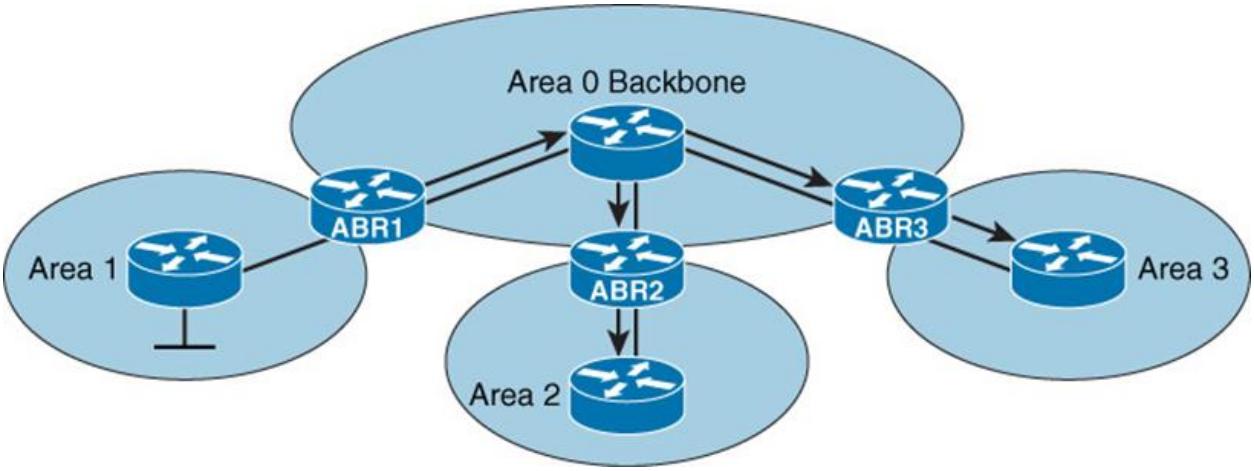
- In Open Shortest Path First (OSPF) dynamic protocol Area is like a Subnetting.
- It allows separating the large internetwork into smaller networks known as areas.
- OSPF implements two levels hierarchy with areas: backbone and area off backbone.

Backbone:

- In Open Shortest Path First Protocol Backbone is central point of this implementation.
- Routers running in this area required to maintain complete database of entire network.
- All areas In Open Shortest Path First (OSPF) Protocol is needed to connect with this area.

Area off Backbone:

- In Open Shortest Path First (OSPF), Area off backbone is the extension of the backbone.
- Routes running in this area required to maintain specific database instead of complete.
- In Open Shortest Path First (OSPF), protocol It will speed-up the convergence time.



Router ID:

- Every Router in Open Shortest Path First network, needs the unique OSPF Router ID.
- The OSPF Router ID is used to provide & give a unique identity to the OSPF Router.
- There are different ways in Open Shortest Path First protocol which it can be identified.
- The highest IP address of the active Physical interface of the router becomes the Router ID.
- If a logical interface is configured , then highest IP address of logical interface becomes RID.
- If specify the Router-ID manually then it takes priority over all and become the Router-ID.

Link:

- Link is an interface running Open Shortest Path First (OSPF) routing protocol.
- When we add an interface in OSPF process, it will be considered as a link.

State:

- In Open Shortest Path First (OSPF), State is the information associated with an interface.
- A link or Interface contains several information such as IP address, up/down status, subnet.
- A link also have subnet mask, type of interface, type of network , bandwidth and delay etc.
- Open Shortest Path First (OSPF) dynamic protocols consider this information as the state.

LSA:

- Link State Advertisement (LSA) is data packet, it contains Link-State & routing information.
- Open Shortest Path First dynamic protocol uses it to share & learn network information.

LSDB:

- Every Open Shortest Path First (OSPF) router maintains a Link State Database (LSDB).
- Link State Database (LSDB) is collection of all Link State Advertisement received by router.
- Every LSA has unique sequence number, OSPF stores LSA in LADB with sequence number.

Internal Router:

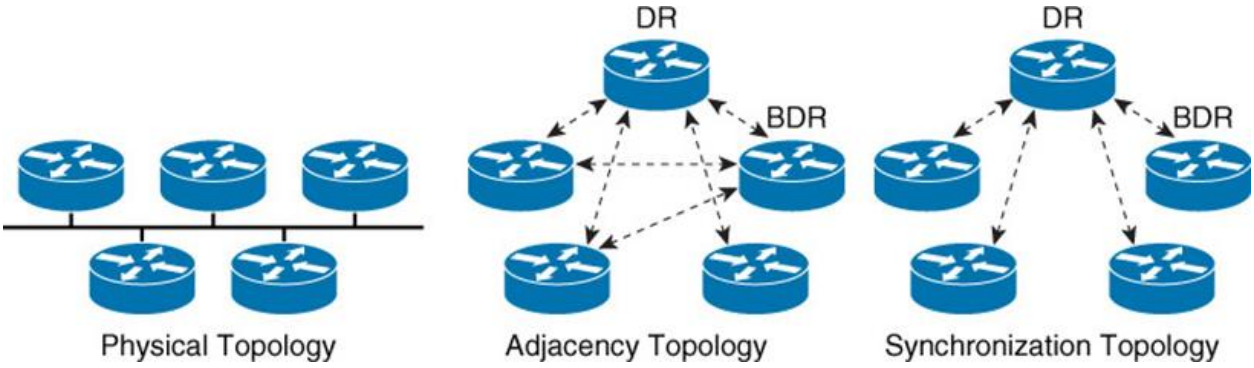
- It is a router that has only OSPF neighbor relationships with routers in the same area.
- In Open Shortest Path First (OSPF) Internal Router has all of its interfaces in single area.

Backbone Router:

- The area 0 is known as backbone area & routers in area 0 are known as backbone routers.

Designated Router (DR) and Backup Designated Router (BDR):

- Designated Router is router interface elected among all routers on network segment.
- And Backup designated (BDR) is a backup for the Designated Router (DR) in OSPF.
- DRs are used for reducing network traffic by providing a source for routing updates.
- The Designated Router (DR) maintains a complete topology table of the network.
- The Designated Router (DR) sends the updates to the other routers via multicast.
- All routers in an area will form slave/master relationship with Designated Router (DR).



Router Priority:

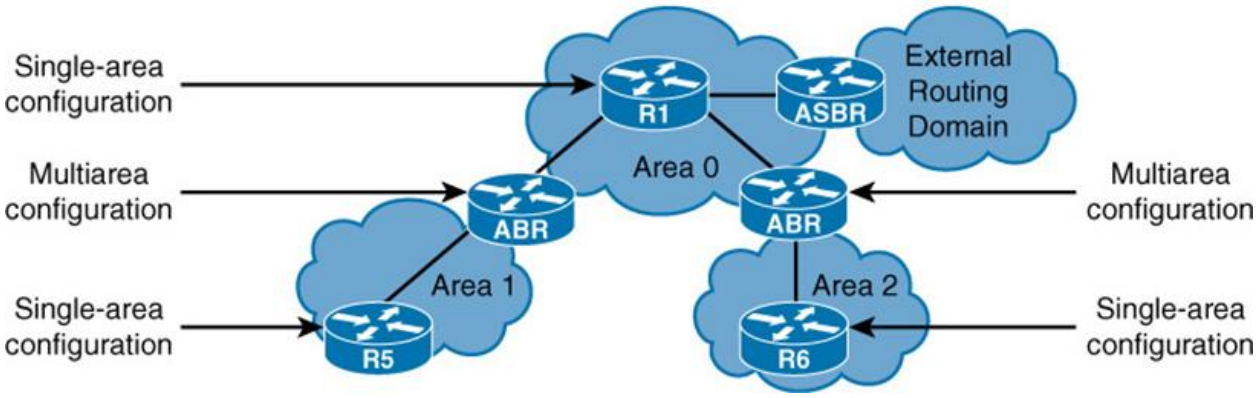
- It is used to determine who will become Designated or Backup Designated Router.
- In Open Shortest Path First (OSPF) Dynamic Protocols The default priority is one (1).
- In Open Shortest Path First (OSPF) Router Priority, value range is between 0 to 255.
- The range of priority values that allow a router to be a candidate are 1 to through 255.
- A priority setting of (0) zero means that the router does not participate in the election.
- Changing the priority setting to zero (0) means router can never become the DR or BDR.

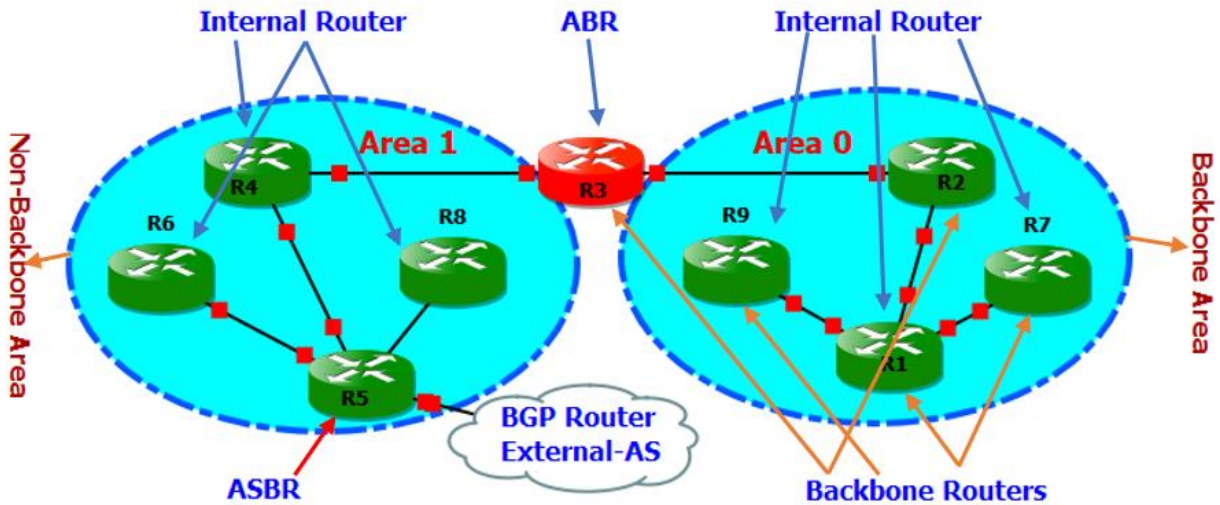
Area Border Router (ABR):

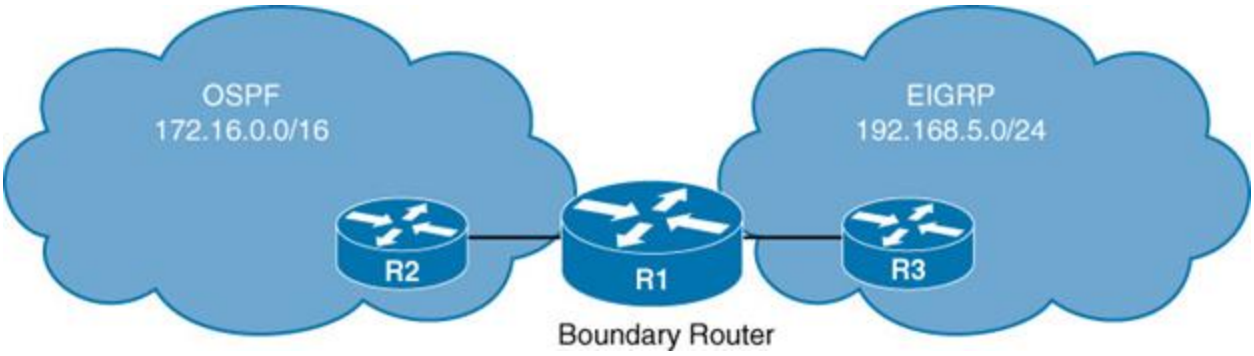
- ABR is router that connects one or more OSPF areas to the main backbone network.
- Area Border Router (ABR) is considered a member of all areas it is connected to.

Autonomous System Boundary Router (ASBR):

- o If it is one interface is in OSPF Domain & other interface in any other routing protocol.
- o It requires redistribution in order to make router as Autonomous System Boundary Router.
- o To check the Autonomous System Boundary Router run the command: show ip protocols.







OSPF Tables:

Each OSPF router stores routing and topology information in three tables: Neighbor table, Topology table and Routing Table.

OSPF Routing Table:

OSPF stores single best route for each destination in this table. Router uses this table to forward the packet. There is a separate routing table for each routed protocol.

```
R1#show ip route ospf
Codes: L - local, 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, + - replicated route

Gateway of last resort is not set

O       192.168.3.0/24 [110/2] via 192.168.2.3, 00:45:57, GigabitEthernet1/0
                       [110/2] via 192.168.1.2, 00:45:19, FastEthernet0/0
```

O	This route was learned through OSPF.
192.168.3.0/24	Destination learn network and 24 is subnet mask.
110	110, is the Administrative Distance of OSPF.
2	This is the metric, Total cost to get to the destination.
192.168.2.3	Next Hop IP Address where to send the traffic.
00:45:57	Time since the route was learnt.
GigabitE1/0	The outbound interface going towards the destination.

OSPF Neighbor Table:

Contain information about the neighbors; Neighbor table includes all neighbors that is directly connected to router using OSPF. Contains all discovered OSPF neighbors with whom routing information will be interchanged.

```
R1#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.3.3       1   FULL/BDR        00:00:38    192.168.2.3     GigabitEthernet1/0
192.168.3.2       1   FULL/BDR        00:00:31    192.168.1.2     FastEthernet0/0
```

Neighbor ID	The Neighbor ID is the router ID of the neighbor router.
Pri	The Pri field indicates the priority of the neighbor router.
State	The State field indicates the functional state of the neighbor router.
Dead Time	The amount of time remaining that the router waits to receive an OSPF hello packet from the neighbor before declaring the neighbor down.
Address	The IP address of the interface to which this neighbor is directly connected.
Interface	The interface on which the OSPF neighbor has formed adjacency.

OSPF Topology Table:

Topology Table contains the entire road map of the network with all available OSPF routers and calculated best and alternative paths. The OSPF database contains all LSAs that describe the network topology.

```
R1#show ip ospf database

            OSPF Router with ID (192.168.2.1) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
192.168.2.1     192.168.2.1     24          0x80000002 0x008E08 2
192.168.3.2     192.168.3.2     20          0x80000003 0x00A8E4 2
192.168.3.3     192.168.3.3     20          0x80000003 0x000581 2

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
192.168.1.2     192.168.3.2     25          0x80000001 0x00B3D0
192.168.2.3     192.168.3.3     25          0x80000001 0x00A2DD
192.168.3.3     192.168.3.3     20          0x80000001 0x00B2CA
```

OSPF Router With ID (192.168.2.1)	This router OSPF router ID that is 192.168.2.1 highest interface IP.
Process ID 1	Process ID of the OSPF configured by Network Administrator.
Link ID	The IDs of the routers in the area. There are three routers in Area 0.
ADV Router	Router ID of the routers who is advertising the LSA.
Age	Maximum age counter in seconds. The maximum is 3600 seconds or 1 hour
Seq#	It starts from 0x80000001 and will increase by 1 for each update.
Checksum	This is check sum of each LSA.
Link	Number of interfaces detected per router. Every router has 2 links in Area.

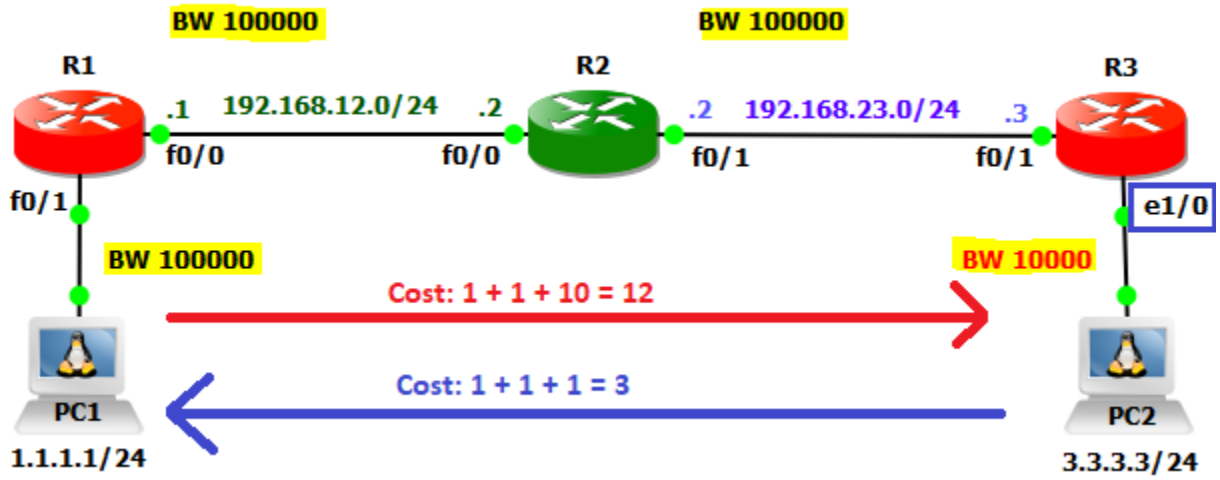
OSPF Metric:

OSPF uses a metric called **cost,** which is based on the bandwidth of an interface.

Cost = Reference Bandwidth / Interface Bandwidth

the reference bandwidth is a default value on Cisco routers which is a 100Mbit (10^8) interface. Divide the reference bandwidth by the bandwidth of the interface and get the cost. The lower the cost the better the path is. In route, that has lowest cumulative cost value between source and destination will be selected for routing table. If two path is equal cost, OSPF will use both paths and will load balance among them 50/50.

Default Cost of Interfaces			
Interface Type	**Bandwidth**	**Metric Calculation**	**Cost**
Ethernet Link	10Mbps	100000000/10000000 = 10	10
FastEthernet Link	100Mbps	100000000/100000000 = 1	1
Serial Link	1544Kbps	100000000/1544000 = 64.76	64
Gigabyte Link	1 Gbps		1
10 Gigabit Link	10 Gbps		1
40 Gigabit Link	40 Gbps		1
100 Gigabit Link	100 Gbps		1



From PC1 to PC2 total OSPF cost is 12 because in the way one Ethernet link which is connected between R3 to PC2. Cost is counting from outgoing interfaces to reach destination. Therefore, from PC1 to PC2 OSPF total cost is cost is 12 of R1, R2 and R3 outgoing interfaces.

```
R1#show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
 Gateway of last resort is not set

      3.0.0.0/24 is subnetted, 1 subnets
O        3.3.3.0 [110/12] via 192.168.12.2, 00:12:49, FastEthernet0/0
O     192.168.23.0/24 [110/2] via 192.168.12.2, 00:12:49, FastEthernet0/0
```

```
R1#show ip ospf int f0/0 | sec Cost
  Process ID 1, Router ID 192.168.12.1, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           1         no          no            Base
R2#show ip ospf interface f0/1 | sec Cost
  Process ID 1, Router ID 192.168.23.2, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           1         no          no            Base
R3#show ip ospf interface e1/0 | sec Cost
  Process ID 1, Router ID 192.168.23.3, Network Type BROADCAST, Cost: 10
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           10        no          no            Base
```

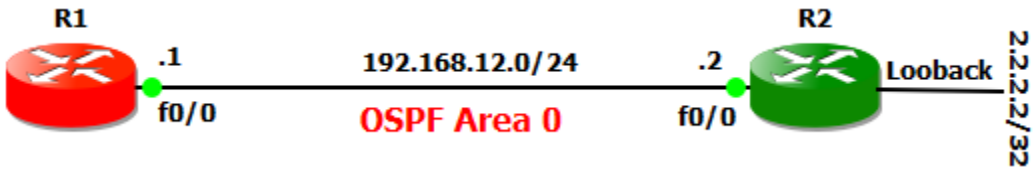
From PC2 to PC1 total OSPF cost is 3 as all link are FasEthernet. Cost is counting from outgoing interfaces to reach destination. Therefore, from PC2 to PC1 OSPF total cost is cost is 3 of R3, R2 and R1 outgoing interfaces.

```
R3#show ip route ospf
Codes: L - local, 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, + - replicated route

Gateway of last resort is not set

      1.0.0.0/24 is subnetted, 1 subnets
O        1.1.1.0 [110/3] via 192.168.23.2, 00:25:43, FastEthernet0/1
O     192.168.12.0/24 [110/2] via 192.168.23.2, 00:25:43, FastEthernet0/1
```

```
R3#show ip ospf interface f0/1 | sec Cost
  Process ID 1, Router ID 192.168.23.3, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           1         no          no            Base
R2#show ip ospf interface f0/0 | sec Cost
  Process ID 1, Router ID 192.168.23.2, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           1         no          no            Base
R1#show ip ospf int f0/1 | sec Cost
  Process ID 1, Router ID 192.168.12.1, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           1         no          no            Base
```

OSPF Basic Configuration:

OSPF Protocols use wildcard mask, which is 32 bits long. It is inverted of subnet masks, with the zero bits indicating that the corresponding bit position must match the same bit position in the IP address. The one bits indicate that the corresponding bit position does not have to match the bit position in the IP address.



Neighbor Configuration:

To make two OSPF routers neighbors, simple enable OSPF on the connected interfaces. There are two ways, by using the network command or by enabling the OSPF process on the interface directly. OSPF Neighbor Requirements are mention below:

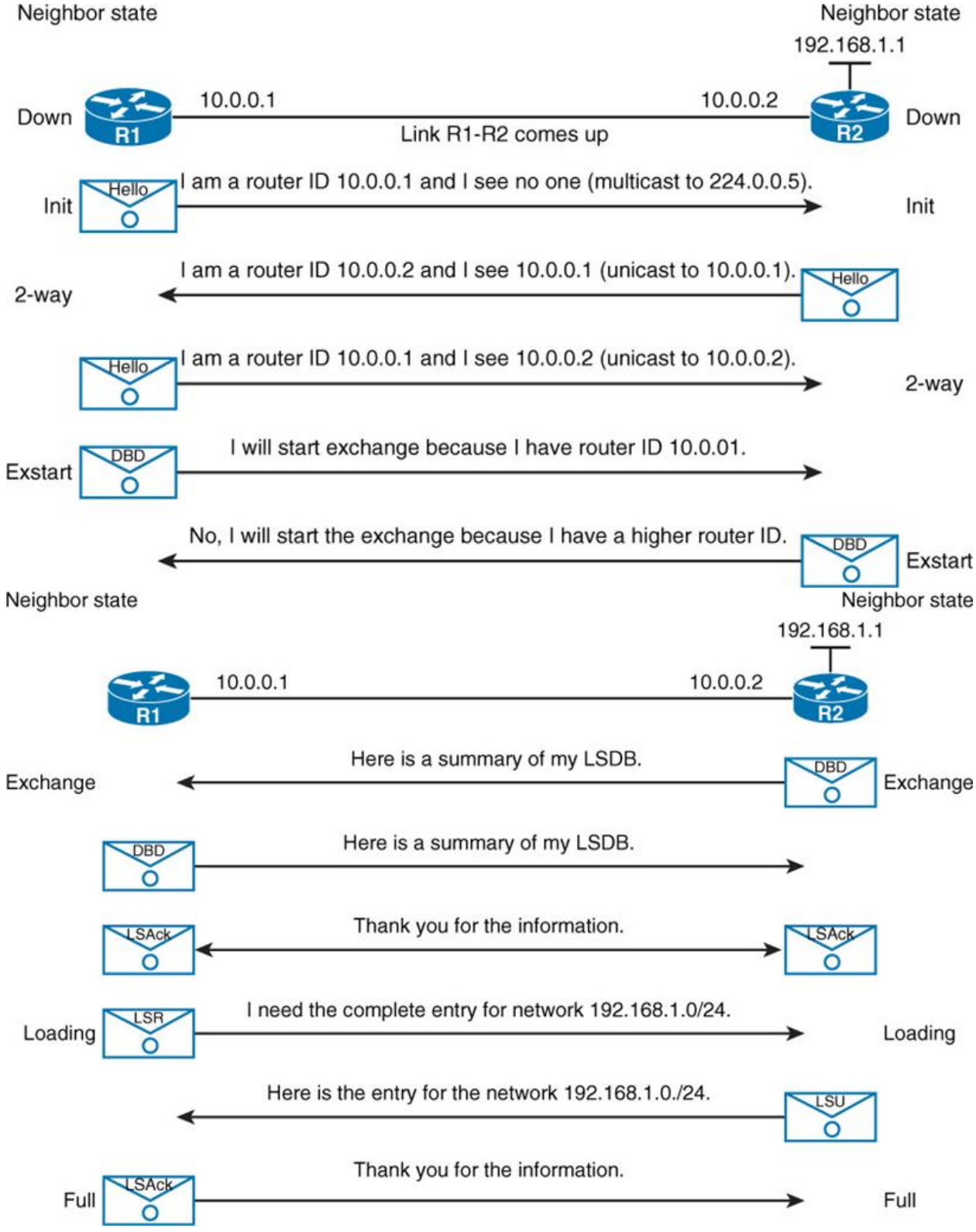
- The devices must be on the same subnet.
- Must not be passive on connected interface.
- The devices must be in the same area.
- The devices hello and dead intervals must match.
- Router IDs must be unique.
- The devices must have the same authentication configuration.

Commands	**Description**
R1(config)#router ospf 1 R1(config-router)#network 192.168.12.0 0.0.0.255 area 0	Enter OSPF mode choose Process ID 1 Enable OSPF by using network command, wildcard and area 0
R2(config)#interface FastEthernet 0/0 R2(config-if)#ip ospf 1 area 0 R2(config-if)#exit R2(config)#interface loopback 2 R2(config-if)#ip ospf 1 area 0	Enter interface mode of R2 Enable OSPF on this interface area 0 Exit from interface mode Enter loopback interface mode of R2 Enable OPSP on this interface area 0
R1# show ip ospf neighbor	Verify ospf neighbor relationship
R1# show ip ospf interface f0/0	Verify OSPF neighbor relationship
R1# show ip ospf	Verify OSPF process
R1# show ip ospf database	Verify OSPF database
R1# show ip protocols	Verify running protocols on Router
R1# debug ip ospf packet	On debug for OSPF packets
R1# debug ip ospf hello	On Debug for OSPF hello packet

OSPF Neighbor Adjacencies :

Before establishing a neighbor relationship, OSPF routers go through several state changes.

Down State, Init State, 2-Way State, Exstart State, Exchange State, Loading State and Full State.



State	Description
Down State	No hello have been received. All OSPF routers begin in this state.
Init State	The interface has detected a Hello packet coming from a neighbor, but bi-directional communication has not yet been established.
2-Way State	When hello is exchanged between two OSPF routers that is called 2 way. Designated Router (DR) and BDR is elected in this stage.
Exstart State	Beginning of the LSDB exchange between both routers. Routers will start to exchange link state information. Master & slave is elected in this stage.
Exchange State	Routers will describe their entire link-state database by sending database description packets. At this state, packets could be flooded to other interfaces on the router.
Loading State	In this state actual database is exchanged means that LS-Request, LS-Update, LS Acknowledgement are also exchanged.
Full State	At this state, the adjacency is complete. The neighboring routers are fully adjacent. Adjacent routers will have a similar link-state database.

R1# debug ip ospf adj

R1# clear ip ospf process

Reset ALL OSPF processes? [no]: yes

```
*Dec 17 15:33:19.287: OSPF: Remember old DR 192.168.12.1 (id)
*Dec 17 15:33:19.295: OSPF: Interface FastEthernet0/0 going Up
*Dec 17 15:33:19.367: OSPF: 2 Way Communication to 2.2.2.2 on FastEthernet0/0, state 2WAY
*Dec 17 15:33:19.371: OSPF: Backup seen Event before WAIT timer on FastEthernet0/0
*Dec 17 15:33:19.371: OSPF: DR/BDR election on FastEthernet0/0
*Dec 17 15:33:19.371: OSPF: Elect BDR 192.168.12.1
*Dec 17 15:33:19.371: OSPF: Elect DR 2.2.2.2
*Dec 17 15:33:19.371: OSPF: Elect BDR 192.168.12.1
*Dec 17 15:33:19.375: OSPF: Elect DR 2.2.2.2
*Dec 17 15:33:19.375:       DR: 2.2.2.2 (Id)   BDR: 192.168.12.1 (Id)
*Dec 17 15:33:19.375: OSPF: FastEthernet0/
R1#0 Nbr 2.2.2.2: Prepare dbase exchange
*Dec 17 15:33:19.379: OSPF: Send DBD to 2.2.2.2 on FastEthernet0/0 seq 0x1B41 opt 0x52 flag 0x7 len 32
*Dec 17 15:33:19.475: OSPF: Rcv DBD from 2.2.2.2 on FastEthernet0/0 seq 0x3 opt 0x52 flag 0x7 len 32  mtu 1500 state EXSTART
*Dec 17 15:33:19.475: OSPF: First DBD and we are not SLAVE
*Dec 17 15:33:19.475: OSPF: Rcv DBD from 2.2.2.2 on FastEthernet0/0 seq 0x1B41 opt 0x52 flag 0x2 len 72  mtu 1500 state EXSTART
*Dec 17 15:33:19.475: OSPF: NBR Negotiation Done. We are the MASTER
*Dec 17 15:33:19.479: OSPF: FastEthernet0/0 Nbr 2.2.2.2: Summary list built, size 0
*Dec 17 15:33:19.479: OSPF: Send DBD to 2.2.2.2 on FastEthernet0/0 seq 0x1B42 opt 0x52 flag 0x1 len 32
*Dec 17 15:33:19.567: OSPF: Rcv DBD from 2.2.2.2 on FastEthernet0/0 seq 0x1B42 opt 0x52 flag 0x0 len 32  mtu 1500 state EXCHANGE
*Dec 17 15:33:19.571: OSPF: Exchange Done with 2.2.2.2 on FastEthernet0/0
*Dec 17 15:33:19.571: OSPF: Send LS REQ to 2.2.2.2 length 24 LSA count 2
*Dec
R1# 17 15:33:19.671: OSPF: Rcv LS UPD from 2.2.2.2 on FastEthernet0/0 length 108 LSA count 2
*Dec 17 15:33:19.671: OSPF: Synchronized with 2.2.2.2 on FastEthernet0/0, state FULL
*Dec 17 15:33:19.675: %OSPF-5-ADJCHG: Process 1, Nbr 2.2.2.2 on FastEthernet0/0 from LOADING to FULL, Loading Done
```

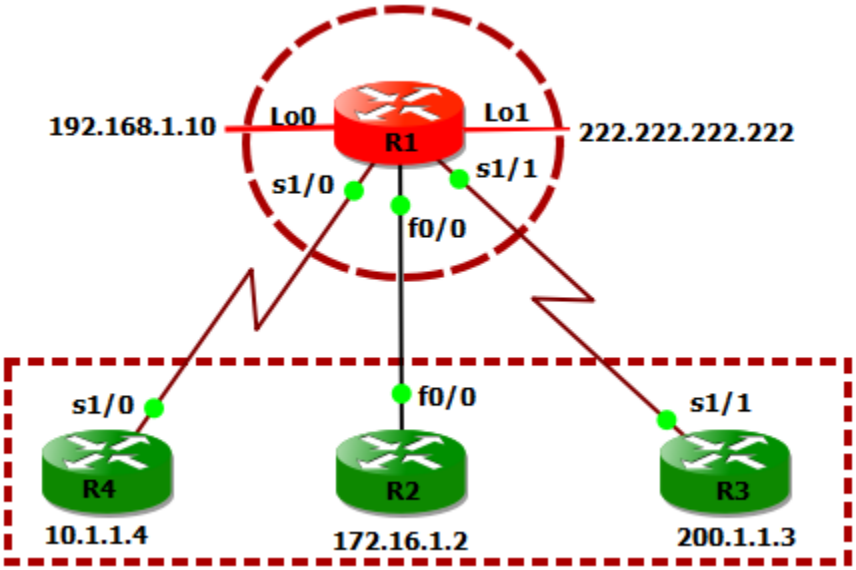
OSPF RID (Router ID):

- RID is a unique identifier of Router in Open Shortest Path First (OSPF) network.
- RID must be unique within the autonomous system in Open Shortest Path First.
- Through Router ID (RID) Routers identify each other in AS (Autonomous System).
- Router ID is 32-bit long number same as Internet Protocol version 4 (IPV4) address.
- IPv4 address is also 32 bit in length you can use IPv4 address as a RID (Router ID).
- Manual configuration => Loopback interface => Active interface while selecting RID.
- If assigned Router ID (RID) manually, OSPF will not look in next two options to use.
- When multiple IP addresses are available, OSPF always pick highest IP address for RID.
- For network, stability always set RID by **router-id** command or using loopback interfaces.

Routers Selection RID:

An Open Shortest Path First (OSPF) Router looks in three places for RID (Router ID):

- In Open Shortest Path First (OSPF) Router look Manual configuration of router ID.
- In Open Shortest Path First Router look Highest IP address on loopback interface.
- In Open Shortest Path First Router look Highest IP address on physical interface.



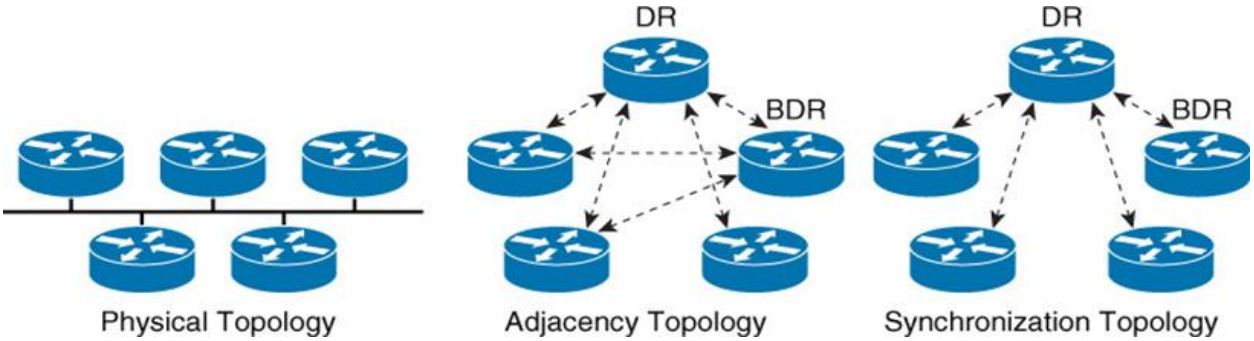
DR (Designated Router) & BDR (Backup Designated Router):

- Open Shortest Path First (OSPF) uses DR and BDR on each multi-access network.
- DR & BDR election occurs in multi-access Broadcast & Non-Broadcast network types.
- DR is the Router in charge to maintain the Open Shortest Path First topology table.
- DR is the Router in charge to distribute updates to other routers within same segment.
- When a router is not the Designated Router (DR) or BDR it is called a **DROTHER**.
- All other routers will form adjacencies only with the elected DR and BDR routers.
- DR reduce the network traffic between neighbors by providing single source of updates.
- It is possible to change the priority if you like by using the **ip ospf priority,** command.
- Default Open Shortest Path First (OSPF) priority is set to one (1) which can be changed.
- A priority of 0 means the router can never be elected as Designated Router DR or BDR.
- In Open Shortest Path First (OSPF) use clear ip ospf process before change takes effect.

DR and BDR Election:

The default Designated Router (DR) election criteria are as follows:

- The Router configured with the highest priority wins the election.
- The default priority is 1 and the possible values range between 0 – 255.
- If the priority is set to 0, the router will not participate in the DR/BDR election.
- If the routers configured priority, tie then it use highest Router ID (RID) as tiebreaker.
- Router with the second highest priority value becomes the Backup Designated Router.
- If a router with the higher priority comes online after the election has taken place;
- It will not become Designated Router (DR) or BDR until DR and BDR router fail.
- If the DR fails, BDR will take over, another election will take place to elect a new BDR.
- In Designated Router and Backup Designated Router, Preemption is not supported.
- First router to come up will be DR and the second will be Backup Designated Router.
- Each other router will exchange routing information only with the DR and the BDR.
- DR will then distribute topology information to every other router inside the same area.
- To send routing information to a DR or BDR, the multicast address of **224.0.0.6** is used.
- A Designated Router DR sends routing updates to the multicast address of **224.0.0.5**.
- If the DR fails, the BDR will take its role of redistributing routing information to other.



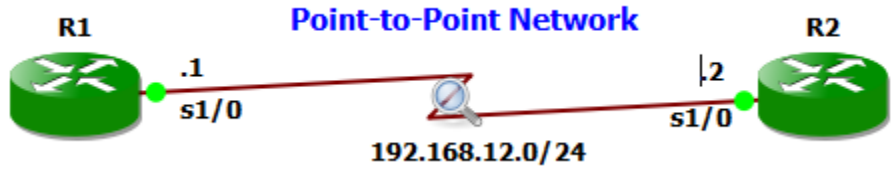
OSPF Network Types:

The network type defines how the neighbor relationship will be formed. Behavior of OSPF when operating in these different network types – whether hellos are multicast or unicast, if DR/BDR are elected, and so on. There are five different OSPF network types on a Cisco router point-to-point, broadcast, non-broadcast, point-to-multipoint non-broadcast and point-to-multipoint.

Network Type	Hello Timer	Dead Timer	Adjacency
Broadcast	10	40	Automatic + DR/BDR
Non-Broadcast	30	120	Manual + DR/BDR
Point-to-Multipoint	30	120	Automatic No DR/BDR
Point-to-Multipoint non-Broadcast	30	120	Manual No DR/BDR
Point-to-Point	10	40	Automatic No DR/BDR

Point-to-Point Network:

This is the simplest form of the network types. Point-to-Point network types are intended to be used between two directly connected routers. An example of a point-to-point link is a serial link connecting just two routers using HDLC or PPP. With point-to-point links, OSPF does not select a DR or BDR. In addition, hello packets are sent to the multicast address 224.0.0.5. The Point-to-Point network type has a 10-second hello and 40-second dead timer. Discovers neighbors dynamically.



R1 Configuration	R2 Configuration
R1(config)#interface s1/0 R1(config-if)#ip address 192.168.12.1 255.255.255.0 R1(config-if)#no shutdown	R2(config)#interface s1/0 R2(config-if)#ip address 192.168.12.2 255.255.255.0 R2(config-if)#no shutdown
R1(config)#router ospf 1 R1(config-router)#network 192.168.12.0 0.0.0.255 area 0	R2(config)#router ospf 1 R2(config-router)#network 192.168.12.0 0.0.0.255 area 0
R1#show ip ospf interface s1/0	R2#show ip ospf interface s1/0
R1#show ip ospf neighbor	R2#show ip ospf neighbor

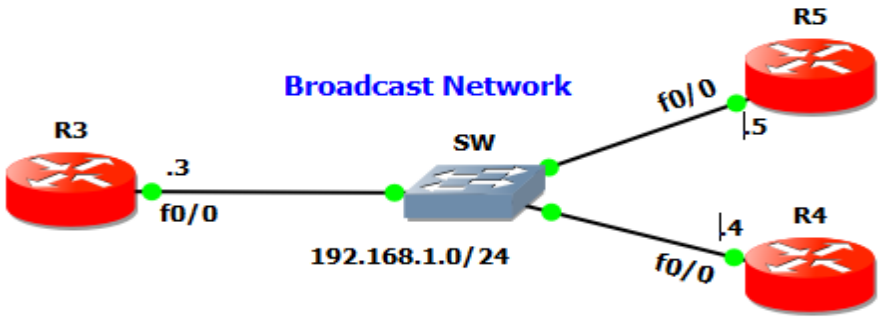
```
R1#show ip ospf interface s1/0
Serial1/0 is up, line protocol is up
  Internet Address 192.168.12.1/24, Area 0
  Process ID 1, Router ID 192.168.12.1, Network Type POINT_TO_POINT, Cost: 64
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           64        no          no            Base
  Transmit Delay is 1 sec, State POINT_TO_POINT
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:01
```

Capture packets of one of the serial interfaces, which will enable to look into the details of the hello packet sent by the routers. The packet is sent to the multicast address of 224.0.0.5. In addition, notice that the 'Designated Router' and 'Backup Designated Router' fields are set to 0.0.0.0 meaning there is no DR or BDR. 10-second hello and 40-second dead timer.

```
> Internet Protocol Version 4, Src: 192.168.12.1, Dst: 224.0.0.5
v Open Shortest Path First
  v OSPF Header
      Version: 2
      Message Type: Hello Packet (1)
      Packet Length: 44
      Source OSPF Router: 192.168.12.1
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0x1ff5 [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  v OSPF Hello Packet
      Network Mask: 255.255.255.0
      Hello Interval [sec]: 10
    > Options: 0x12, (L) LLS Data block, (E) External Routing
      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
```

Broadcast Networks:

A network type that connects two or more OSPF routers over a broadcast media such as Ethernet. The Broadcast network type requires that a link support Layer 2 Broadcast capabilities. On broadcast networks, neighbors are dynamically discovered by the hellos that sent to the multicast address of 224.0.0.5. In addition, DR and BDR are elected on these networks. The Broadcast network type has a 10 second hello and 40 second dead timer.



Routers Configurations	
R3(config)#interface FastEthernet0/0 R3(config-if)#ip address 192.168.1.3 255.255.255.0 R3(config-if)#no shutdown	R4(config)#interface FastEthernet0/0 R4(config-if)#ip add 192.168.1.4 255.255.255.0 R4(config-if)#no shutdown
R5(config)#interface FastEthernet0/0 R5(config-if)#ip add 192.168.1.5 255.255.255.0 R5(config-if)#no shutdown	R3(config)#router ospf 1 R3(config-router)#network 192.168.1.0 0.0.0.255 area 0
R4(config)#router ospf 1 R4(config-router)# network 192.168.1.0 0.0.0.255 area 0	R5(config)#router ospf 1 R5(config-router)# network 192.168.1.0 0.0.0.255 area 0
R3#show ip ospf interface f0/0	R4#show ip ospf interface f0/0
R5#show ip ospf interface f0/0	R3# show ip ospf neighbor

```
R3#show ip ospf interface f0/0
FastEthernet0/0 is up, line protocol is up
  Internet Address 192.168.1.3/24, Area 0
  Process ID 1, Router ID 192.168.1.3, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown      Topology Name
        0           1         no          no            Base
  Transmit Delay is 1 sec, State DROTHER, Priority 1
  Designated Router (ID) 192.168.1.5, Interface address 192.168.1.5
  Backup Designated router (ID) 192.168.1.4, Interface address 192.168.1.4
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

A packet capture of the hello packet shown below. Notice that a DR and a BDR have been elected on this network. The packet is sent to the multicast address of 224.0.0.5.

```
> Internet Protocol Version 4, Src: 192.168.1.5, Dst: 224.0.0.5
v Open Shortest Path First
  v OSPF Header
      Version: 2
      Message Type: Hello Packet (1)
      Packet Length: 52
      Source OSPF Router: 192.168.1.5
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0x2436 [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  v OSPF Hello Packet
      Network Mask: 255.255.255.0
      Hello Interval [sec]: 10
    > Options: 0x12, (L) LLS Data block, (E) External Routing
      Router Priority: 1
      Router Dead Interval [sec]: 40
      Designated Router: 192.168.1.5
      Backup Designated Router: 192.168.1.4
      Active Neighbor: 192.168.1.3
      Active Neighbor: 192.168.1.4
```