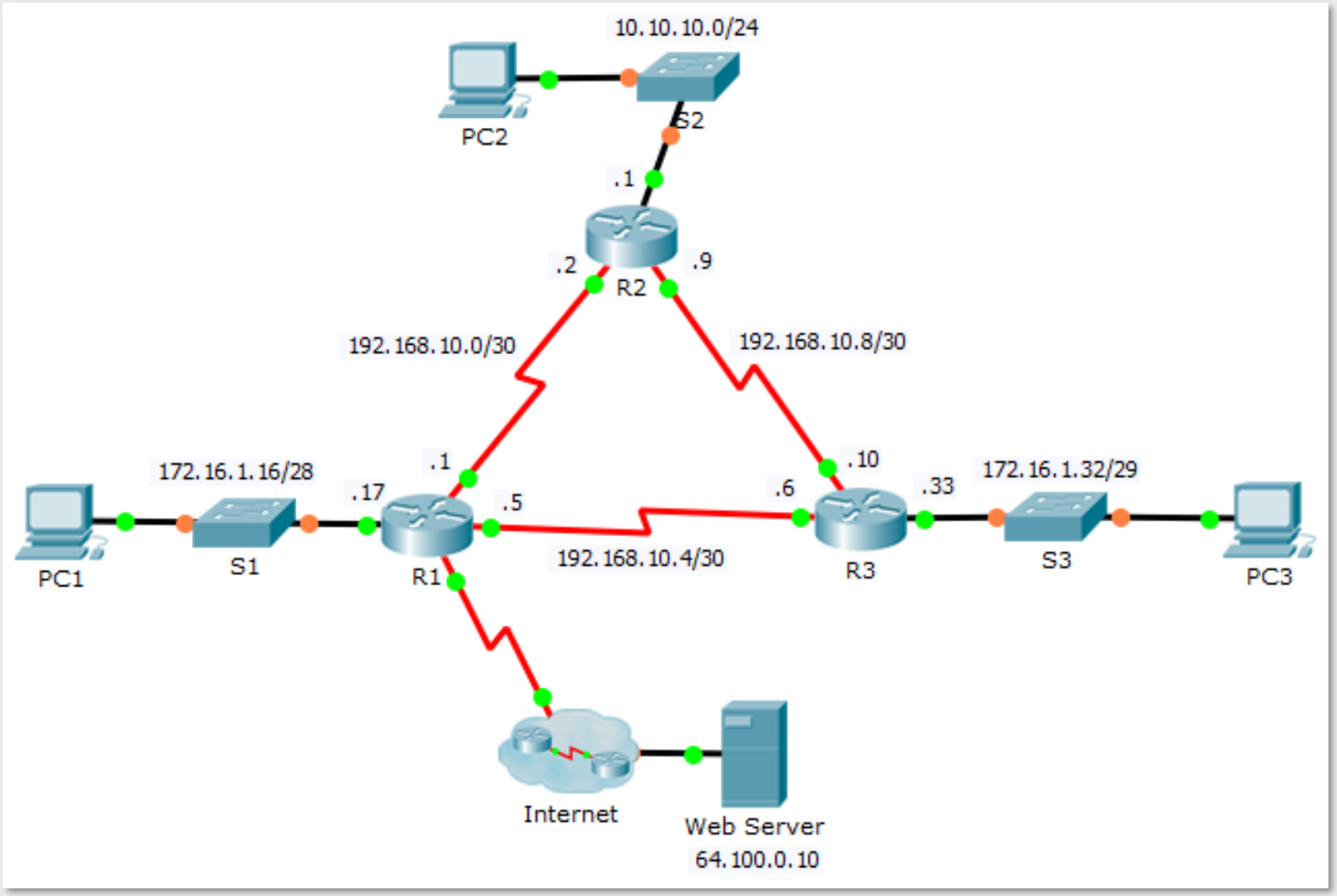
Lab 7

OSPF configuration

IOS OSPF configuration – single area

- Reference topology

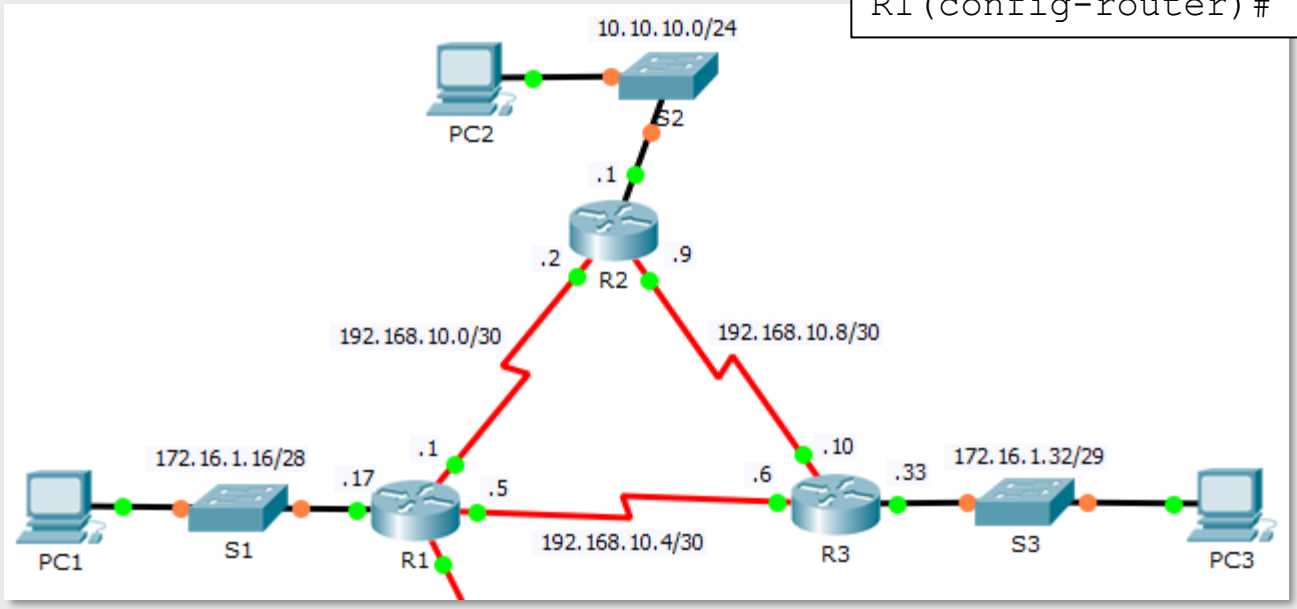


IOS OSPF configuration

```
Router(config)#router ospf process-id
```

- Enables OSPF routing
  - Default bandwidth: 1544 Kbps on all serial links

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



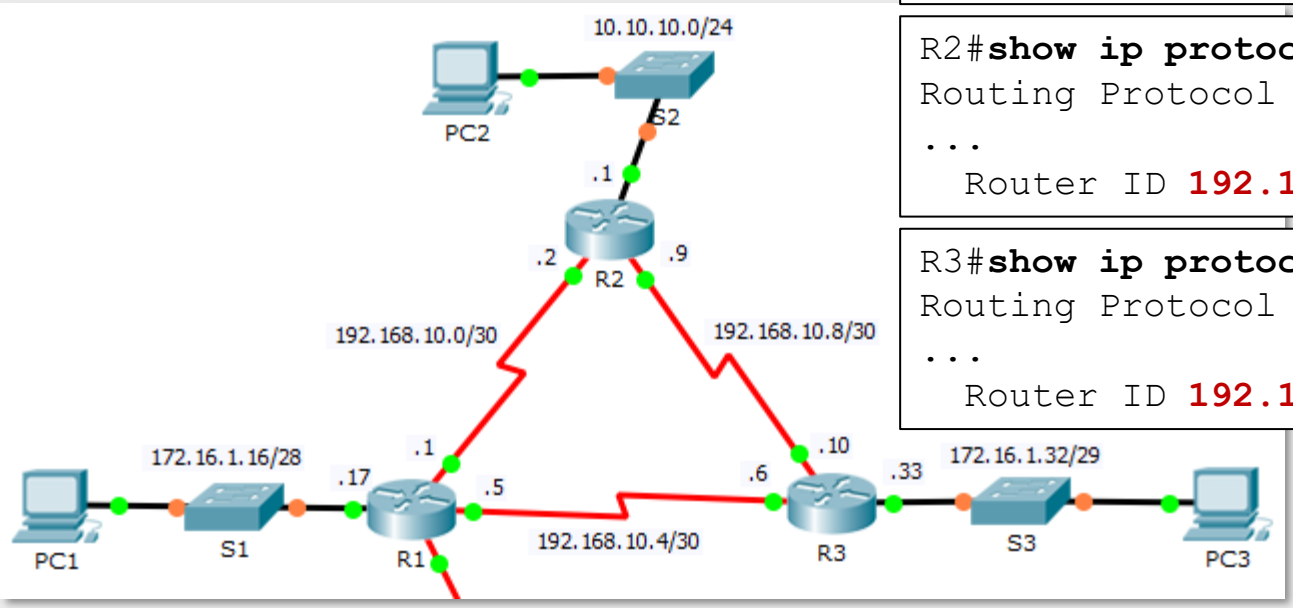
IOS OSPF configuration

- Determining the Router ID
  1. IP address configured with the **router-id** command
  2. The highest IP address of any of its loopback interfaces
  3. The highest active IP address of any of its physical interfaces

```
R1#show ip protocols
Routing Protocol is "ospf 1"
...
  Router ID 209.165.200.225
```

```
R2#show ip protocols
Routing Protocol is "ospf 1"
...
  Router ID 192.168.10.9
```

```
R3#show ip protocols
Routing Protocol is "ospf 1"
...
  Router ID 192.168.10.10
```



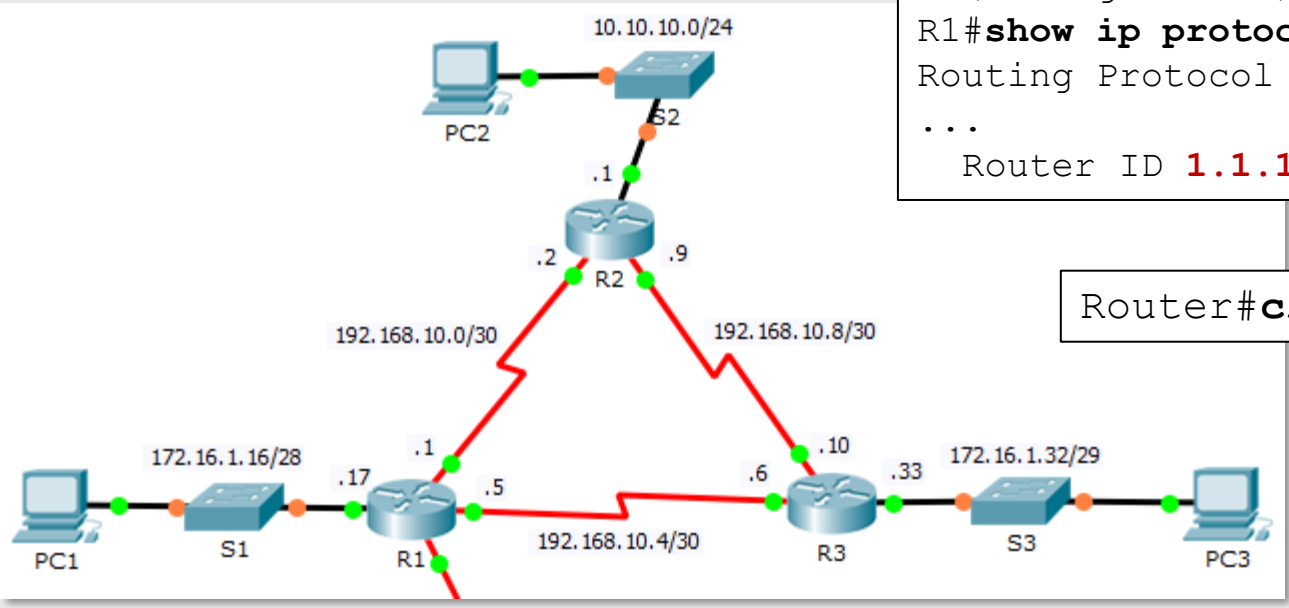
IOS OSPF configuration

```
Router(config-router)#router-id ip-address
```

- Determining the Router ID
  1. IP address configured with the **router-id** command
  2. The highest IP address of any of its loopback interfaces
  3. The highest active IP address of any of its physical interfaces

```
R1(config)#router ospf 1
R1(config-router)#router-id 1.1.1.1
R1(config-router)#^Z
R1#show ip protocols
Routing Protocol is "ospf 1"
...
  Router ID 1.1.1.1
```

```
Router#clear ip ospf process
```

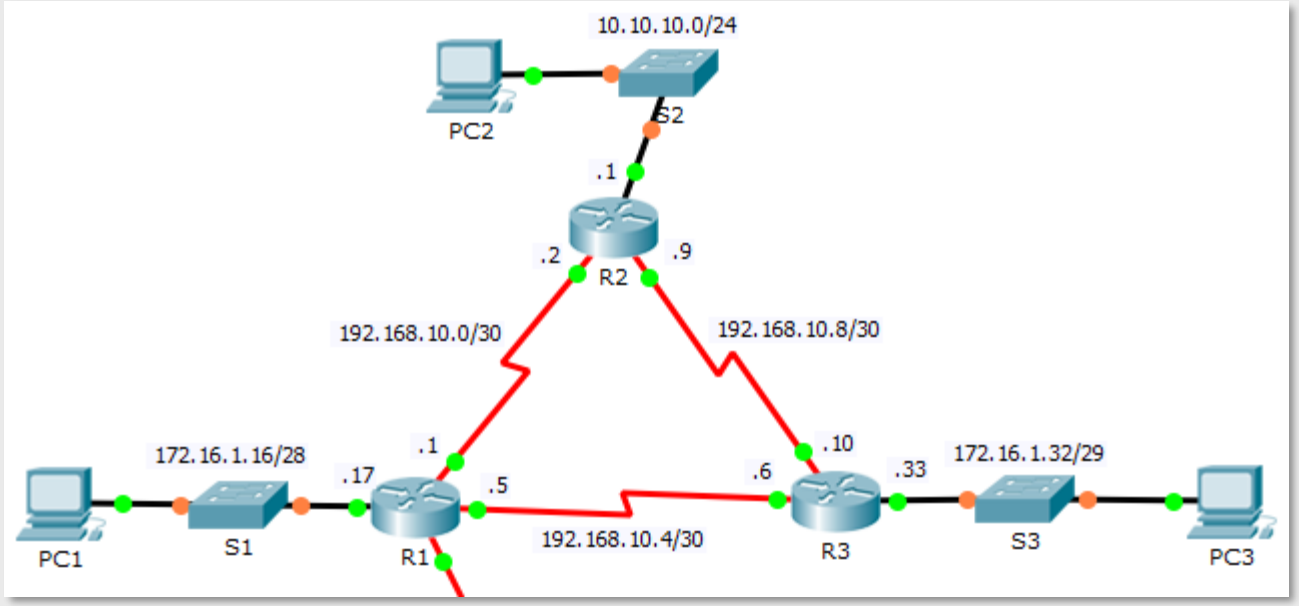


IOS OSPF configuration

```
Router(config-router)#router-id ip-address
```

- Determining the Router ID
  1. IP address configured with the **router-id** command
  2. The highest IP address of any of its loopback interfaces
  3. The highest active IP address of any of its physical interfaces

```
R1(config)#interface loopback 0
R1(config-if)#ip address 1.1.1.1 255.255.255.255
R1(config-if)#end
```

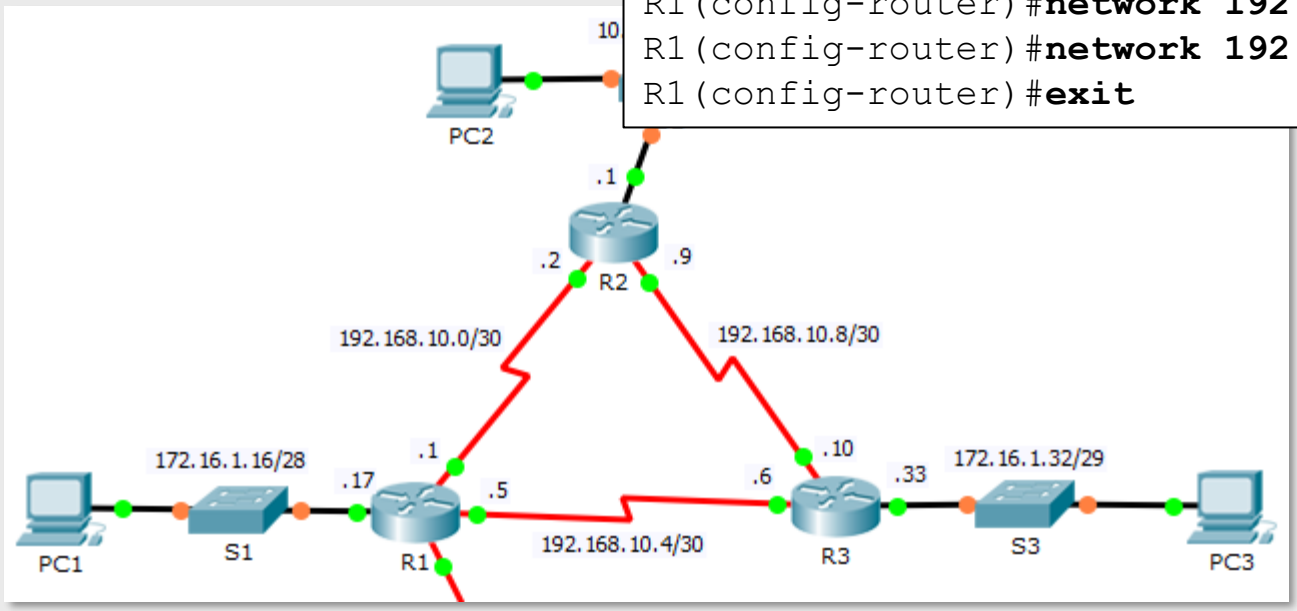


IOS OSPF configuration

```
Router(config-router)#network network-address wildcard-mask area area-id
```

- Determines which interfaces, per area, participate in the OSPF routing process
  - Any interface matching the network address will be enabled to send and receive OSPF packets
  - This network will be included in OSPF routing updates

```
R1(config)#router ospf 1
R1(config-router)#network 172.16.1.16 0.0.0.15 area 0
R1(config-router)#network 192.168.10.0 0.0.0.3 area 0
R1(config-router)#network 192.168.10.4 0.0.0.3 area 0
R1(config-router)#exit
```

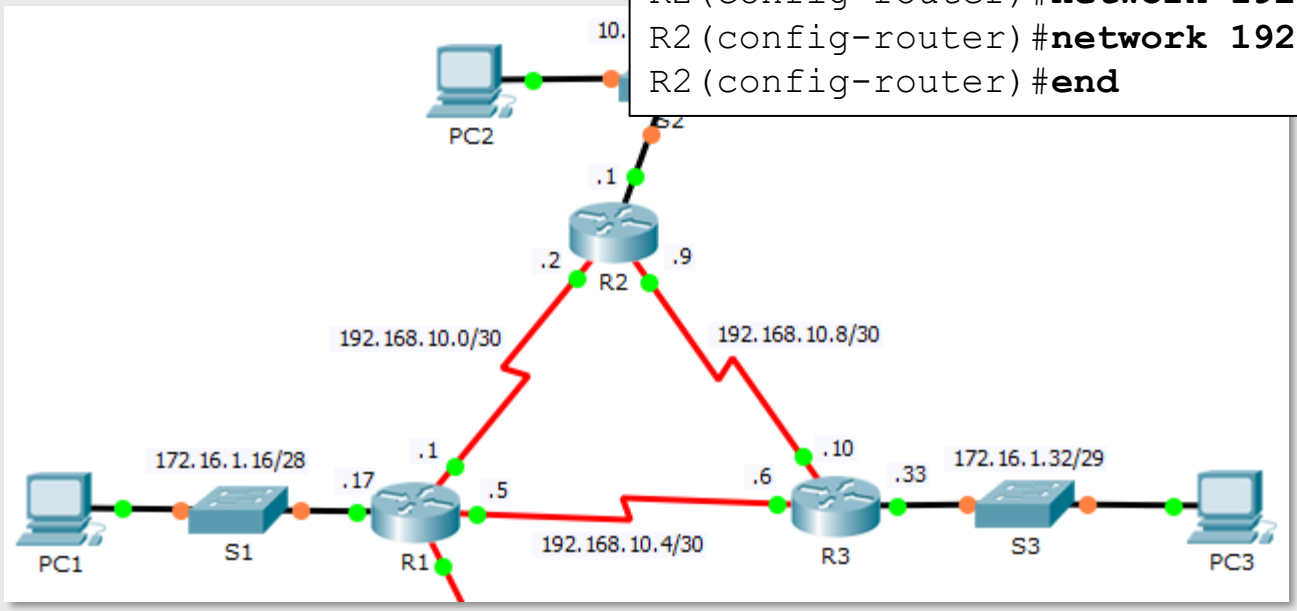


IOS OSPF configuration

```
Router(config-router)#network intf-ip-address 0.0.0.0 area area-id
```

- Determines which interfaces, per area, participate in the OSPF routing process
  - The interface with the specified address will be enabled to send and receive OSPF packets
  - The network on the interface will be included in OSPF routing updates

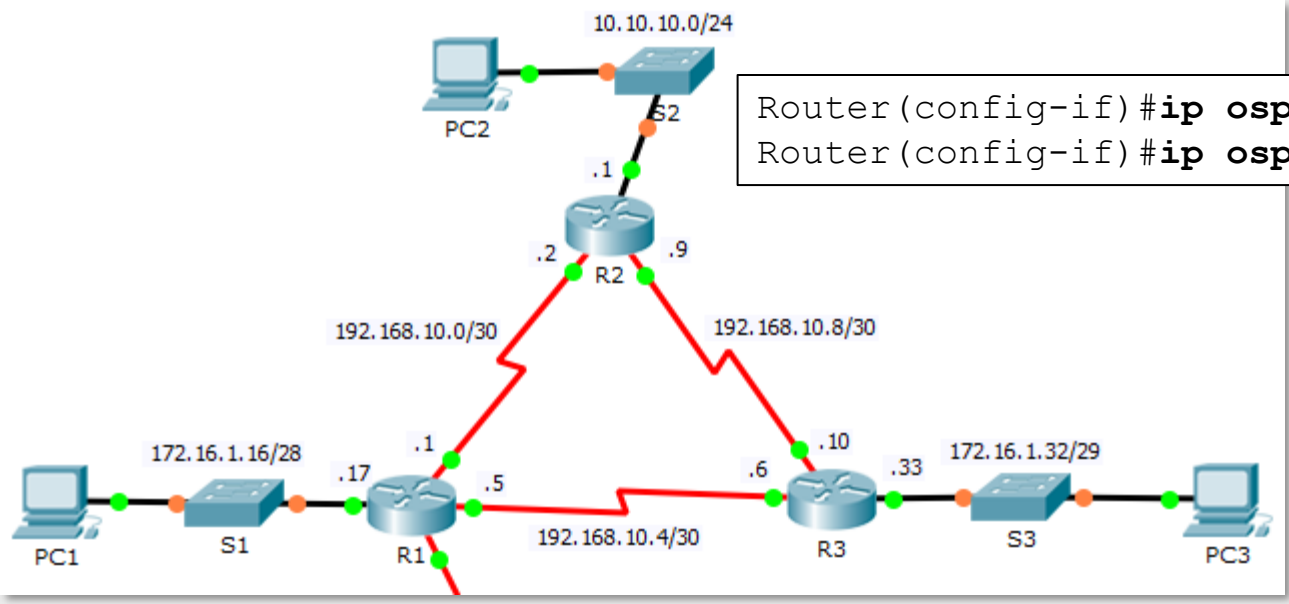
```
R2(config)#router ospf 1
R2(config-router)#network 10.10.10.1 0.0.0.0 area 0
R2(config-router)#network 192.168.10.2 0.0.0.0 area 0
R2(config-router)#network 192.168.10.9 0.0.0.0 area 0
R2(config-router)#end
```



Verifying neighbor adjacency

- Two routers may not form an OSPF adjacency if
  - the subnet masks do not match
  - OSPF Hello or Dead Timers do not match
  - OSPF Network Types do not match
  - there is a missing or incorrect OSPF network command

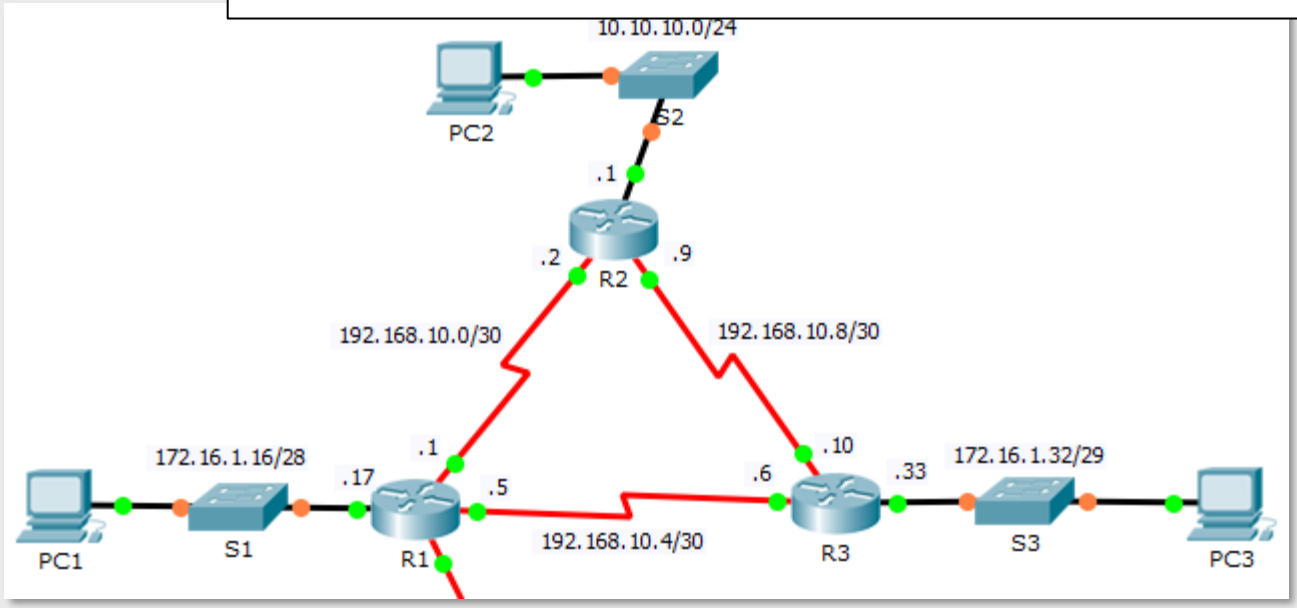
```
R1#show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           0   FULL/  -        00:00:33    192.168.10.2    Serial0/0/0
3.3.3.3           0   FULL/  -        00:00:32    192.168.10.6    Serial0/0/1
```




```
Router(config-if)#ip ospf hello-interval seconds
Router(config-if)#ip ospf dead-interval seconds
```

Verifying OSPF configuration

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
(**output omitted**)

     10.0.0.0/24 is subnetted, 1 subnets
O       10.10.10.0 [110/65] via 192.168.10.2, 00:03:01, Serial0/0/0
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.1.16/28 is directly connected, FastEthernet0/0
O       172.16.1.32/29 [110/65] via 192.168.10.6, 00:03:01, Serial0/0/1
     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/0/0
C       192.168.10.4 is directly connected, Serial0/0/1
O       192.168.10.8 [110/128] via 192.168.10.2, 00:03:01, Serial0/0/0
                     [110/128] via 192.168.10.6, 00:03:01, Serial0/0/1
     209.165.200.0/30 is subnetted, 1 subnets
C       209.165.200.224 is directly connected, Serial0/1/0
```



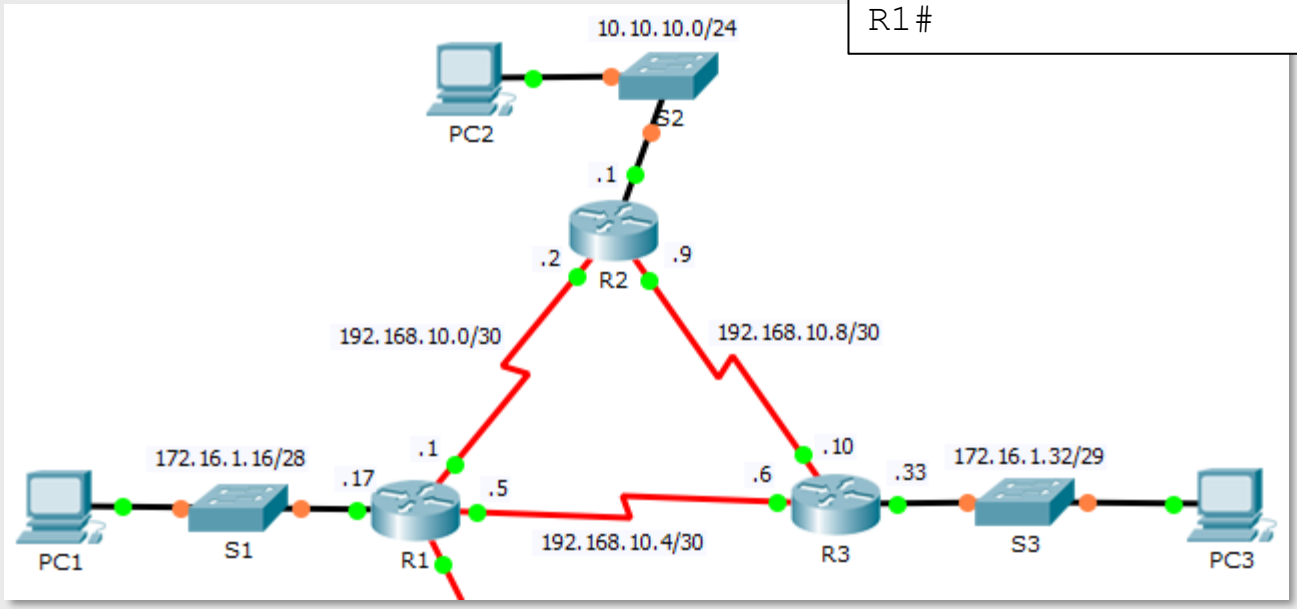
Passive interfaces

- By default, OSPF messages are forwarded out all OSPF-enabled interfaces

```
Router(config-router)#passive-interface interface-type interface-number
```

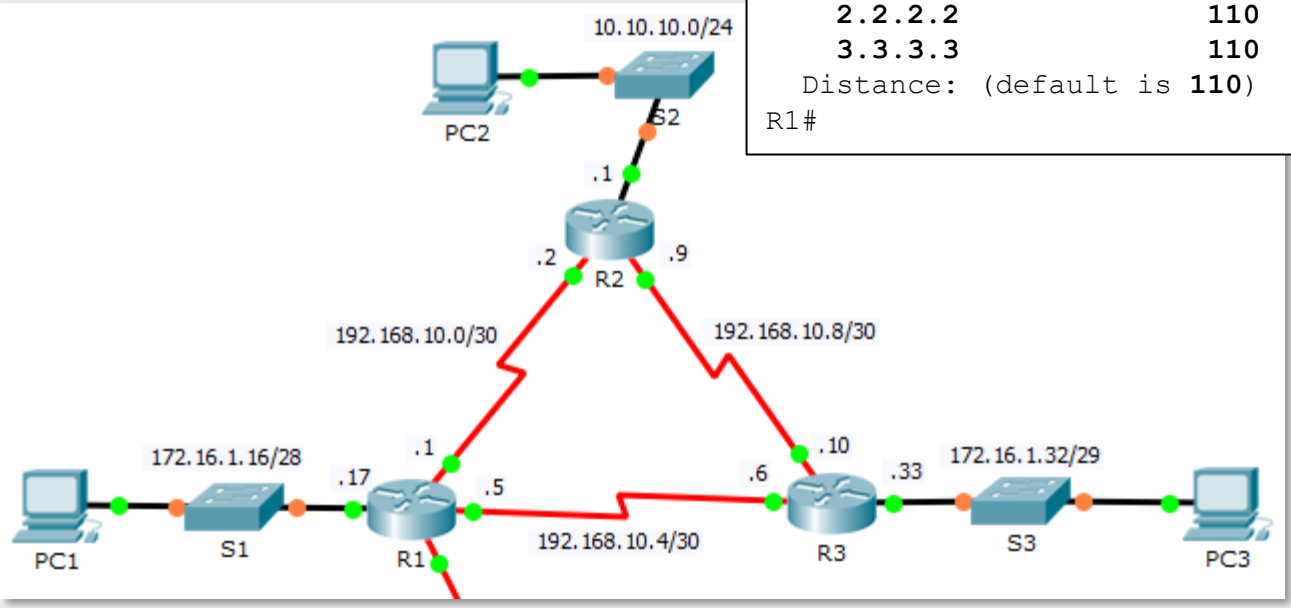
- Prevents the transmission of routing messages from the specified interface, but still allows that network to be advertised to other routers

```
R1(config)#router ospf 1
R1(config-router)#passive-interface fa0/0
R1(config-router)#^Z
R1#
```



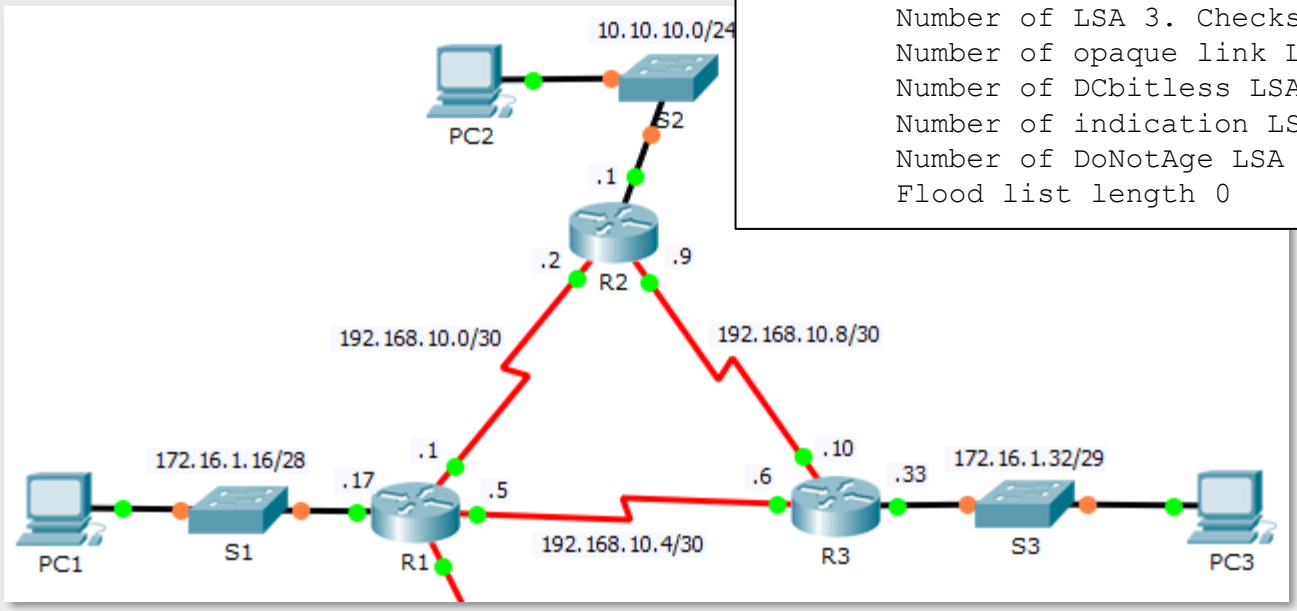
Verifying OSPF configuration

```
R1#show ip protocols

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 1.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    172.16.1.16 0.0.0.15 area 0
    192.168.10.0 0.0.0.3 area 0
    192.168.10.4 0.0.0.3 area 0
  Passive Interface(s):
    FastEthernet0/0
  Routing Information Sources:
    Gateway         Distance      Last Update
    1.1.1.1              110      00:18:45
    2.2.2.2              110      00:18:25
    3.3.3.3              110      00:18:25
  Distance: (default is 110)
R1#
```



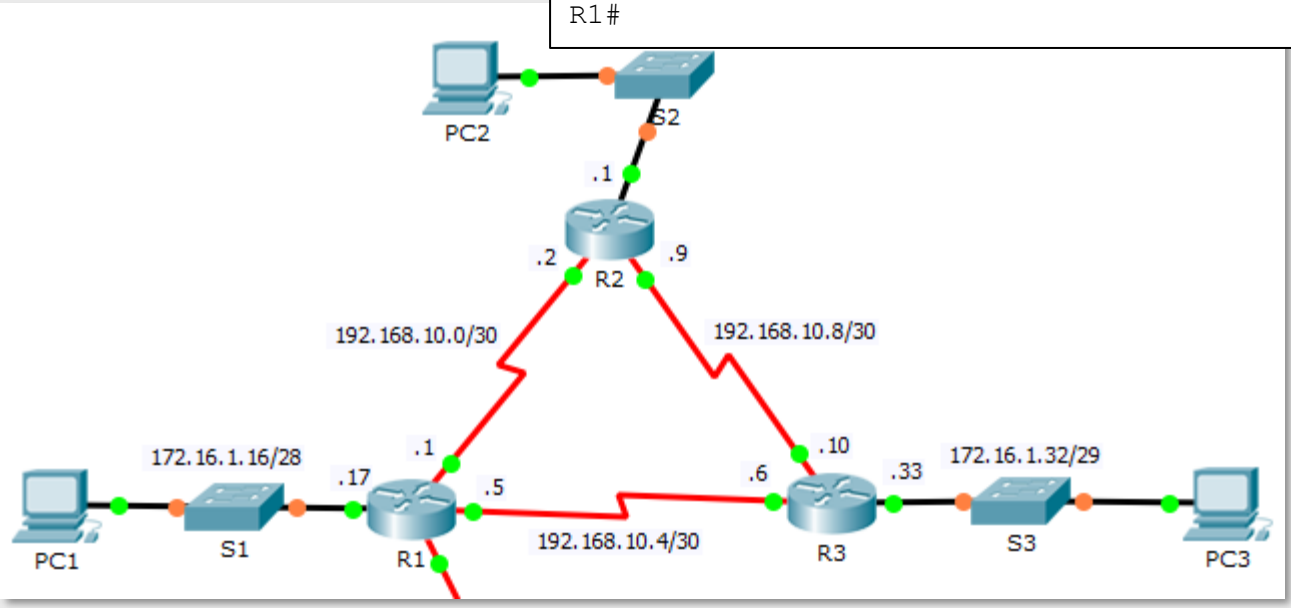
Verifying OSPF configuration

```
R1#show ip ospf
 Routing Process "ospf 1" with ID 1.1.1.1
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 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
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 3
        Area has no authentication
        SPF algorithm executed 9 times
        Area ranges are
        Number of LSA 3. Checksum Sum 0x017f02
        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
```



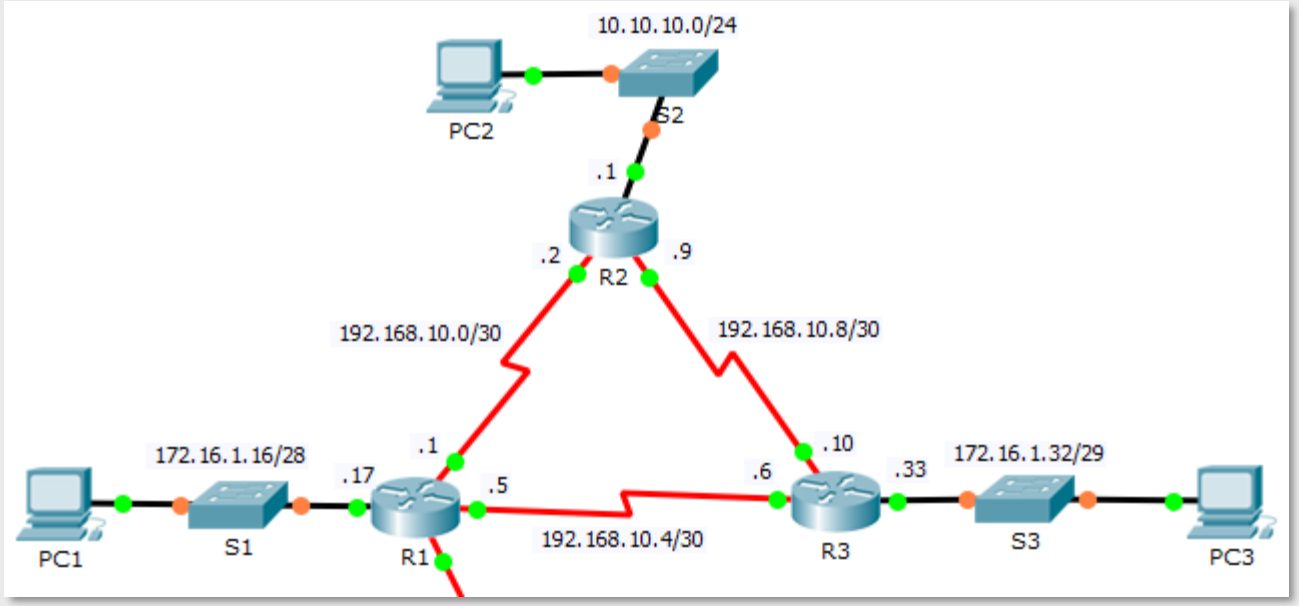
Verifying OSPF configuration

```
R1#show ip ospf interface se0/0/0

Serial0/0/0 is up, line protocol is up
  Internet address is 192.168.10.1/30, Area 0
  Process ID 1, Router ID 1.1.1.1, Network Type POINT-TO-POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT-TO-POINT, Priority 0
  No designated router on this network
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:05
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 2.2.2.2
  Suppress hello for 0 neighbor(s)
R1#
```

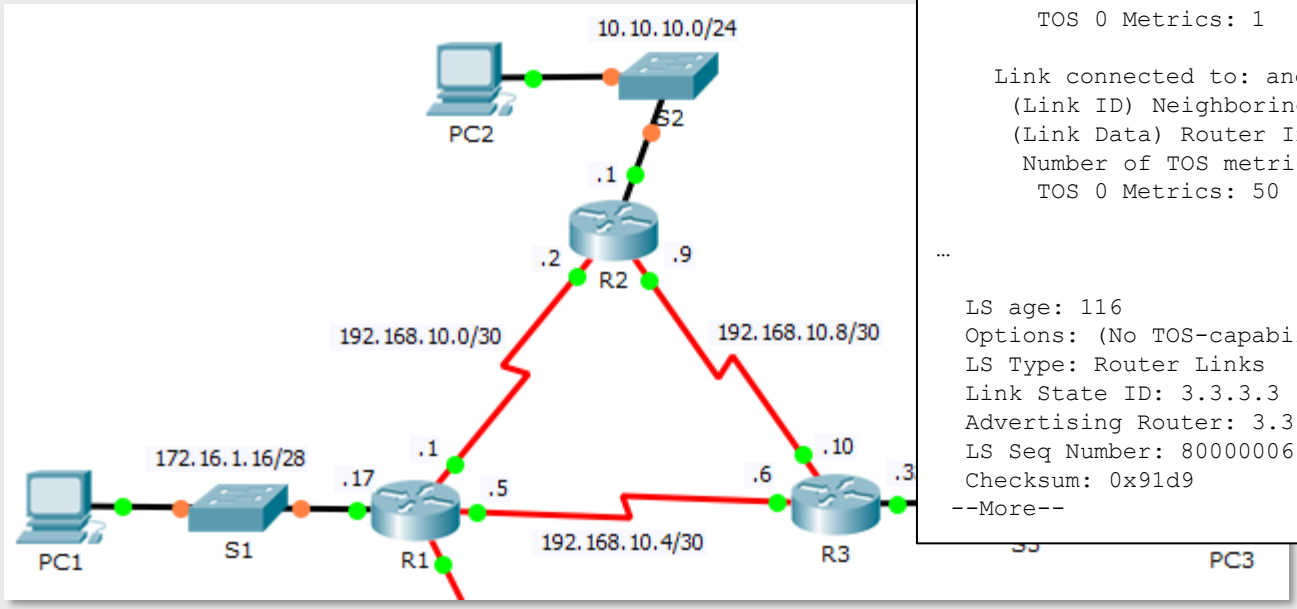


Verifying OSPF configuration

```
R1#show ip ospf database
            OSPF Router with ID (1.1.1.1) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
1.1.1.1         1.1.1.1         551         0x80000007 0x003367 5
2.2.2.2         2.2.2.2         551         0x80000006 0x00131e 5
3.3.3.3         3.3.3.3         551         0x80000006 0x0091d9 5

                Type-5 AS External Link States
Link ID         ADV Router      Age         Seq#       Checksum Tag
0.0.0.0         1.1.1.1         561         0x80000001 0x00fecf 1
R1#
```



Verifying OSPF configuration




```
R1#show ip ospf database router

            OSPF Router with ID (1.1.1.1) (Process ID 1)

                Router Link States (Area 0)

  LS age: 116
  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: 80000007
  Checksum: 0x3367
  Length: 84
  AS Boundary Router
  Number of Links: 5

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 172.16.1.16
     (Link Data) Network Mask: 255.255.255.240
      Number of TOS metrics: 0
       TOS 0 Metrics: 1

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 2.2.2.2
     (Link Data) Router Interface address: 192.168.10.1
      Number of TOS metrics: 0
       TOS 0 Metrics: 50

…

  LS age: 116
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 3.3.3.3
  Advertising Router: 3.3.3.3
  LS Seq Number: 80000006
  Checksum: 0x91d9
 --More--
```

OSPF costs

- Administrative Distance

Route Source	Administrative Distance
Connected	0
Static	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

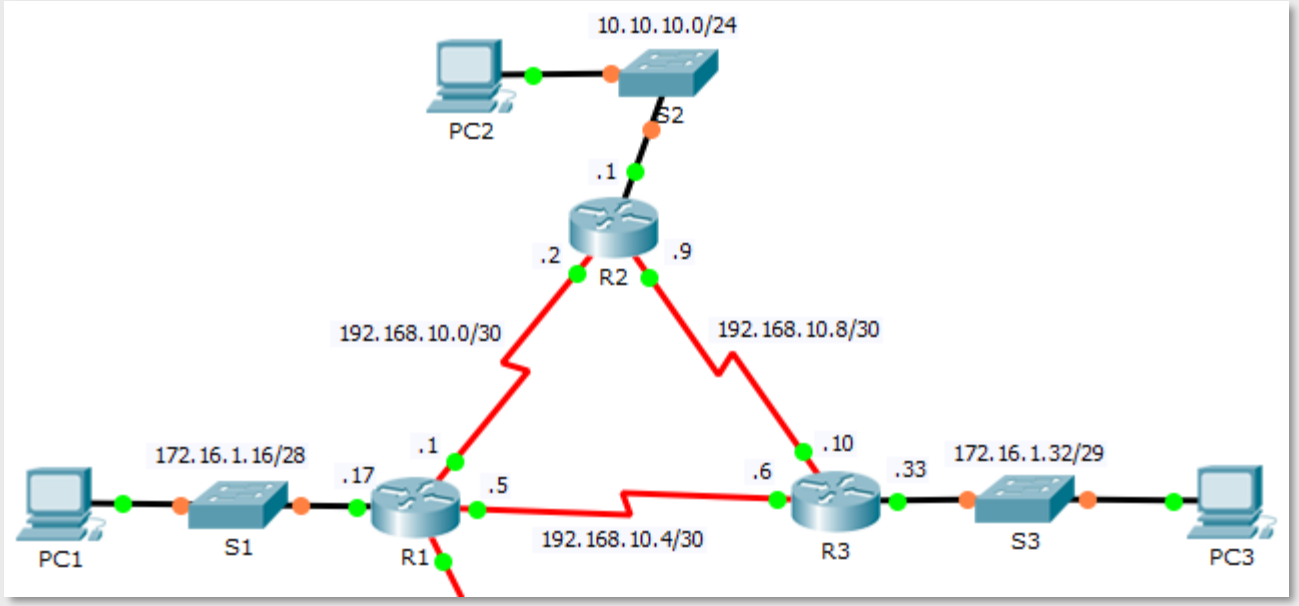
OSPF costs – IOS default

- Cisco IOS uses the bandwidth of the interface to calculate the OSPF cost:
  - **cost = *reference-bandwidth*/*interface-bandwidth***
- *reference-bandwidth* value is **100 Mbps** by default
  - can be changed with the OSPF command
    - **`auto-cost reference-bandwidth`** *`reference-bandwidth`*
- *bandwidth* value is determined by the interface configuration

Interface Type	100/bw in Mbps	Cost
10 Gigabit Ethernet	100/10,000	1
Gigabit Ethernet	100/1,000	1
Fast Ethernet	100/100	1
Ethernet	100/10	10
E1	100/2.048	48
T1	100/1.544	64
128 kbps	100/0.128	781
64 kbps	100/0.064	1562

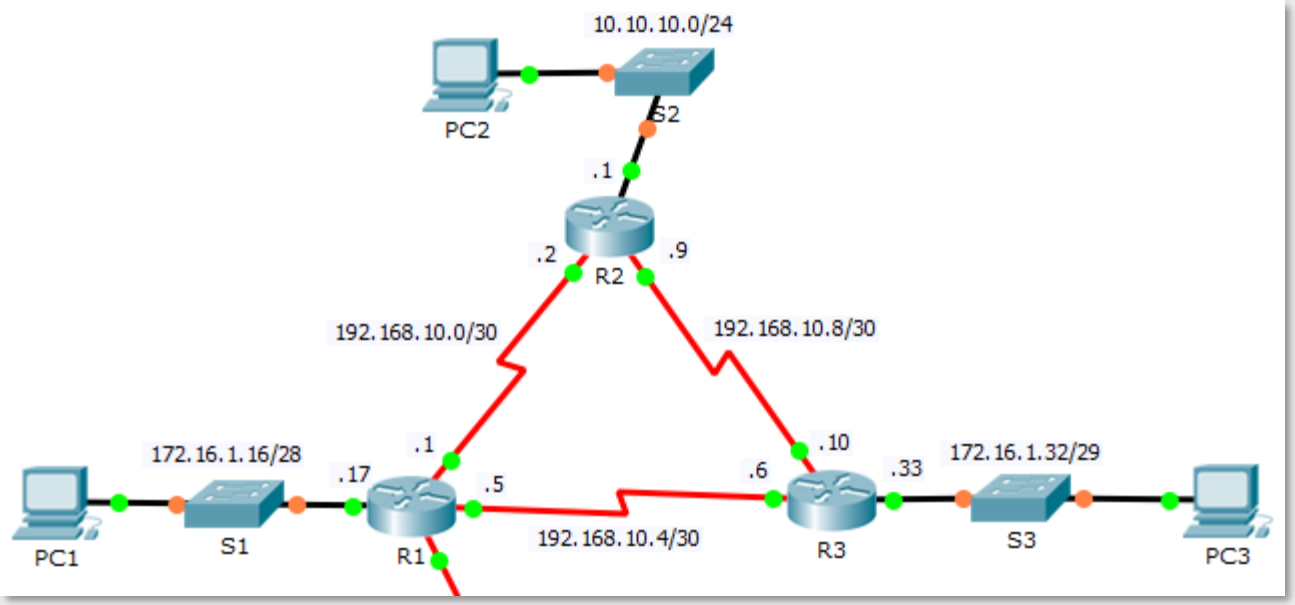
OSPF costs – cumulative cost

```
R1#show ip route
(**output omitted**)
O       10.10.10.0 [110/65] via 192.168.10.2, 01:07:18, Serial0/0/0
(**output omitted**)
R1#show ip route 10.10.10.0
Routing entry for 10.10.10.0/24
Known via "ospf 1", distance 110, metric 65, type intra area
  Last update from 192.168.10.2 on Serial0/0/0, 01:07:20 ago
  Routing Descriptor Blocks:
  * 192.168.10.2, from 2.2.2.2, 01:07:20 ago, via Serial0/0/0
      Route metric is 65, traffic share count is 1
R1#
```



Adjusting OSPF costs

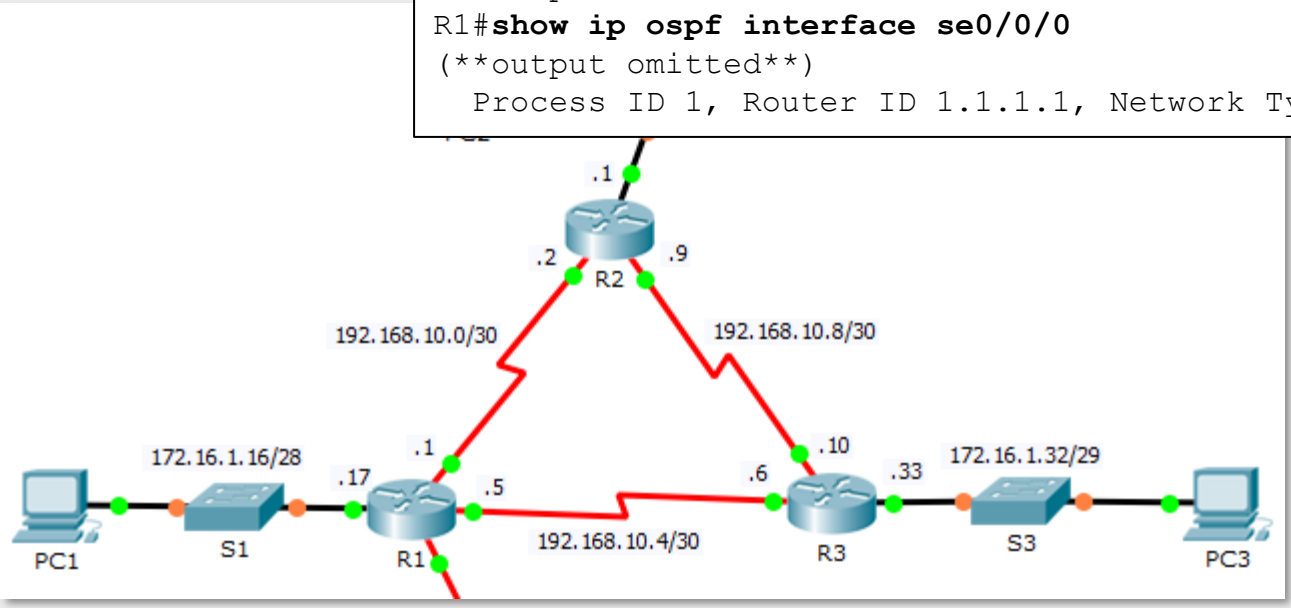
- The actual speed of a link may be different than the default *bandwidth* value
  - Most serial links default to 1.544 Mbps
- The *bandwidth* value should be always configured to reflect the actual speed of the link
  - **Important**: this *bandwidth* value does not actually **affect** the speed of the link



Adjusting OSPF costs

- The actual speed of a link may be different than the default *bandwidth* v
  - Most seria
- The *bandwi*
  actual speed
  - **Importa**
    speed of t

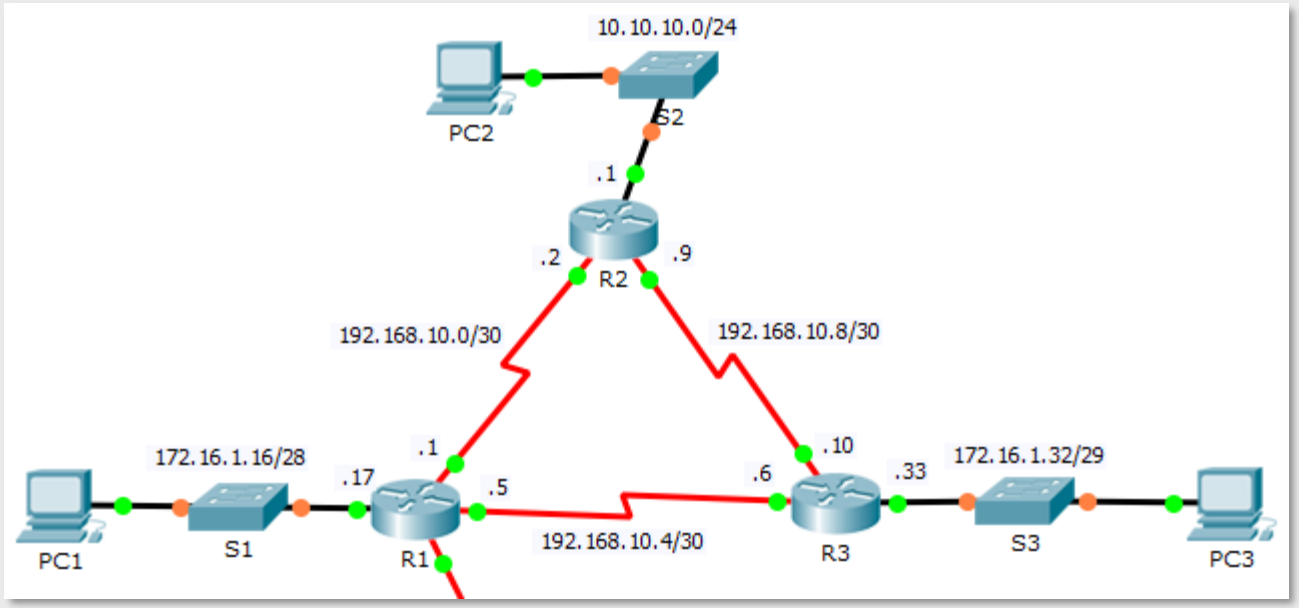
```
R1#show interface se0/0/0
(**output omitted**)
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
(**output omitted**)
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int se0/0/0
R1(config-if)#bandwidth 2000
R1(config-if)#^Z
R1#show interface se0/0/0
(**output omitted**)
  MTU 1500 bytes, BW 2000 Kbit, DLY 20000 usec,
(**output omitted**)
R1#show ip ospf interface se0/0/0
(**output omitted**)
  Process ID 1, Router ID 1.1.1.1, Network Type POINT-TO-POINT, Cost: 50
```



Adjusting OSPF costs

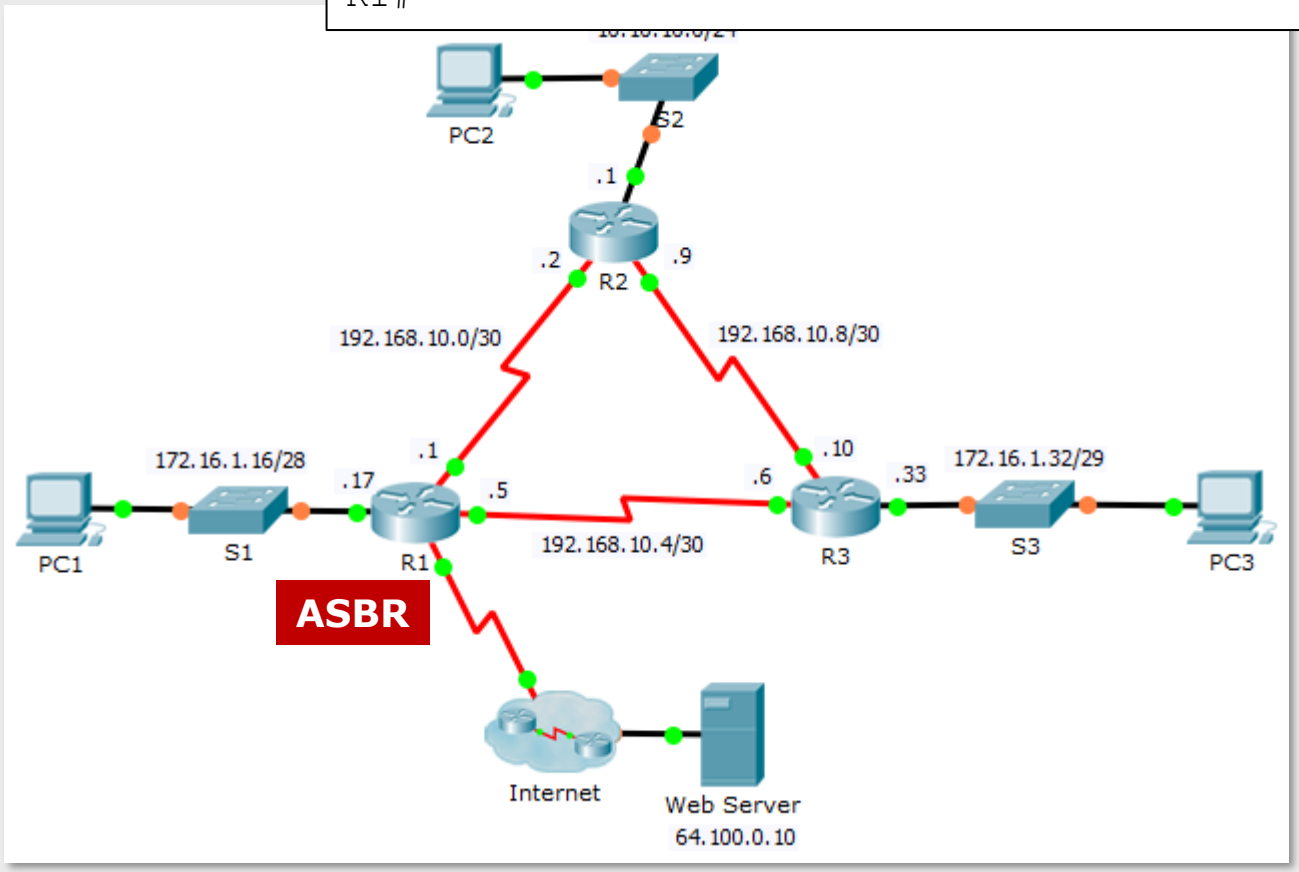
- Alternatively, costs can be administratively configured

```
R2(config)#int se0/0/0
R2(config-if)#ip ospf cost 50
R2(config-if)#^Z
R2#show interface se0/0/0
(**output omitted**)
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
(**output omitted**)
R2#show ip ospf interface se0/0/0
(**output omitted**)
  Process ID 1, Router ID 2.2.2.2, Network Type POINT-TO-POINT, Cost: 50
```



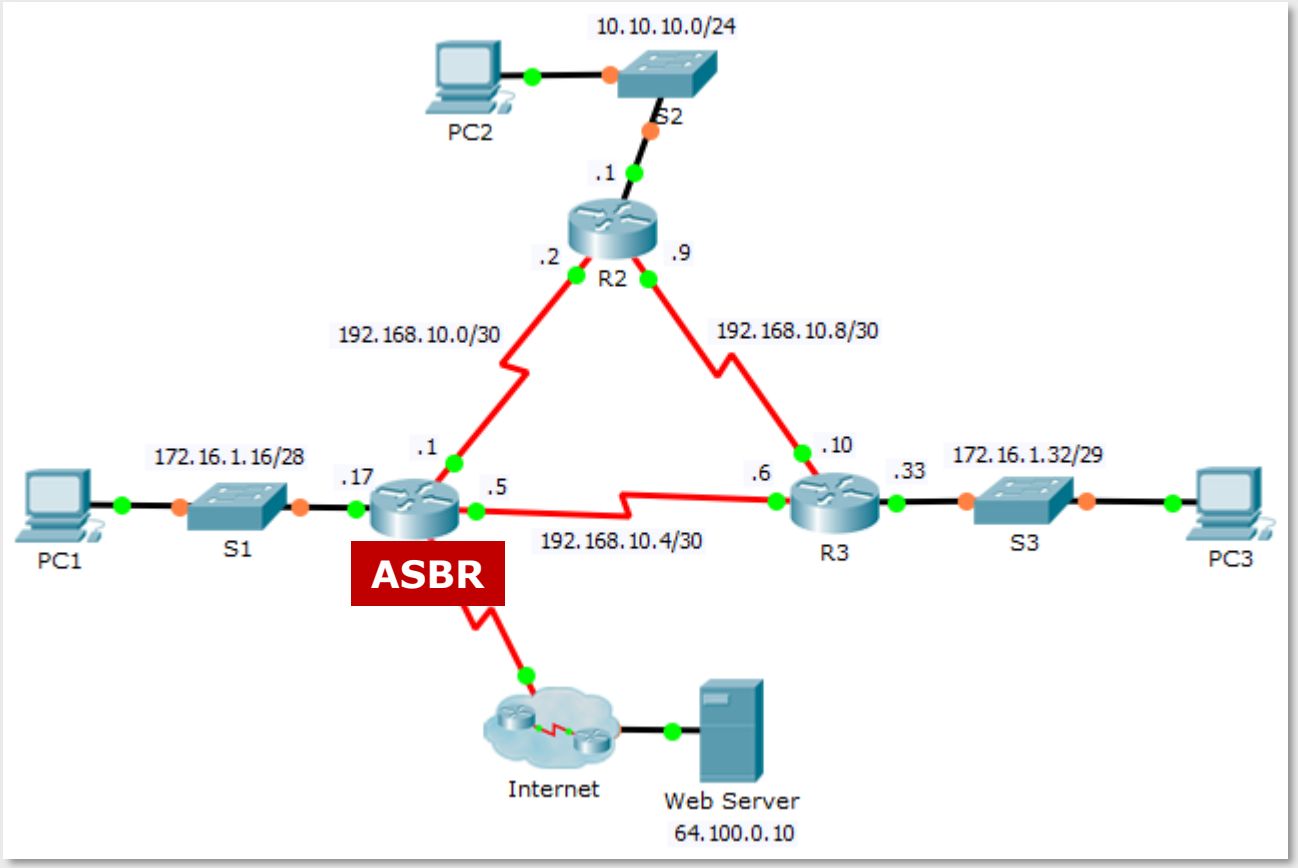
OSPF – redistributing a default route

```
R1(config)#ip route 0.0.0.0 0.0.0.0 se0/1/0
R1(config)#router ospf 1
R1(config-router)#default-information originate
R1(config-router)#^Z
R1#
```



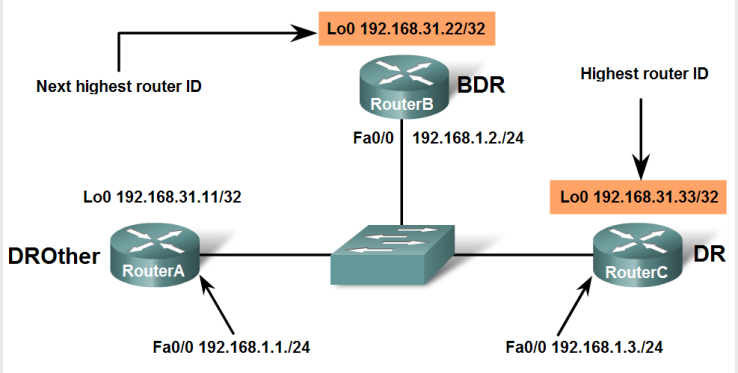
OSPF – redistributing a default route

```
R2#show ip route
(**output omitted**)
Gateway of last resort is 192.168.10.1 to network 0.0.0.0

(**output omitted**)
O*E2 0.0.0.0/0 [110/1] via 192.168.10.1, 00:00:17, Serial0/0/0
R2#
```



OSPF – multiaccess networks

- Designated Router (DR) and Backup Designated Router (BDR) election
  - **DR**: Router with the highest OSPF interface priority
  - **BDR**: Router with the second highest OSPF interface priority
    - `Router(config-if)#ip ospf priority {0 - 255}`
  - If OSPF interface priorities are equal, the highest router ID is used to break the tie




```
RouterA#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.31.33     1   FULL/DR         00:00:39    192.168.1.3     FastEthernet0/0
192.168.31.22     1   FULL/BDR        00:00:36    192.168.1.2     FastEthernet0/0
```

```
RouterB#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.31.33     1   FULL/DR         00:00:34    192.168.1.3     FastEthernet0/0
192.168.31.11     1   FULL/DROTHER    00:00:38    192.168.1.1     FastEthernet0/0
```

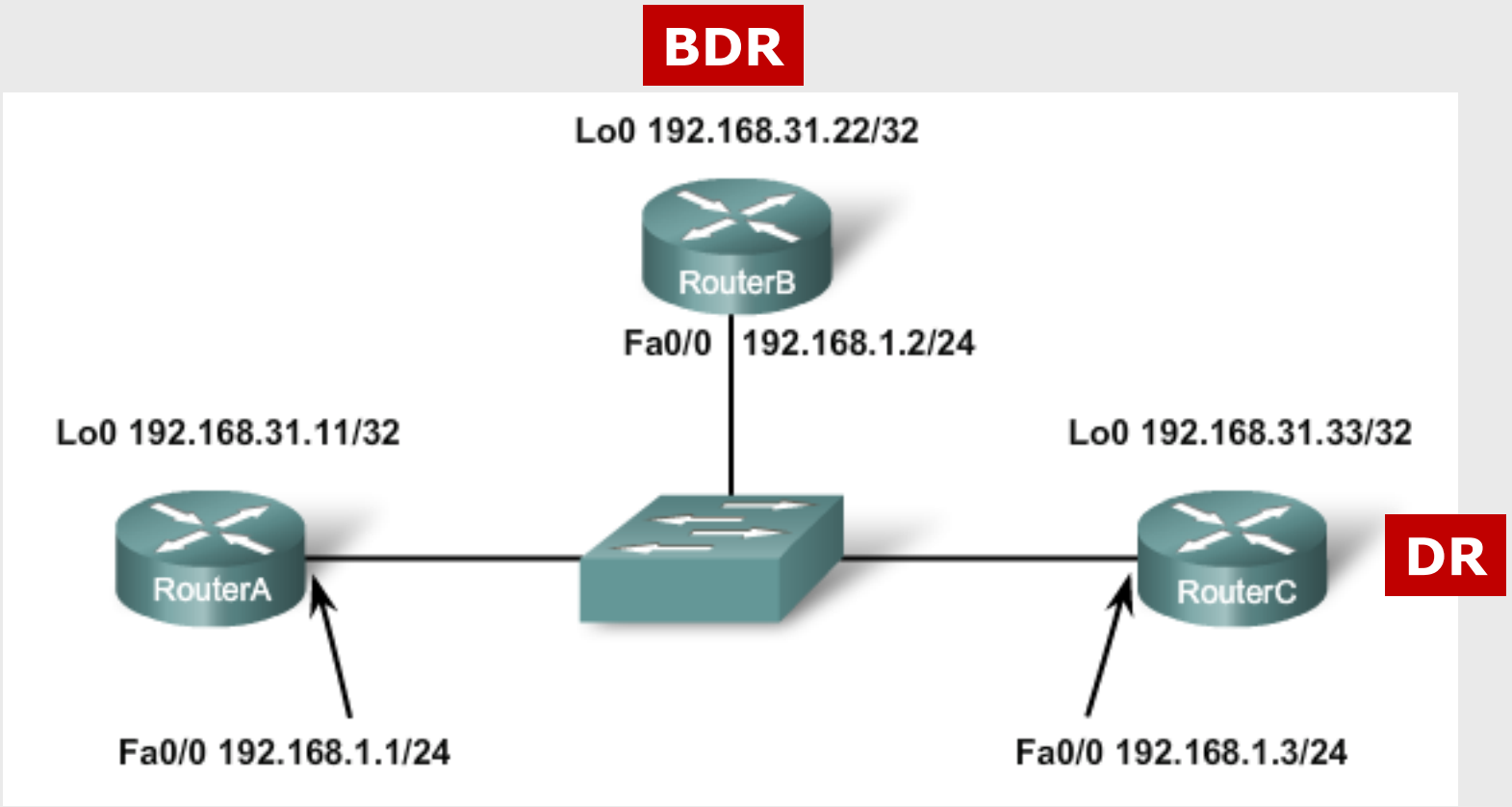
```
RouterC#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.31.22     1   FULL/BDR        00:00:35    192.168.1.2     FastEthernet0
192.168.31.11     1   FULL/DROTHER    00:00:32    192.168.1.1     FastEthernet0
```

Priority is equal at the default value of 1.

```
RouterA#show ip ospf interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Internet Address 192.168.1.1/24, Area 0
  Process ID 1, Router ID 192.168.31.11, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DROTHER, Priority 1
  Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
  Backup Designated router (ID) 192.168.31.22, Interface address 192.168.1.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:06
  Supports Link-local Signaling (LLS)
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 2, Adjacent neighbor count is 2
    Adjacent with neighbor 192.168.31.22  (Backup Designated Router)
    Adjacent with neighbor 192.168.31.33  (Designated Router)
  Suppress hello for 0 neighbor(s)
```

OSPF – multiaccess networks

- Election takes place as soon as the first router is active
  - It is possible that a router with a lower Router ID becomes the DR
- When the DR is elected, it remains until it fails



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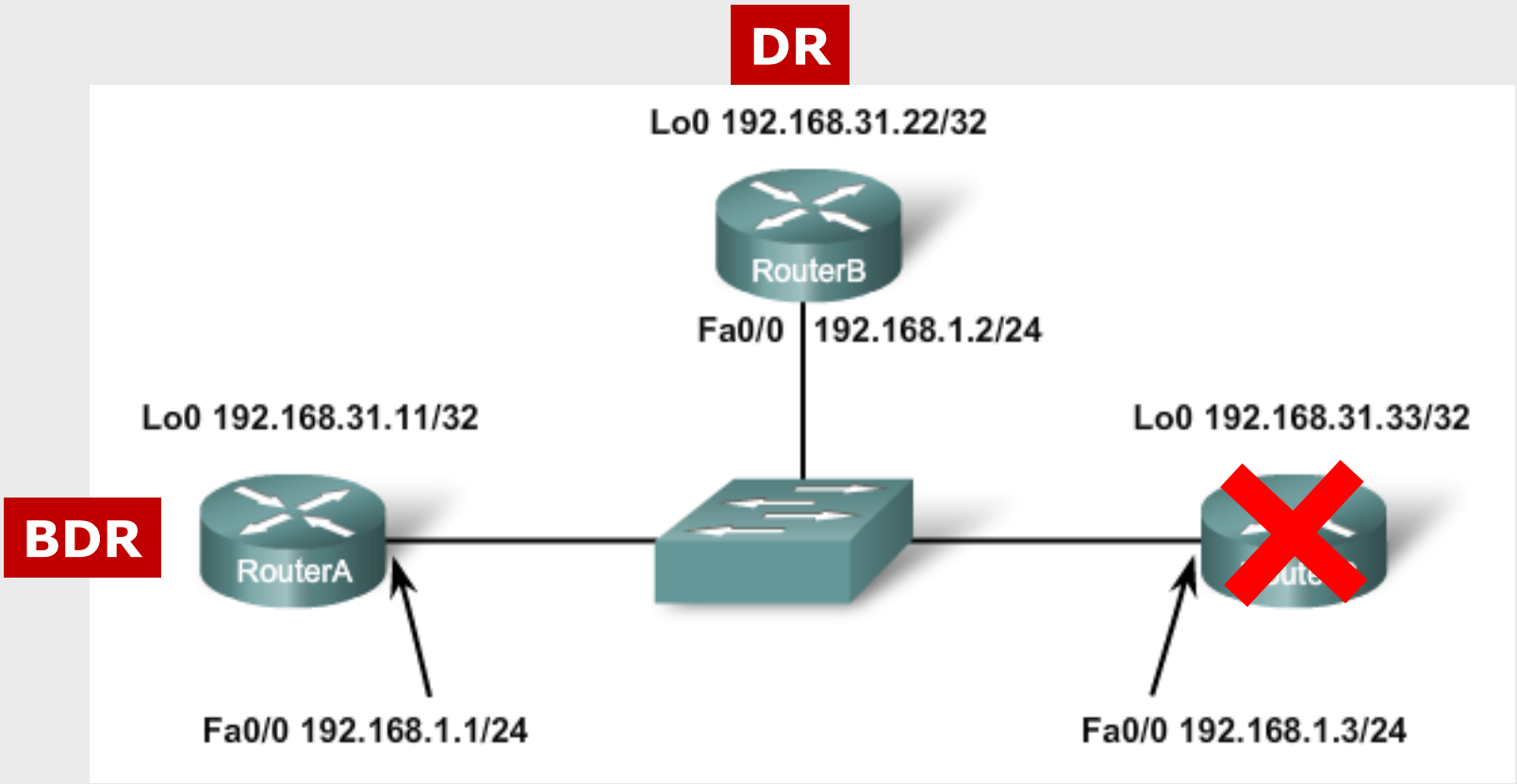

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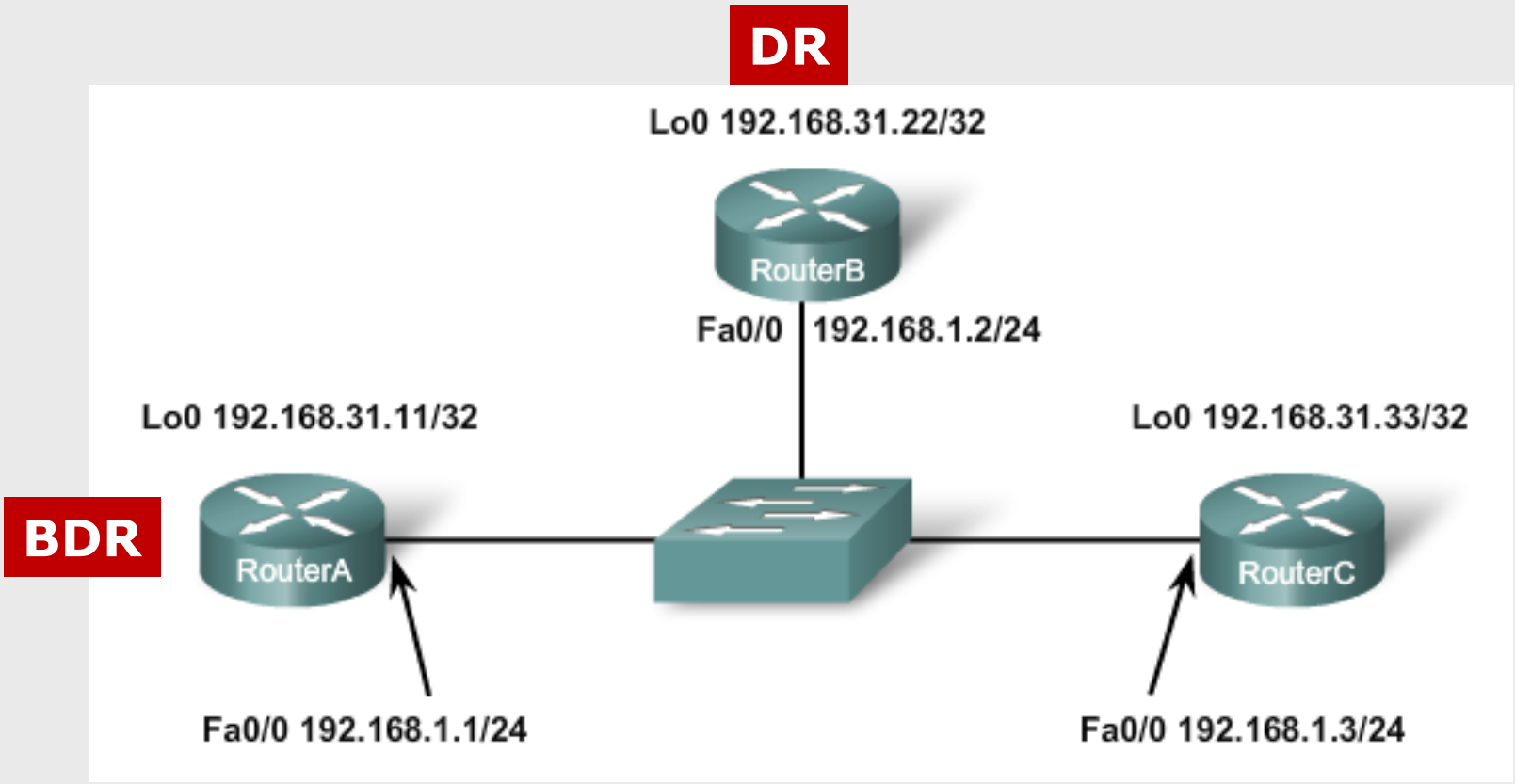
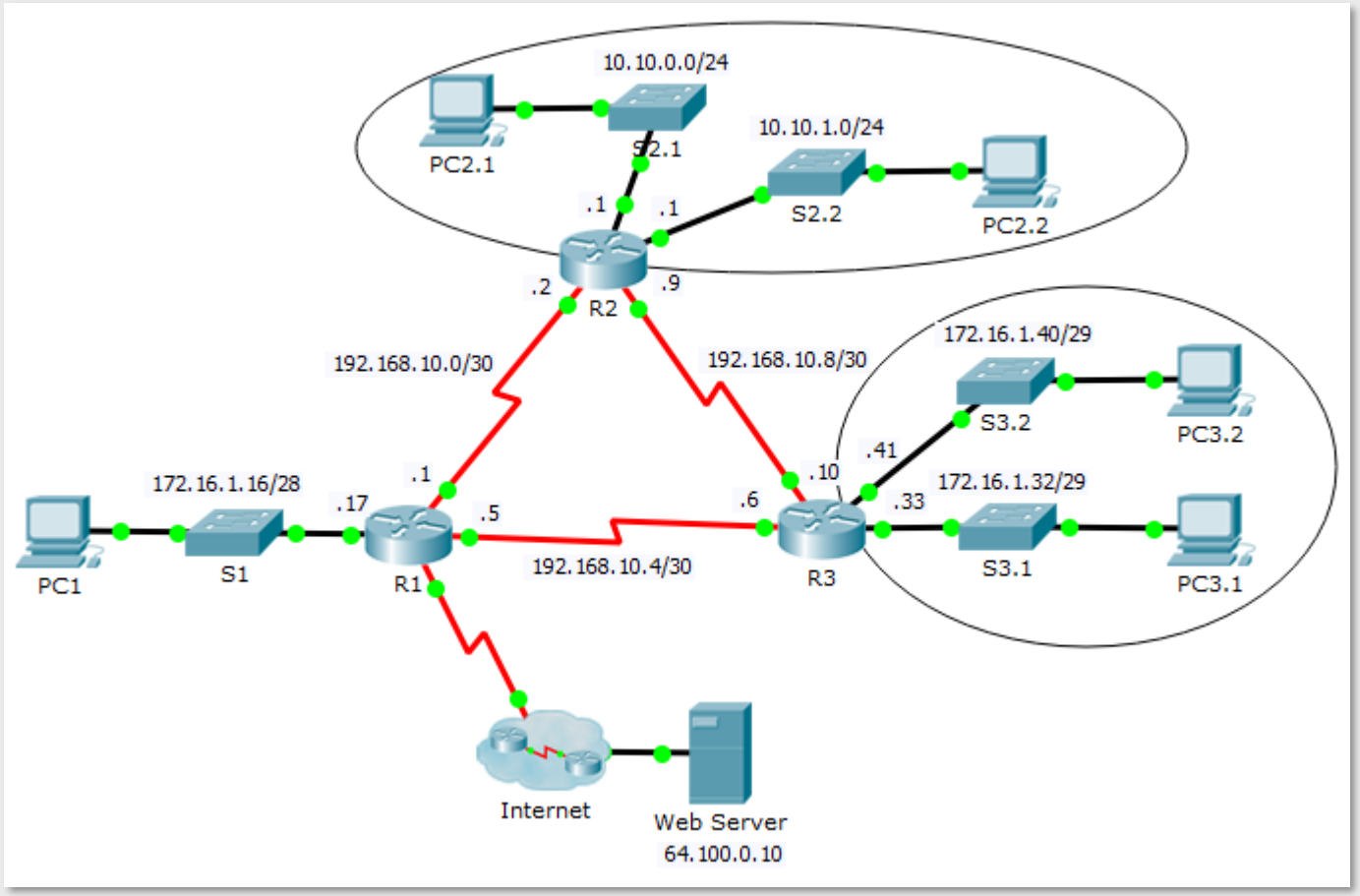


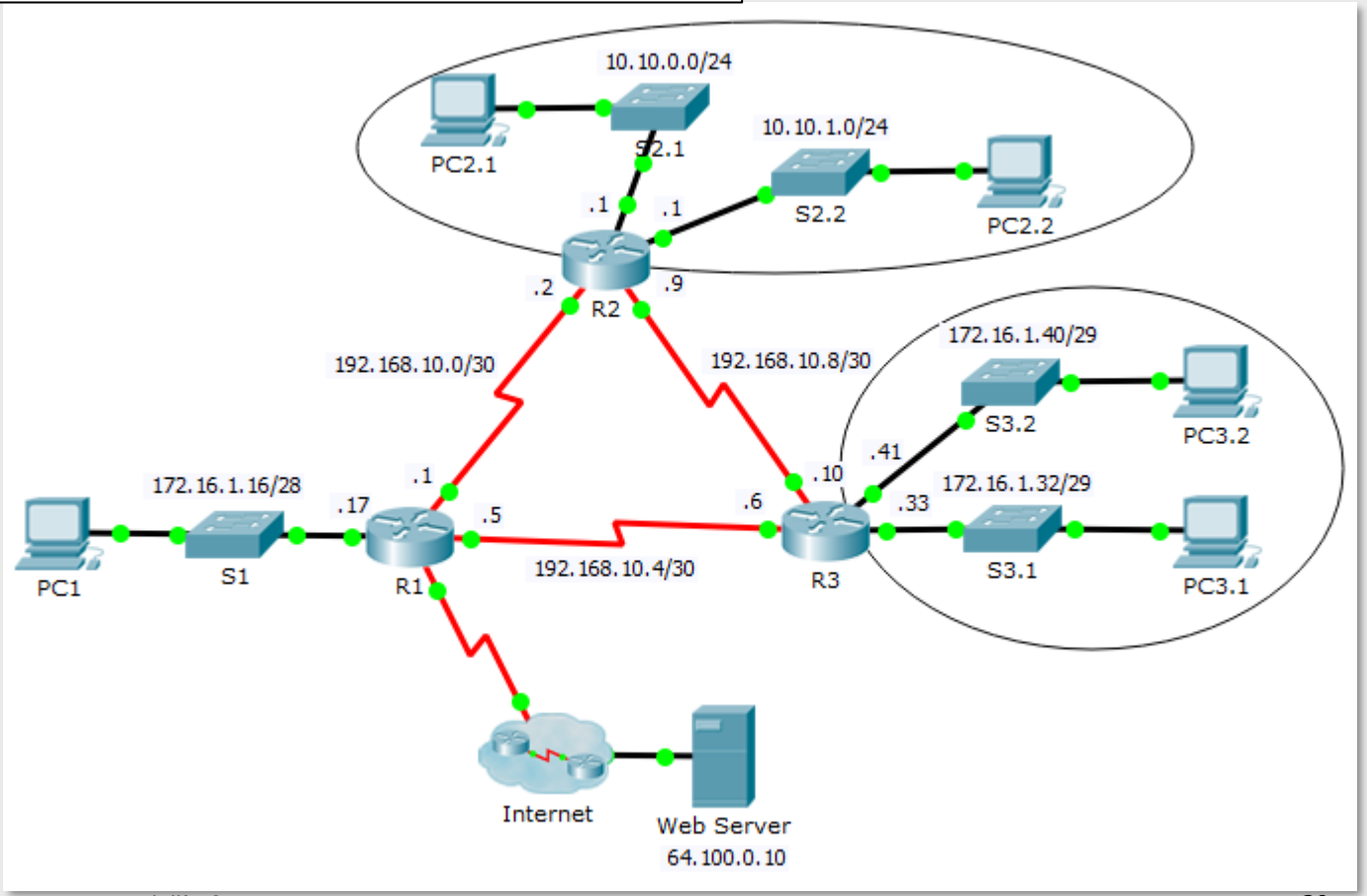
IOS OSPF configuration – multi area

- Reference topology



IOS OSPF configuration

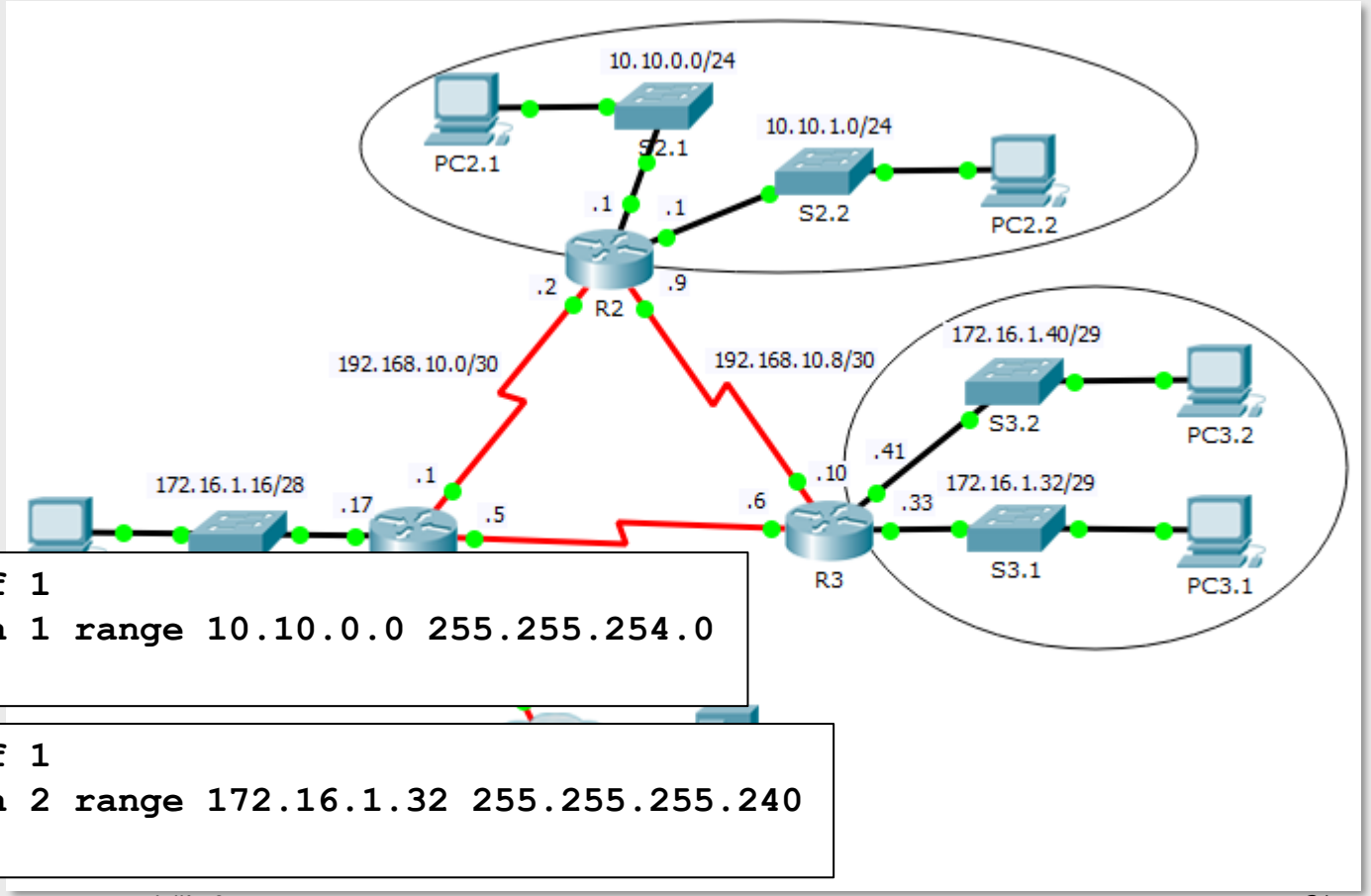
```
R2(config)#router ospf 1
R2(config-router)#network 192.168.10.2 0.0.0.0 area 0
R2(config-router)#network 192.168.10.9 0.0.0.0 area 0
R2(config-router)#network 10.10.0.1 0.0.0.0 area 1
R2(config-router)#network 10.10.1.1 0.0.0.0 area 1
R2(config-router)#^Z
```



OSPF inter-area route summarization

- OSPF does not perform auto-summarization
- Inter-area summarization must be manually configured on ABRs

```
Router(config-router)#area area-id range address mask
```

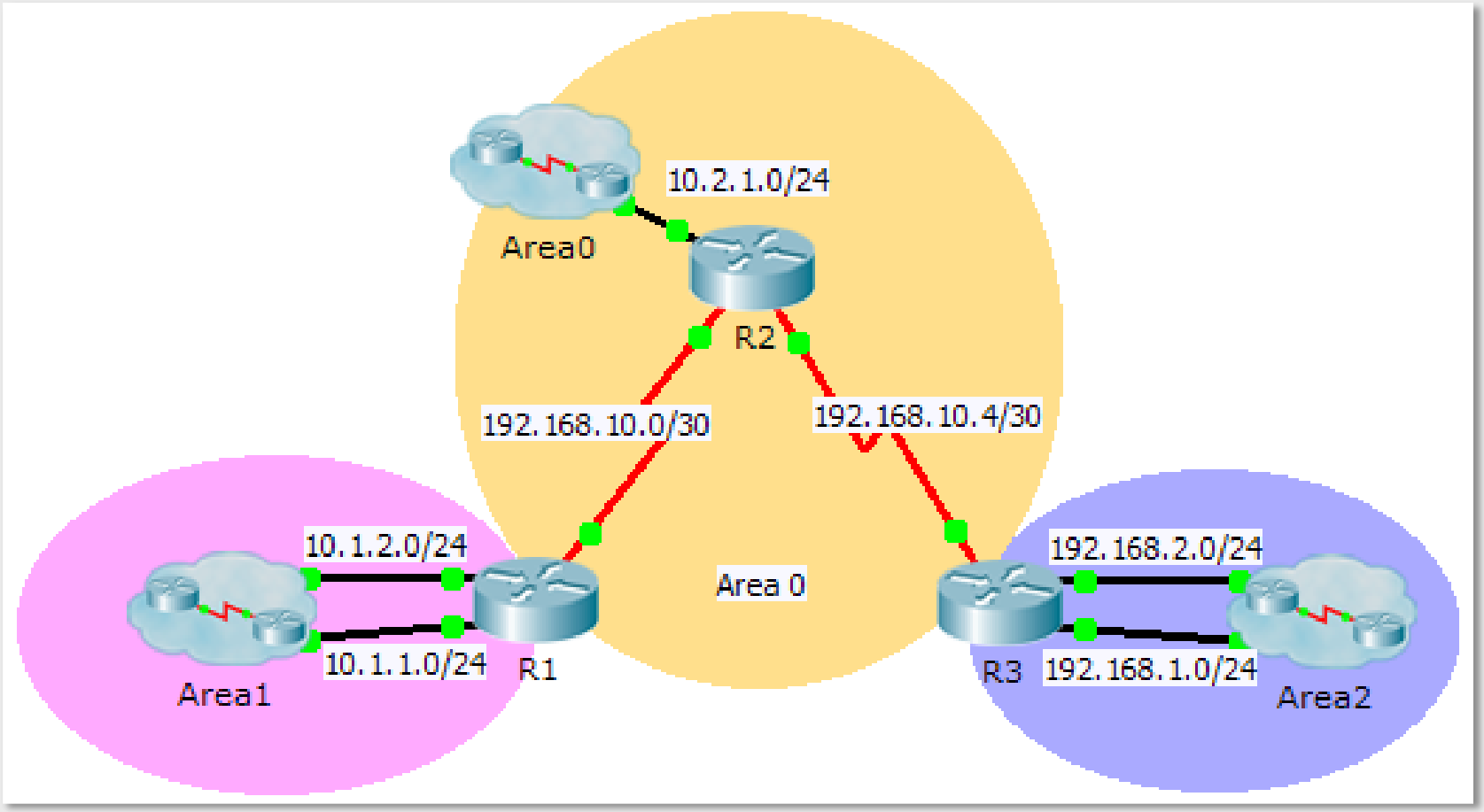



```
R2(config)#router ospf 1
R2(config-router)#area 1 range 10.10.0.0 255.255.254.0
R2(config-router)#^Z
```

```
R3(config)#router ospf 1
R3(config-router)#area 2 range 172.16.1.32 255.255.255.240
R3(config-router)#^Z
```

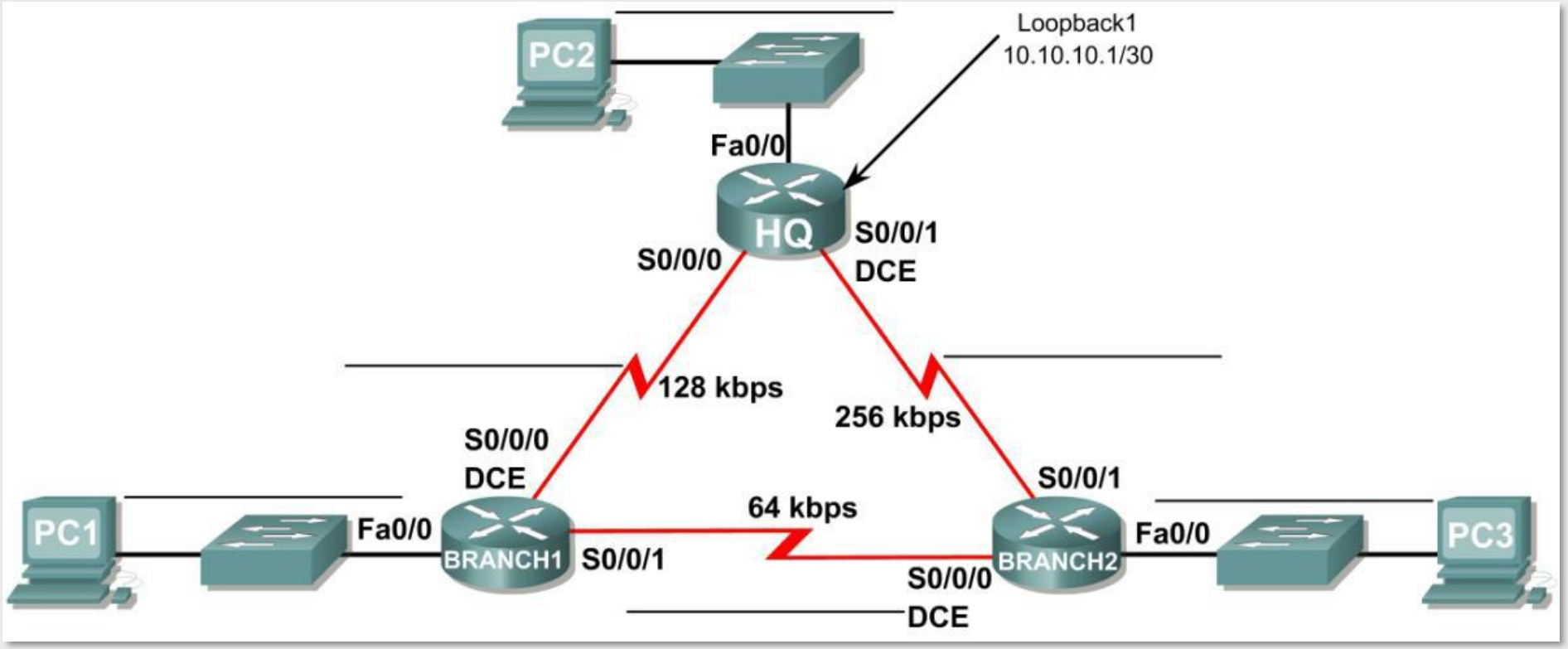
Lab activity

- OSPF multi-area



Lab activity

- OSPF – single area



Lab activity

- OSPF – multi area