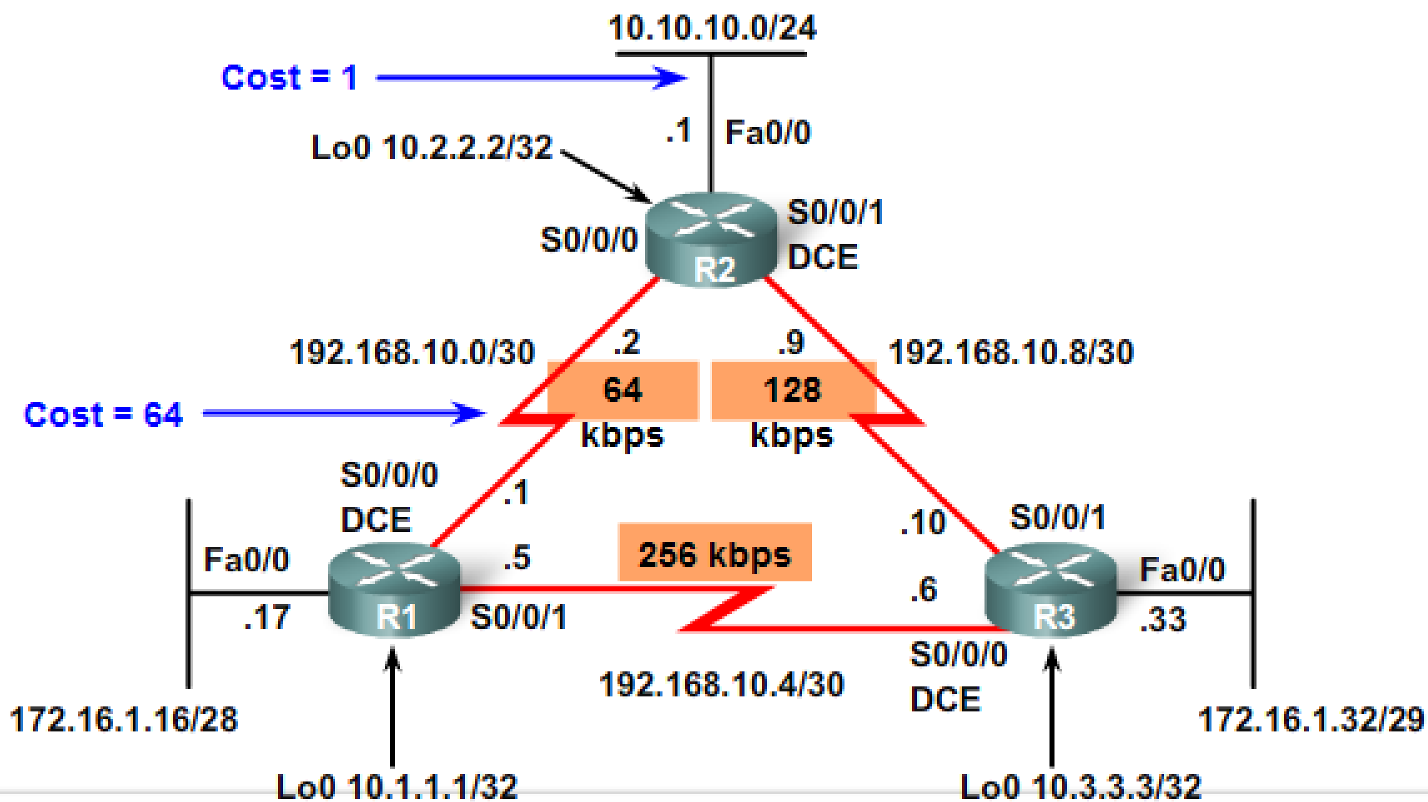
Cisco OSPF Cost Values

Interface Type	10^8/ bps = Cost
Fast Ethernet and faster	10^8/ 100,000,000 bps = 1
Ethernet	10^8/ 10,000,000 bps = 10
E1	10^8/ 2,048,000 bps = 48
T1	10^8/ 1,544,000 bps = 64
128 kbps	10^8/ 128,000 bps = 781
64 kbps	10^8/ 64,000 bps = 1562
56 kbps	10^8/ 56,000 bps = 1785

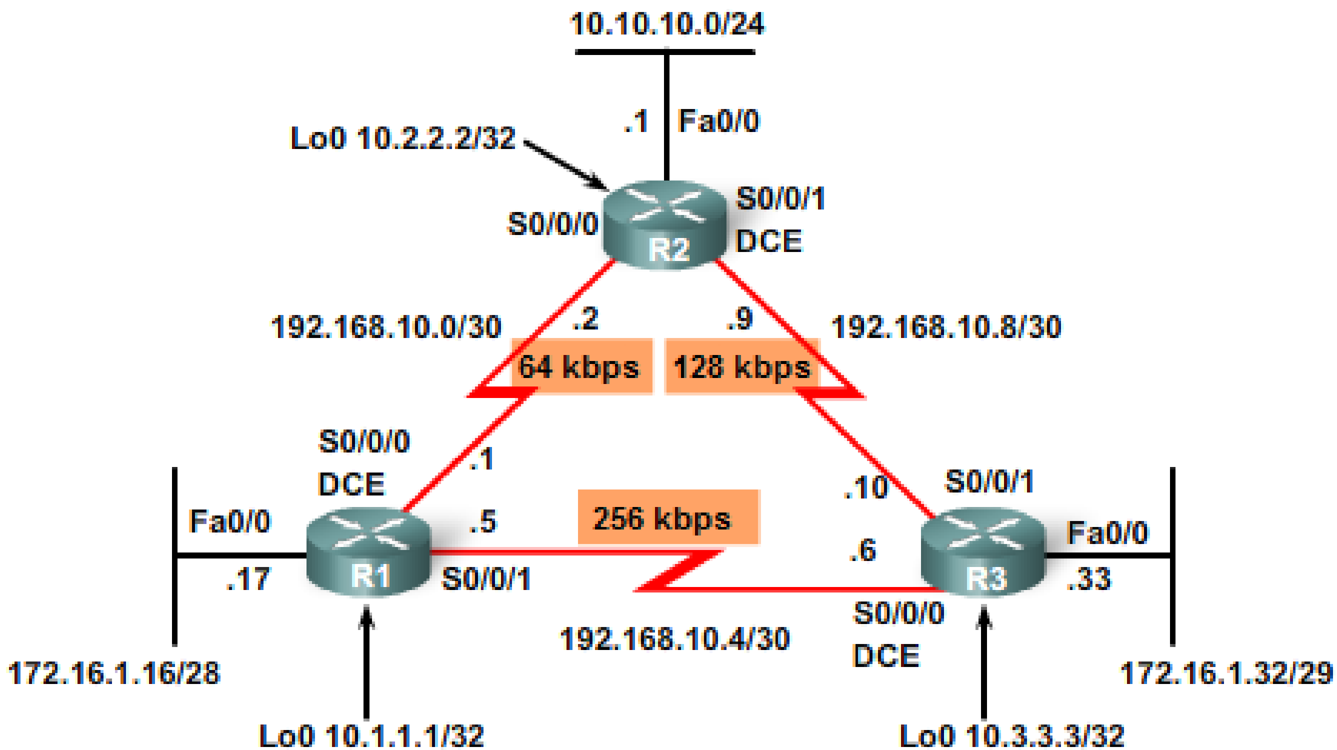
OSPF Accumulates Cost




```
R1#show ip route
Codes: <some code output omitted>
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

<route ouput omitted.
O       10.10.10.0/24 [110/65] via 192.168.10.2, 14:27:57, Serial0/0/0
```

Accumulated Cost = 65

Differences Between Default and Actual Bandwidth

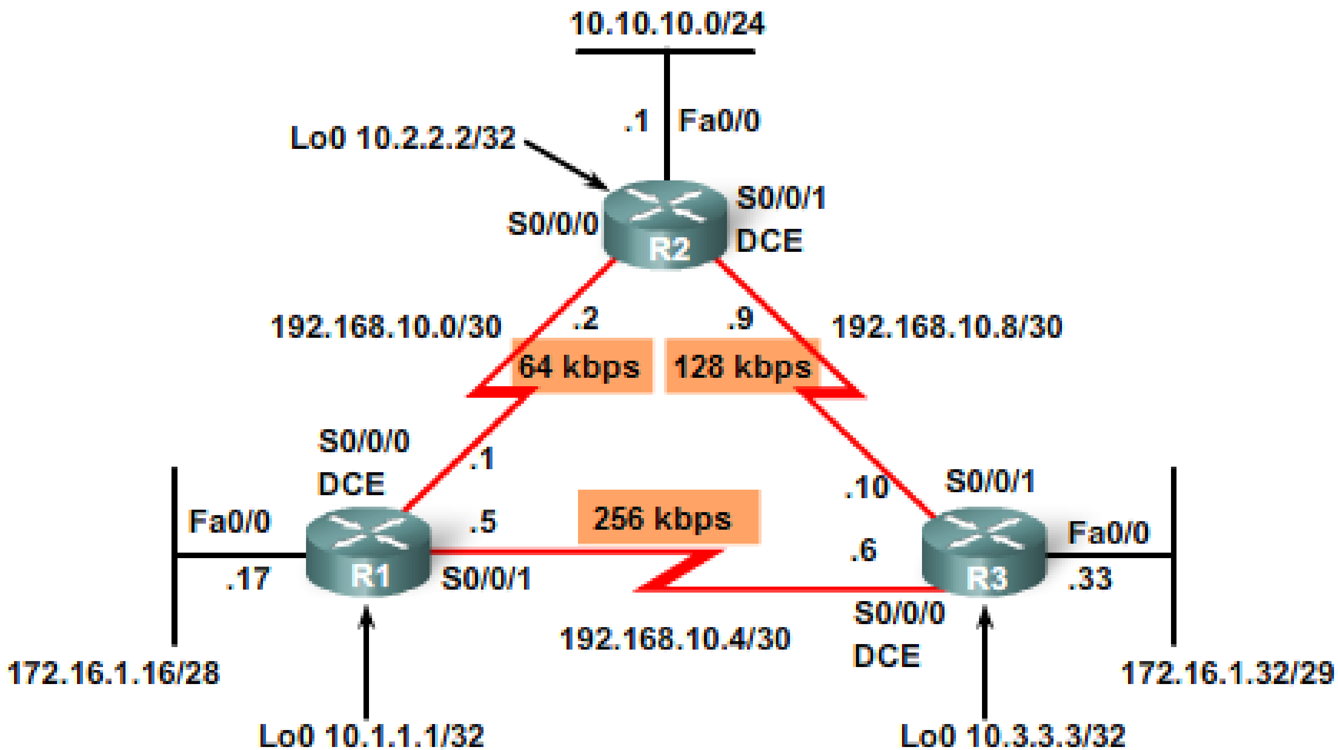



```
R1#show interface serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Hardware is GT96K Serial
  Description: Link to R2
  Internet address is 192.168.10.1/30
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
```

Default Bandwidth = 1544 kbps

Actual Bandwidth = 64 kbps

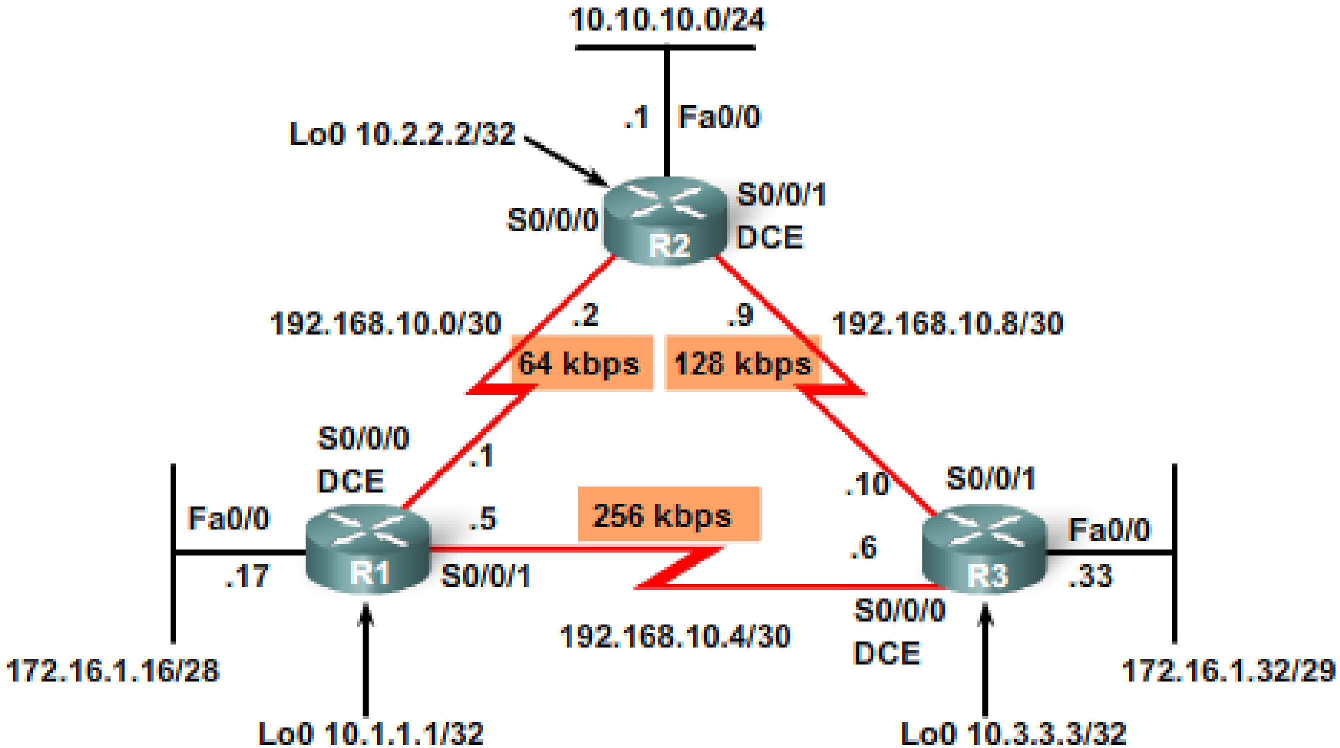
Differences Between Default and Actual Bandwidth




```
R1#show ip route
Codes: <some code output omitted>
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

O       192.168.10.8 [110/128] via 192.168.10.6, 14:27:57, Serial0/0/1
                     [110/128] via 192.168.10.2, 14:27:57, Serial0/0/0
```

R1 assumes that cost to 192.168.10.8 is equal through R2 or R3.

Differences Between Default and Actual Bandwidth




```
R1#show ip ospf interface serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Internet Address 192.168.10.1/30, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT_TO_POINT, Cost: 64
  <output omitted>
```

The OSPF cost value of 64 is not the same as 64 kbps.
The OSPF cost value of a 64 kbps link is 1562.

The `bandwidth` Command

```
R1(config)#inter serial 0/0/0
R1(config-if)#bandwidth 64
R1(config-if)#inter serial 0/0/1
R1(config-if)#bandwidth 256
R1(config-if)#end
R1#show ip ospf interface serial 0/0/0
Serial0/0 is up, line protocol is up
  Internet Address 192.168.10.1/30, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT_TO_POINT, Cost: 1562
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  <output omitted>
```

10^8/64,000 bps = 1562

```
R2(config)#inter serial 0/0/0
R2(config-if)#bandwidth 64
R2(config-if)#inter serial 0/0/1
R2(config-if)#bandwidth 128
```

```
R3(config)#inter serial 0/0/0
R3(config-if)#bandwidth 256
R3(config-if)#inter serial 0/0/1
R3(config-if)#bandwidth 128
```

The `ip ospf cost` Command

```
R1(config)#inter serial 0/0/0
R1(config-if)#ip ospf cost 1562
R1(config-if)#end
R1#show ip ospf interface serial 0/0/0
Serial0/0 is up, line protocol is up
  Internet Address 192.168.10.1/30, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT_TO_POINT, Cost: 1562
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  <output omitted>
```

No Calculation Needed

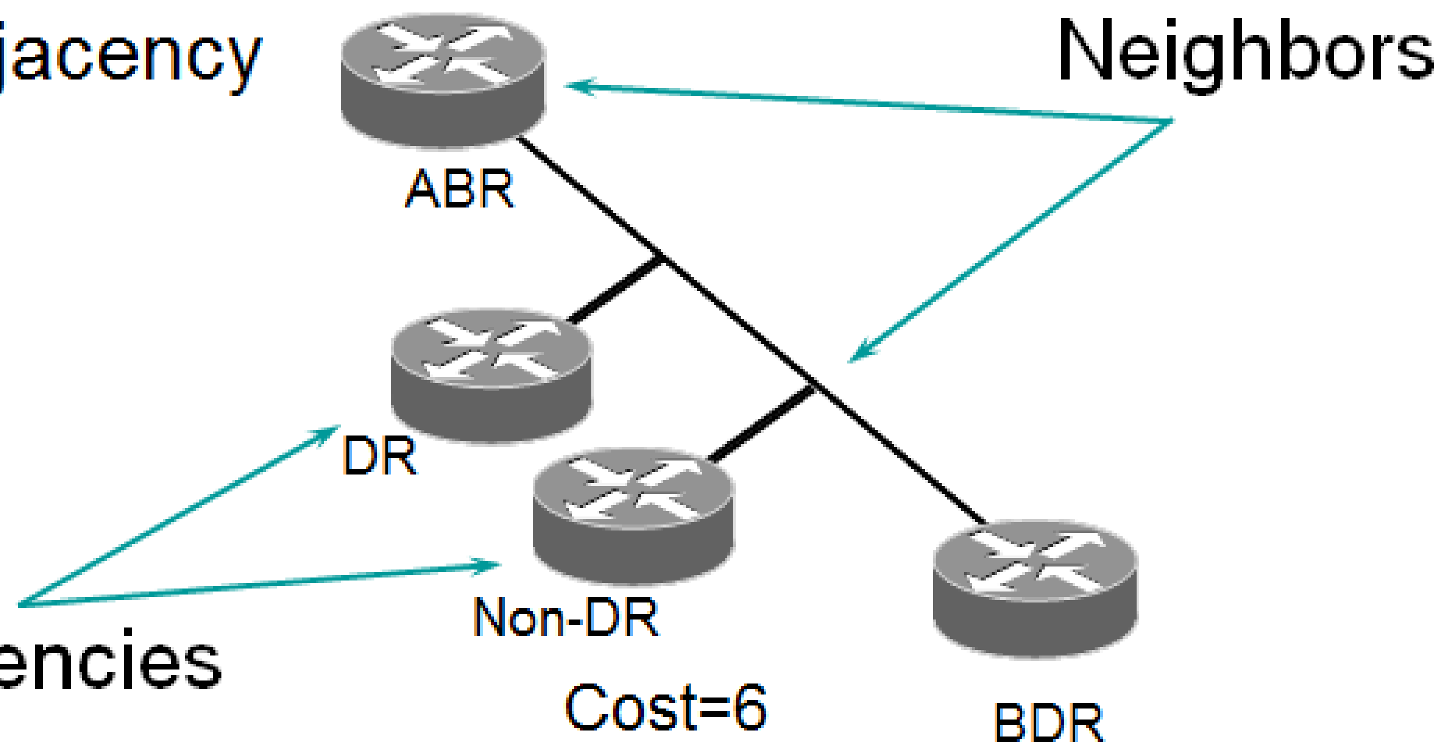
Equivalent Commands

bandwidth **Commands**		ip ospf cost **Commands**
Router R1 R1(config)#interface serial 0/0/0 R1(config-if)#bandwidth 64	=	Router R1 R1(config)#interface serial 0/0/0 R1(config-if)#ip ospf cost 1562
R1(config)#interface serial 0/0/1 R1(config-if)#bandwidth 256	=	R1(config)#interface serial 0/0/1 R1(config-if)#ip ospf cost 390
Router R2 R2(config)#interface serial 0/0/0 R2(config-if)#bandwidth 64	=	Router R2 R2(config)#interface serial 0/0/0 R2(config-if)#ip ospf cost 1562
R2(config)#interface serial 0/0/1 R2(config-if)#bandwidth 128	=	R2(config)#interface serial 0/0/1 R2(config-if)#ip ospf cost 781
Router R3 R3(config)#interface serial 0/0/0 R3(config-if)#bandwidth 256	=	Router R3 R3(config)#interface serial 0/0/0 R3(config-if)#ip ospf cost 390
R3(config)#interface serial 0/0/1 R3(config-if)#bandwidth 128	=	R3(config)#interface serial 0/0/0 R3(config-if)#ip ospf cost 781

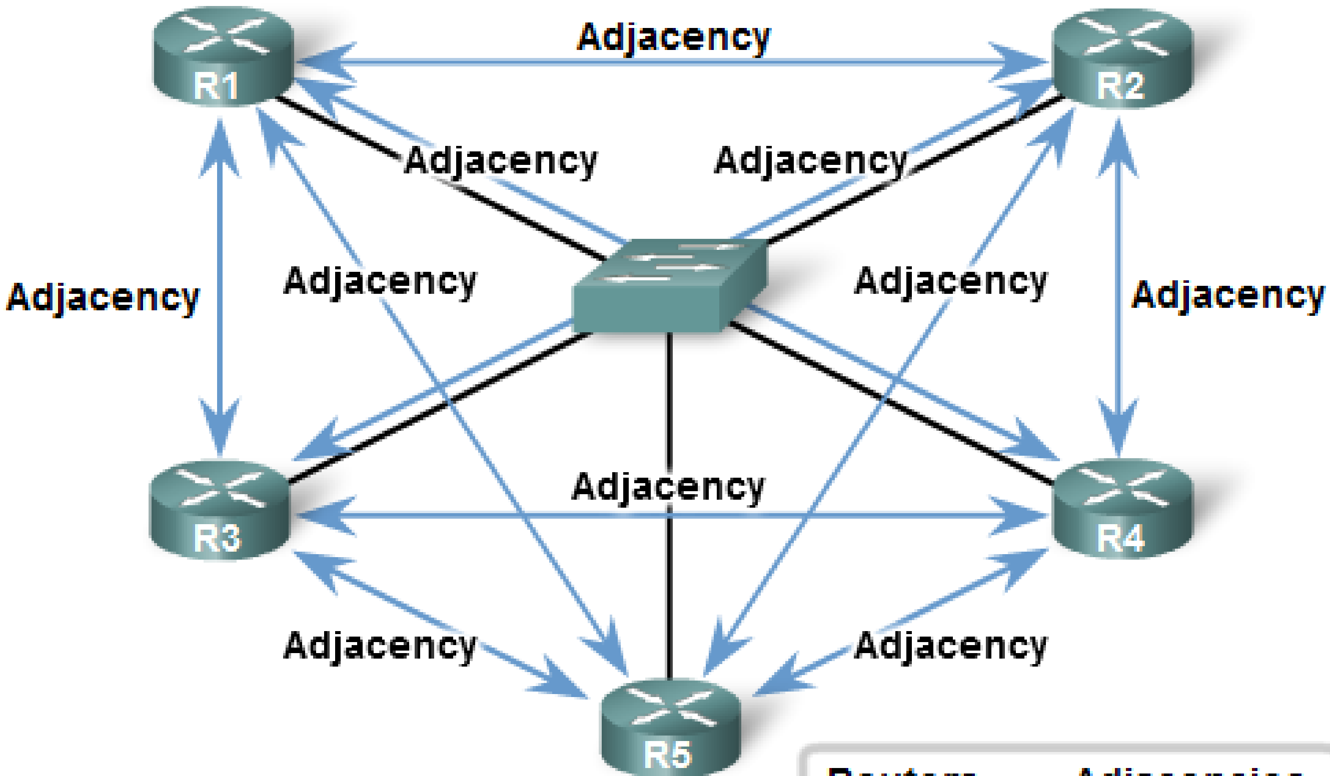
Practice 02

OSPF Terminology

- Neighbor
- Adjacency



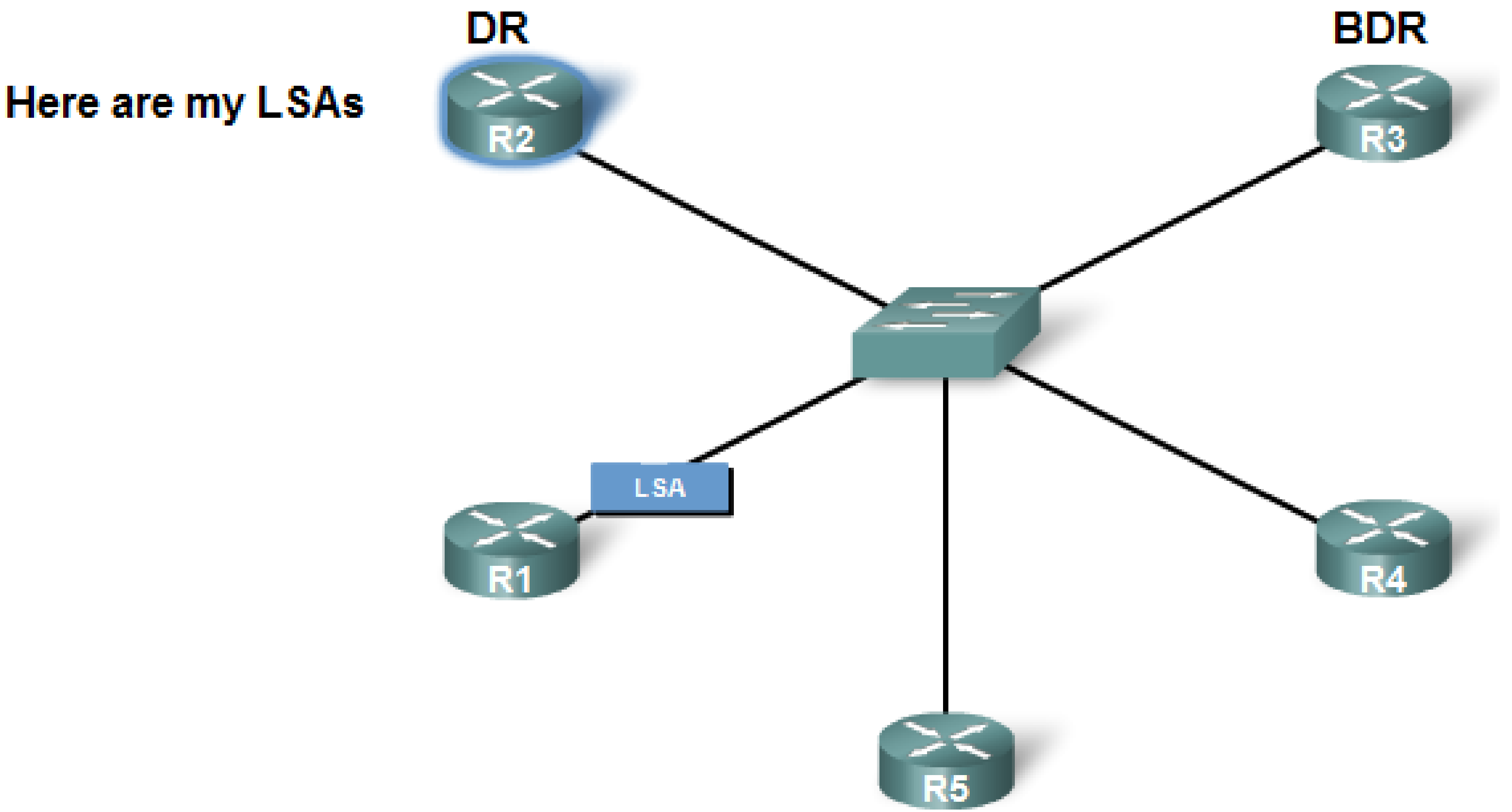
Number of Adjacencies Grows Exponentially



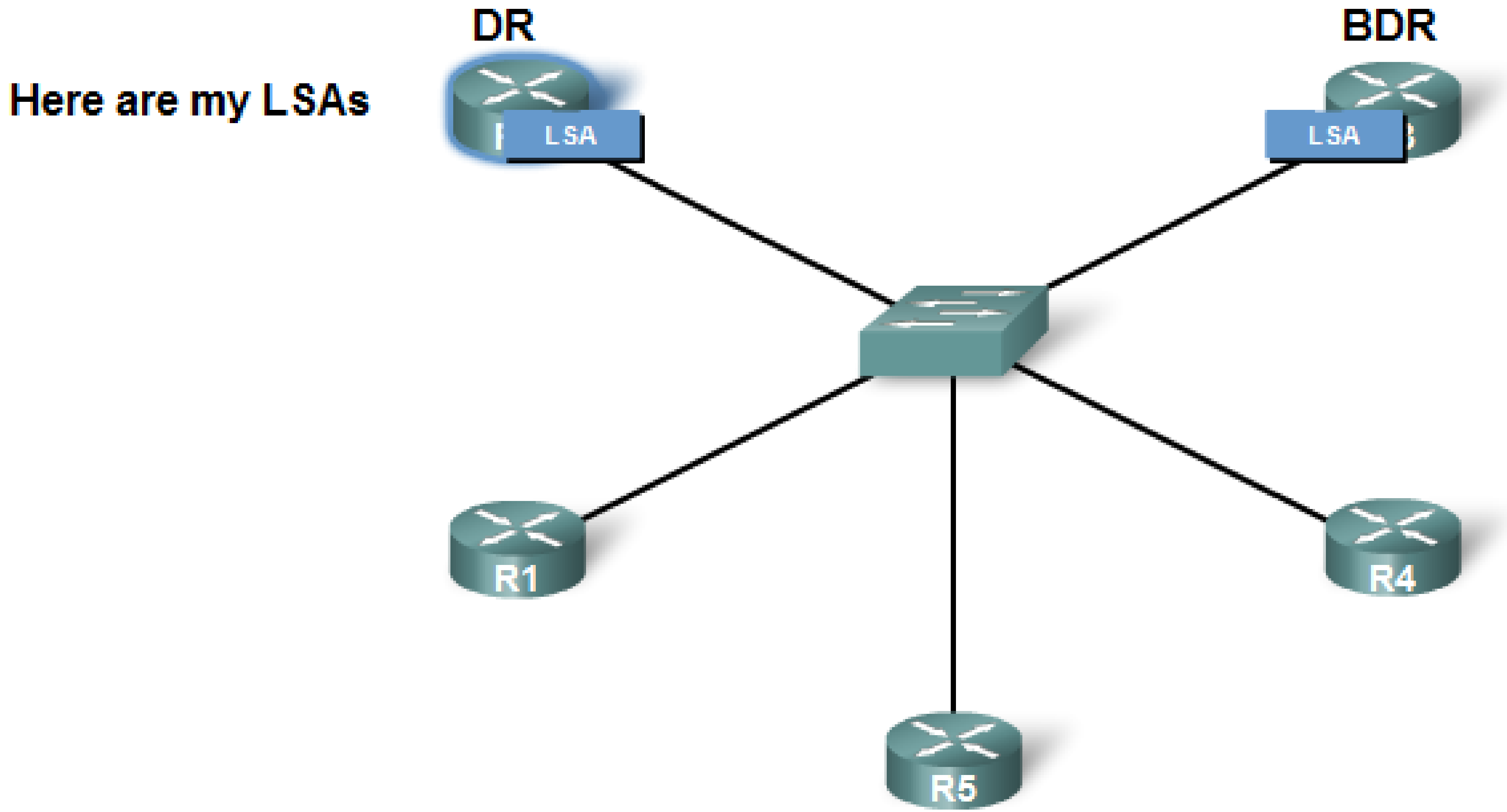
Number of Adjacencies = n(n-1)/2
n = number of routers
Example: 5 routers (5 - 1)/2 = 10 adjacencies

Routers	Adjacencies
n	n(n-1)/2
5	**10**
10	45
20	190
100	4,950

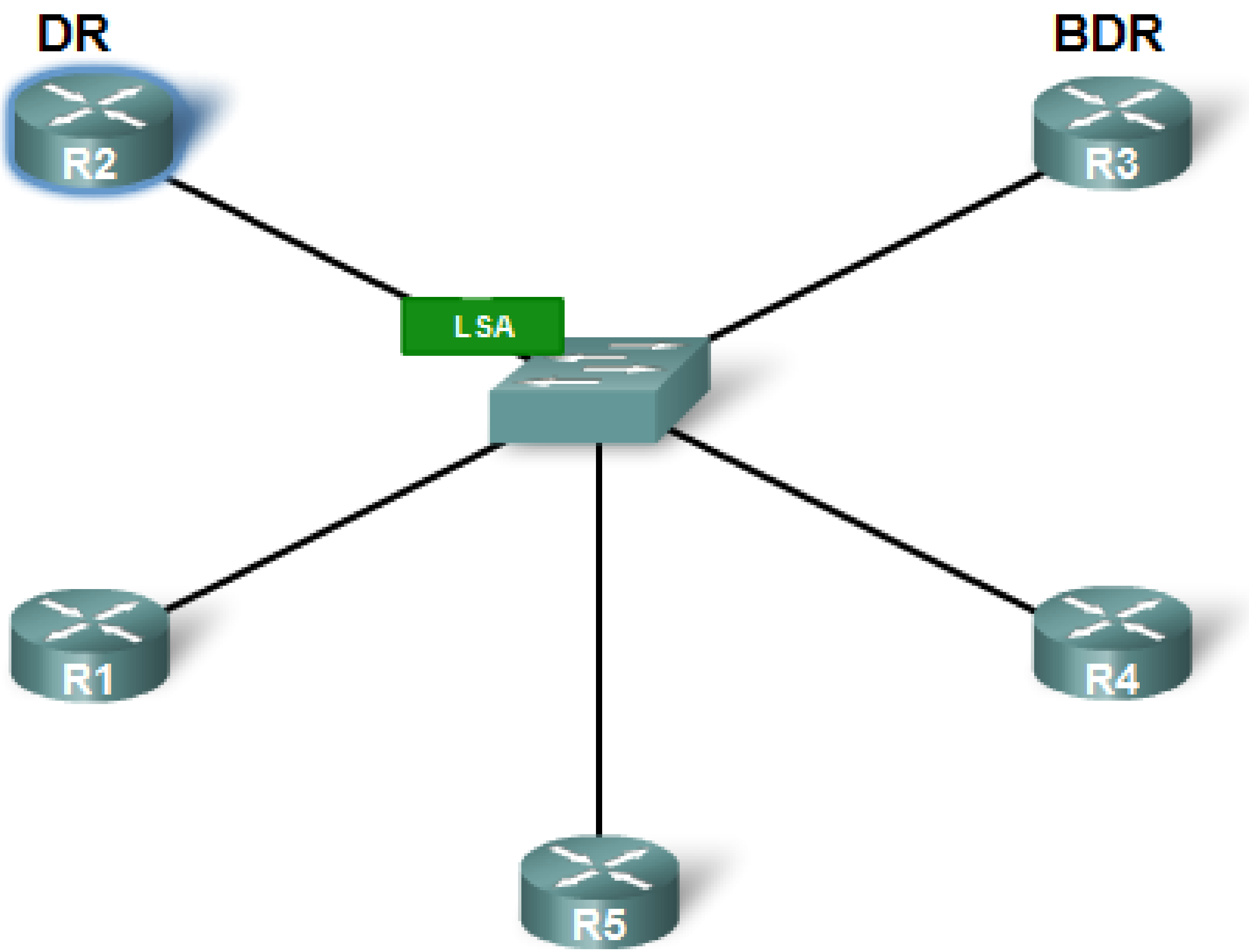
Adjacencies are formed with DR and BDR only.
LSAs are sent to the DR. BDR listens.



Adjacencies are formed with DR and BDR only.
LSAs are sent to the DR. BDR listens.

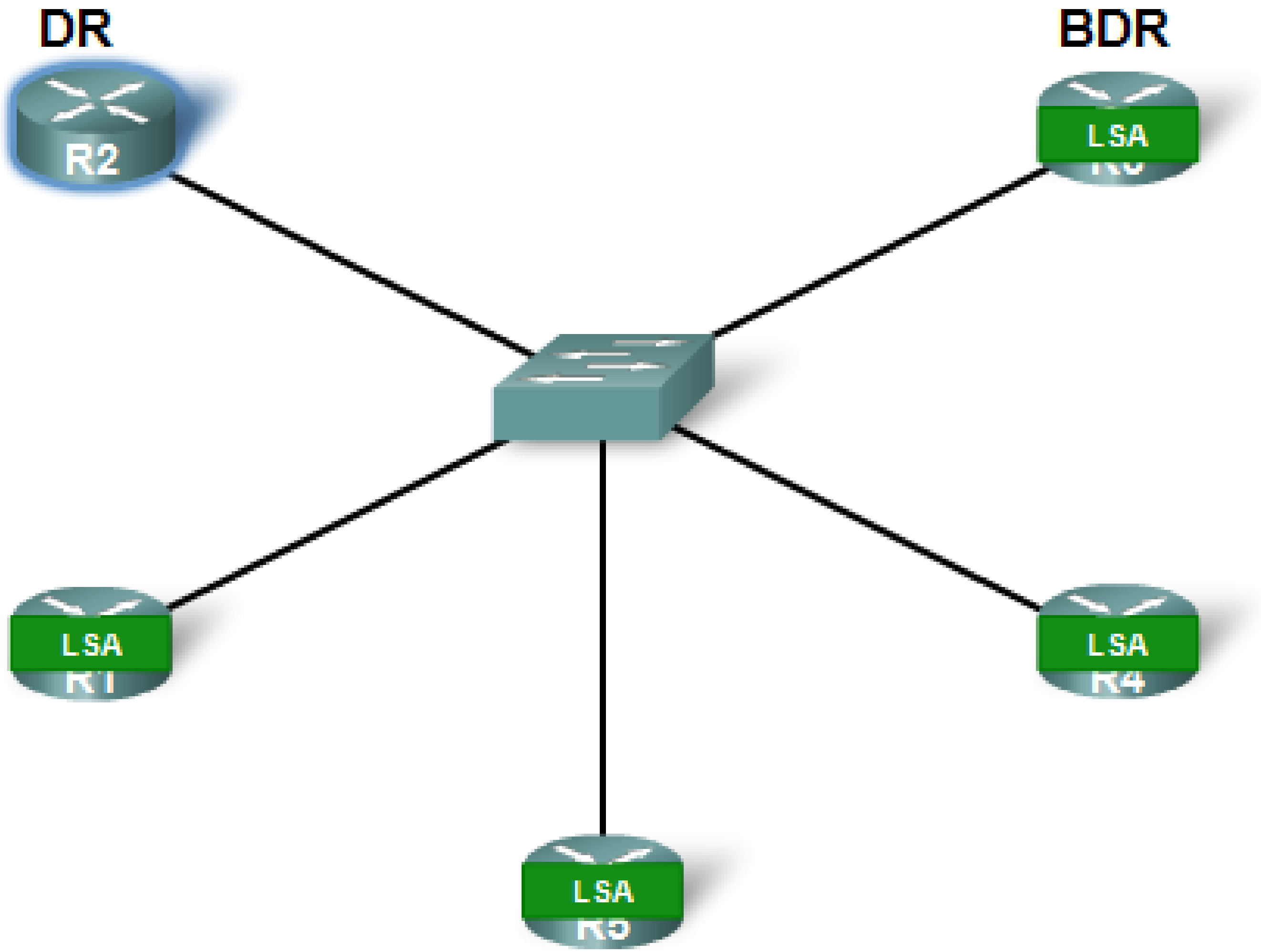


DR sends out any LSAs to all other routers.



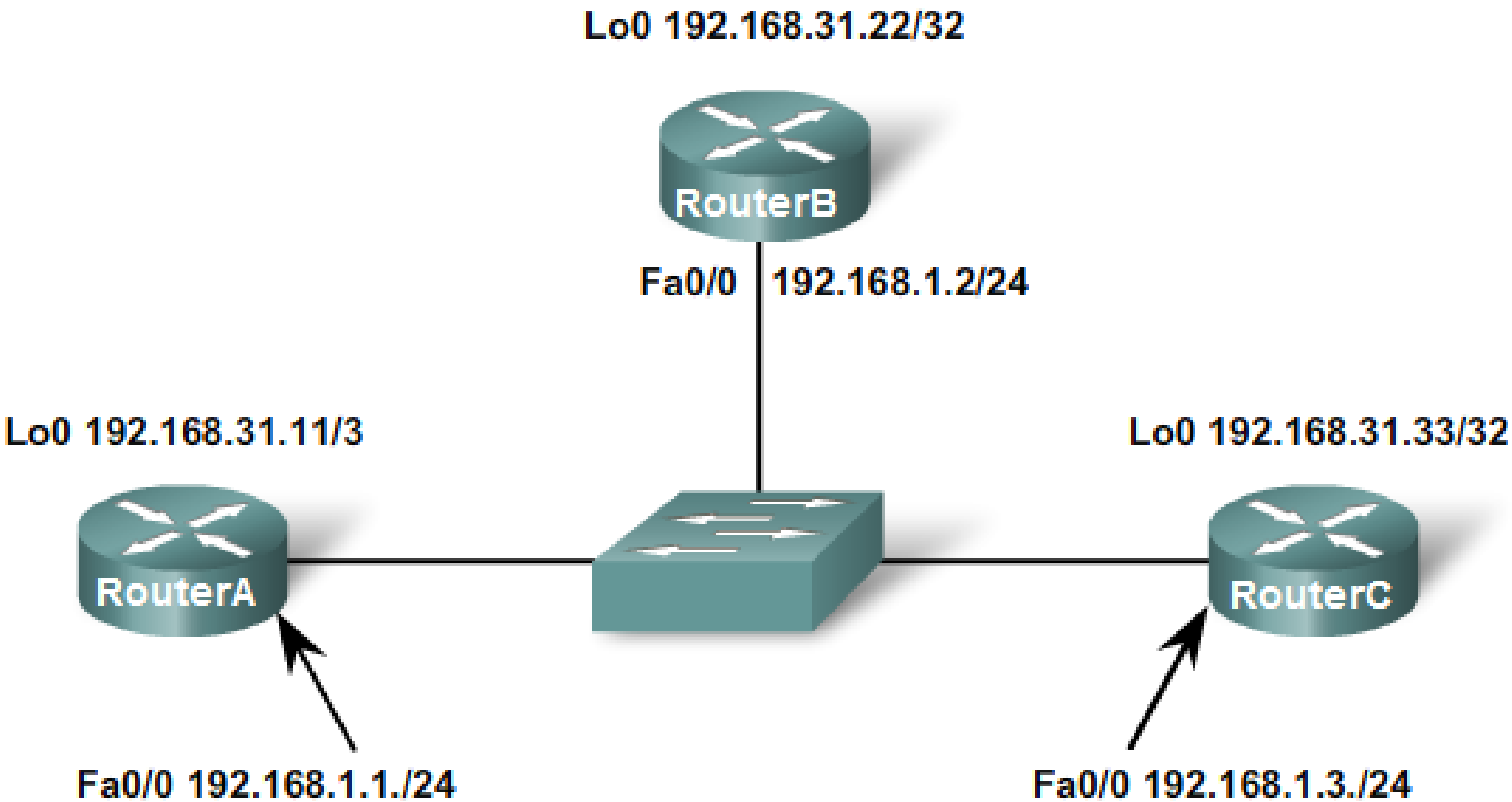
Here are 10.1.1.1's LSAs

DR sends out any LSAs to all other routers.



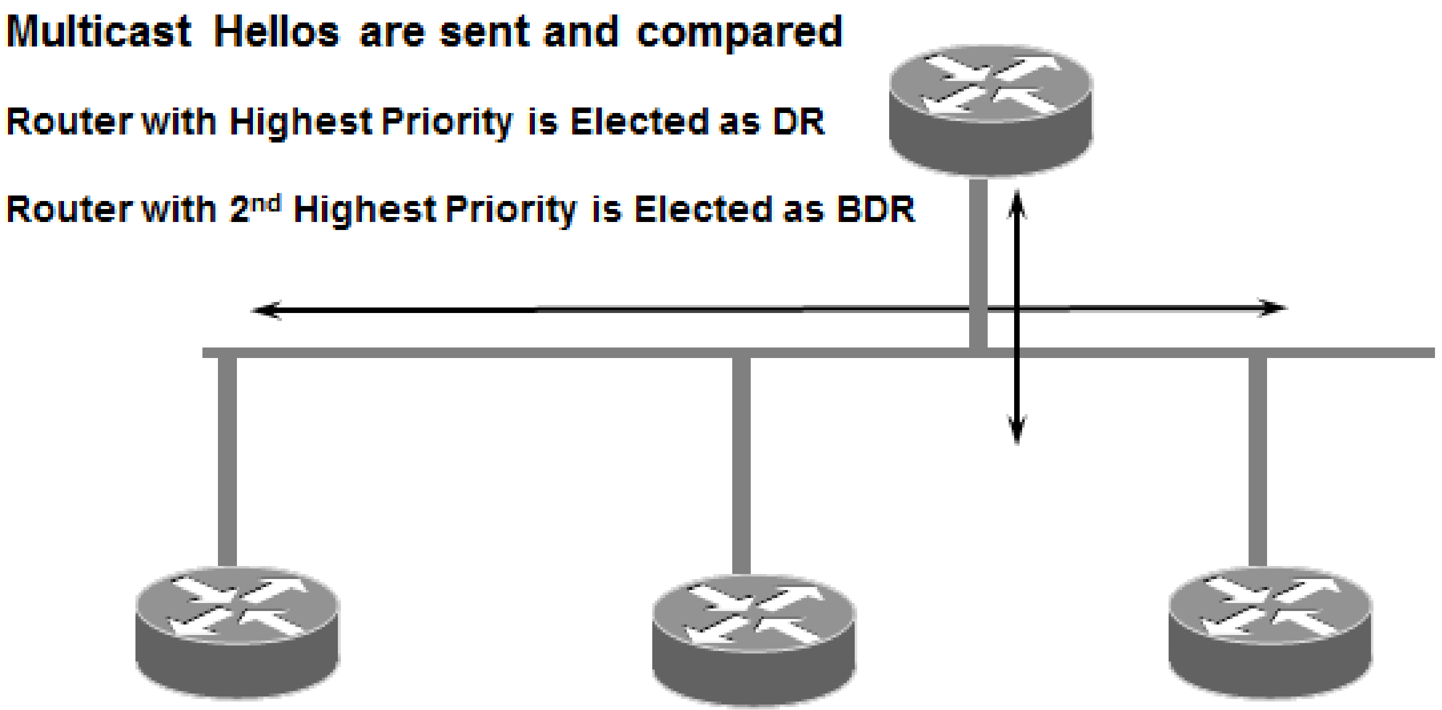
Here are 10.1.1.1's LSAs

Multiaccess Three Router Topology

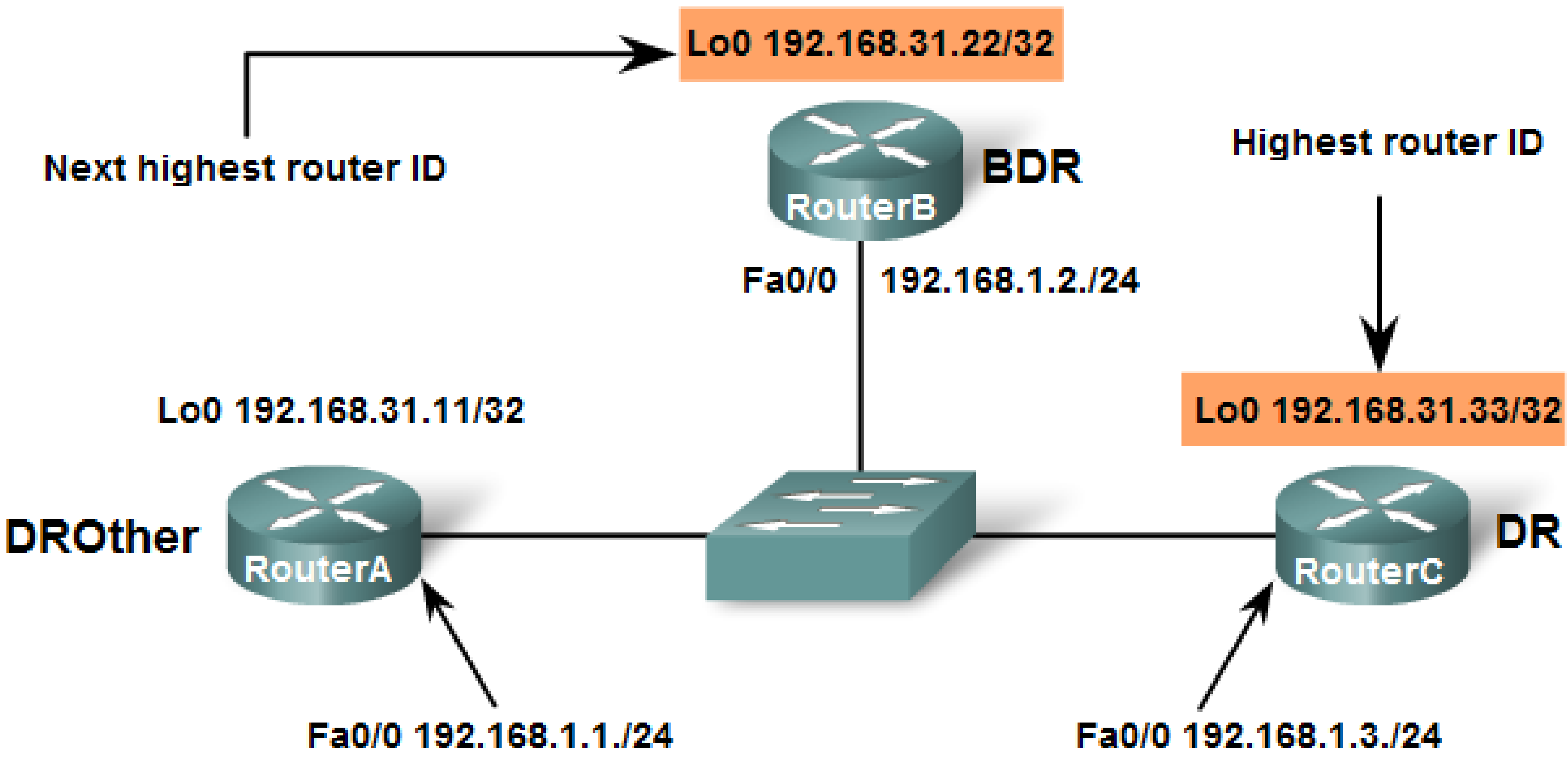


Notice that routers are now communicating via LAN interfaces.

Electing the DR and BDR



- OSPF sends Hellos which elect DRs and BDRs
- Router form adjacencies with DRs and BDRs in a multi-access environment


Lo0 192.168.31.22/32
Next highest router ID
RouterB
BDR
Highest router ID
Fa0/0
192.168.1.2./24
Lo0 192.168.31.11/32
Lo0 192.168.31.33/32
DROther
RouterA
RouterC
DR
Fa0/0 192.168.1.1./24
Fa0/0 192.168.1.3./24

```
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
```

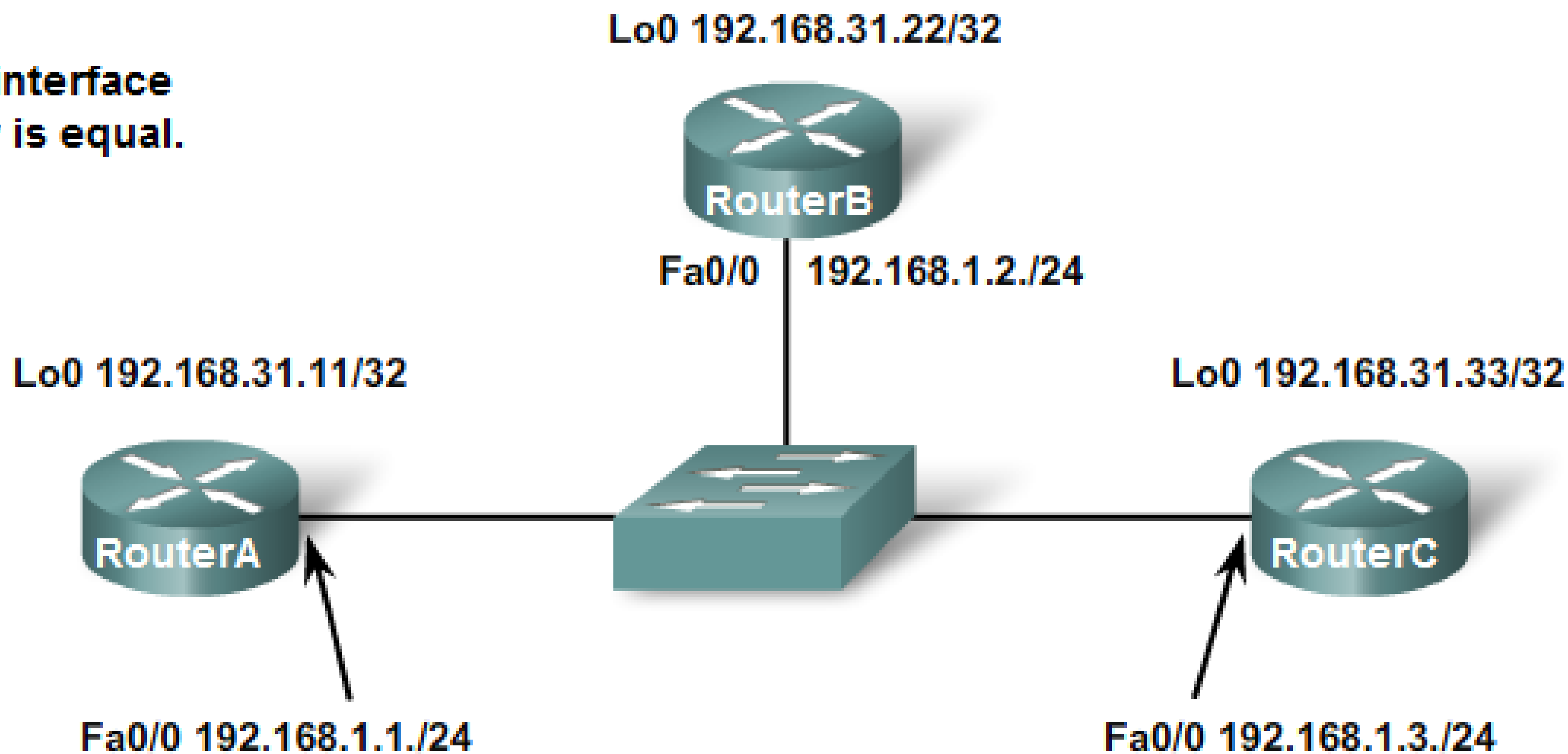
```
RouterC#show ip ospf neighbor

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
```

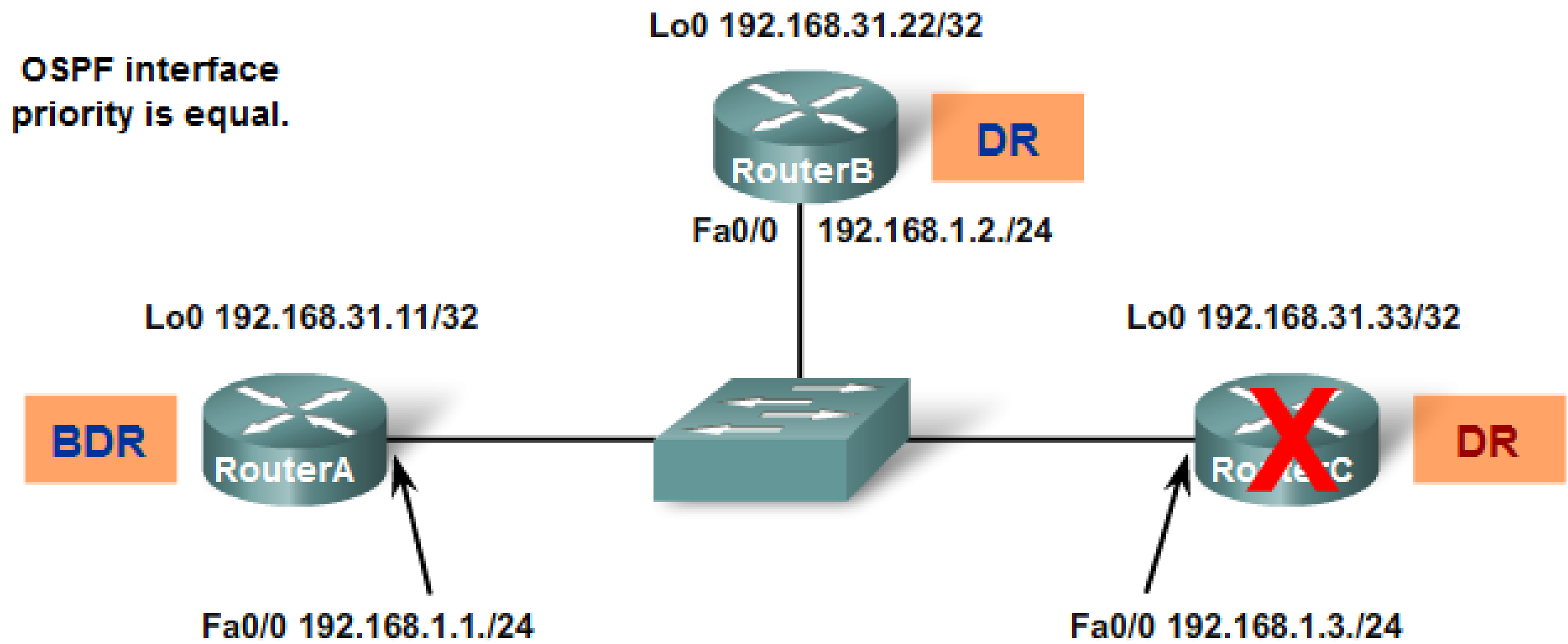
Priority is equal at the default value of 1.

```
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)
```

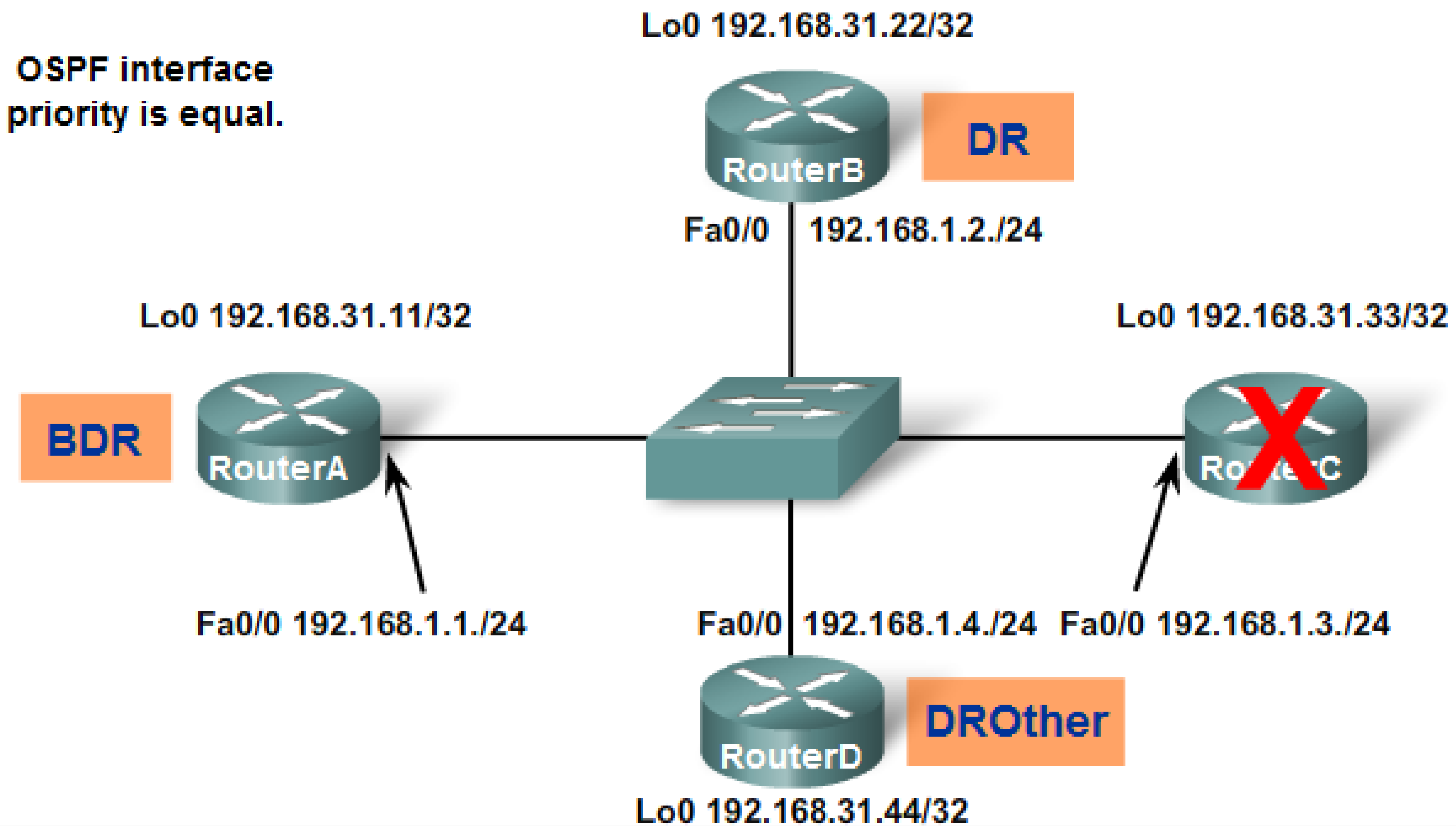
DR/BDR Election Scenarios

OSPF interface priority is equal.

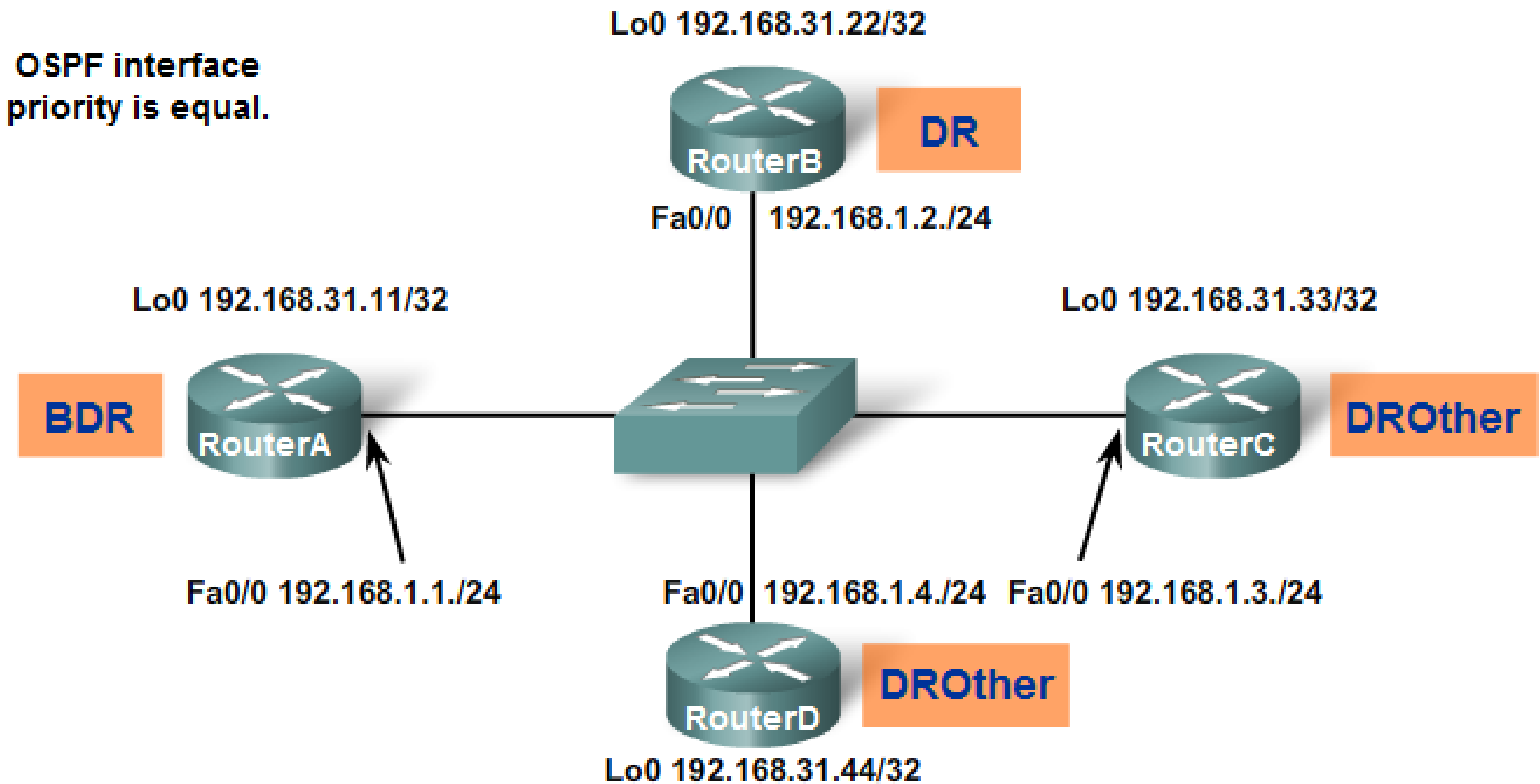




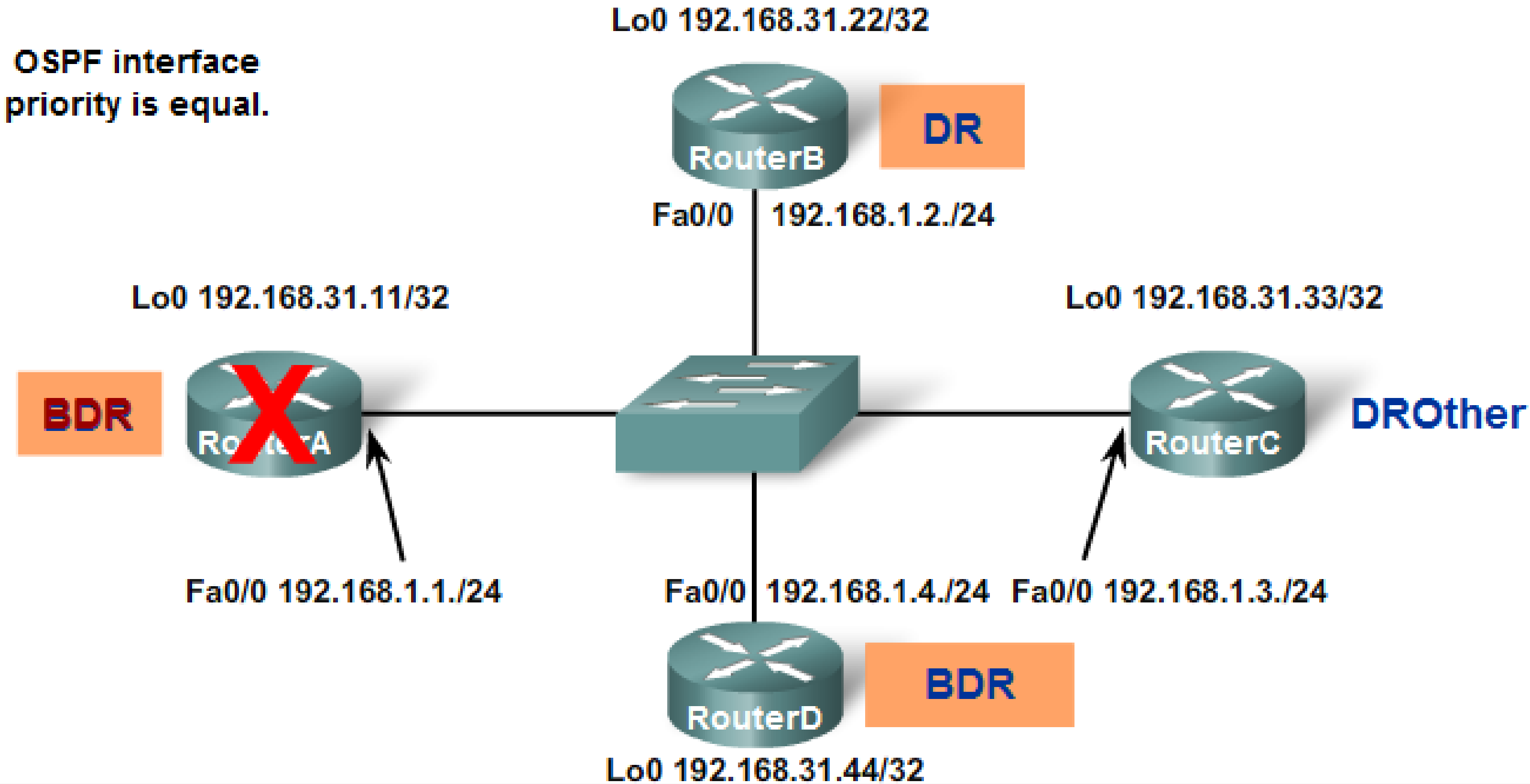
Router C fails and RouterB becomes the DR.



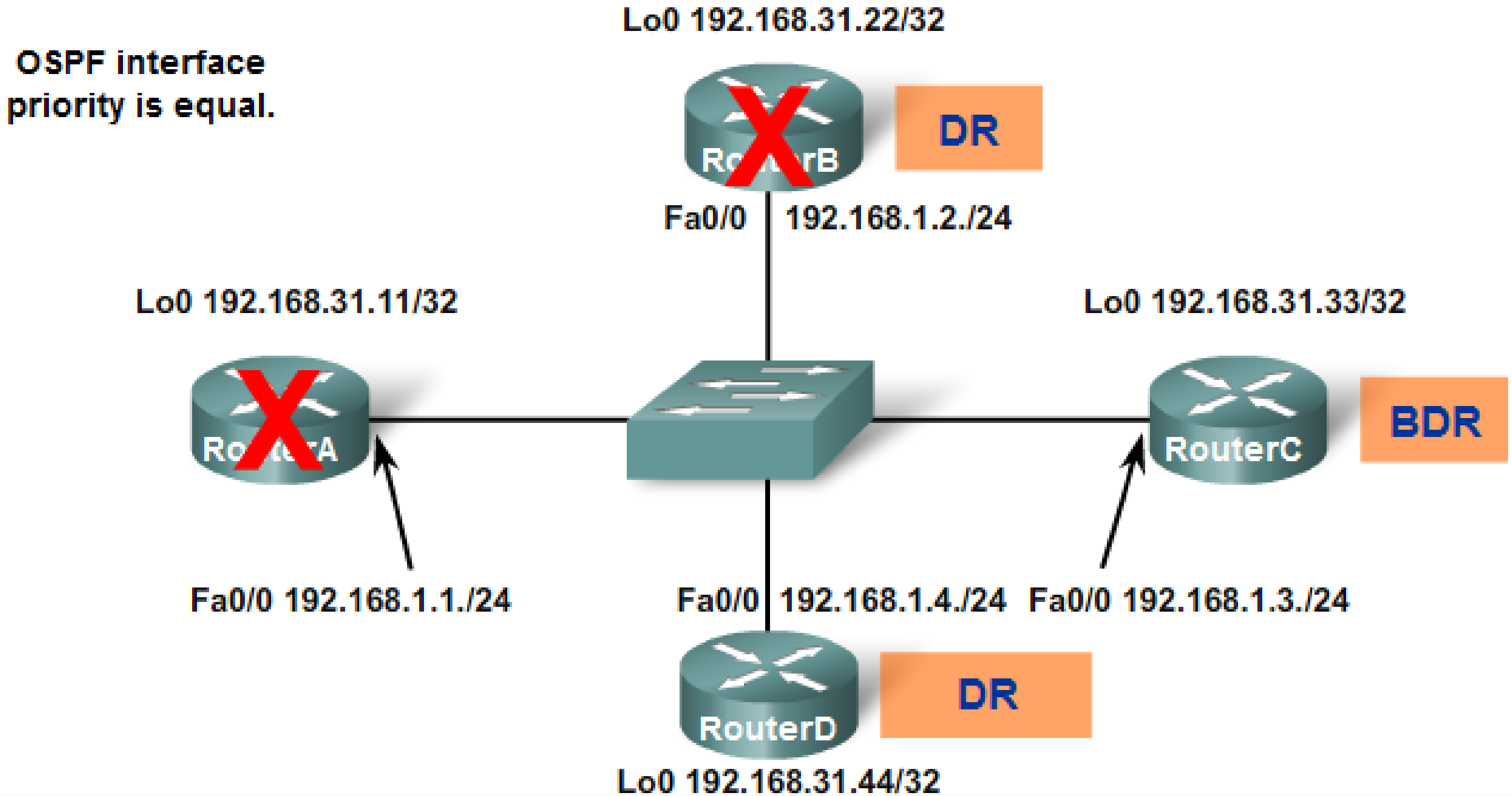
RouterB remains the DR even when new router is added.



RouterB remains the DR even when former DR returns.

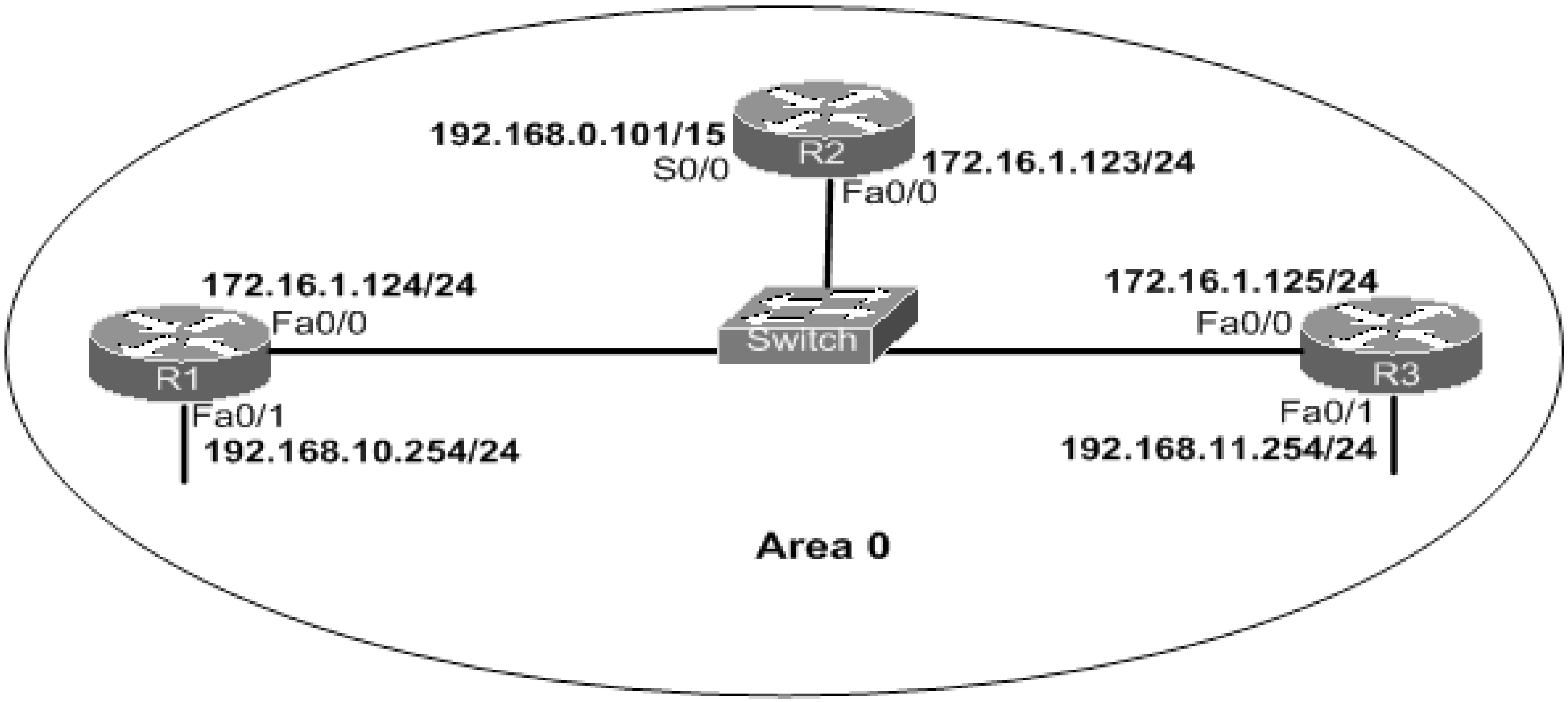


BDR fails, highest router ID among the DROthers becomes new BDR.



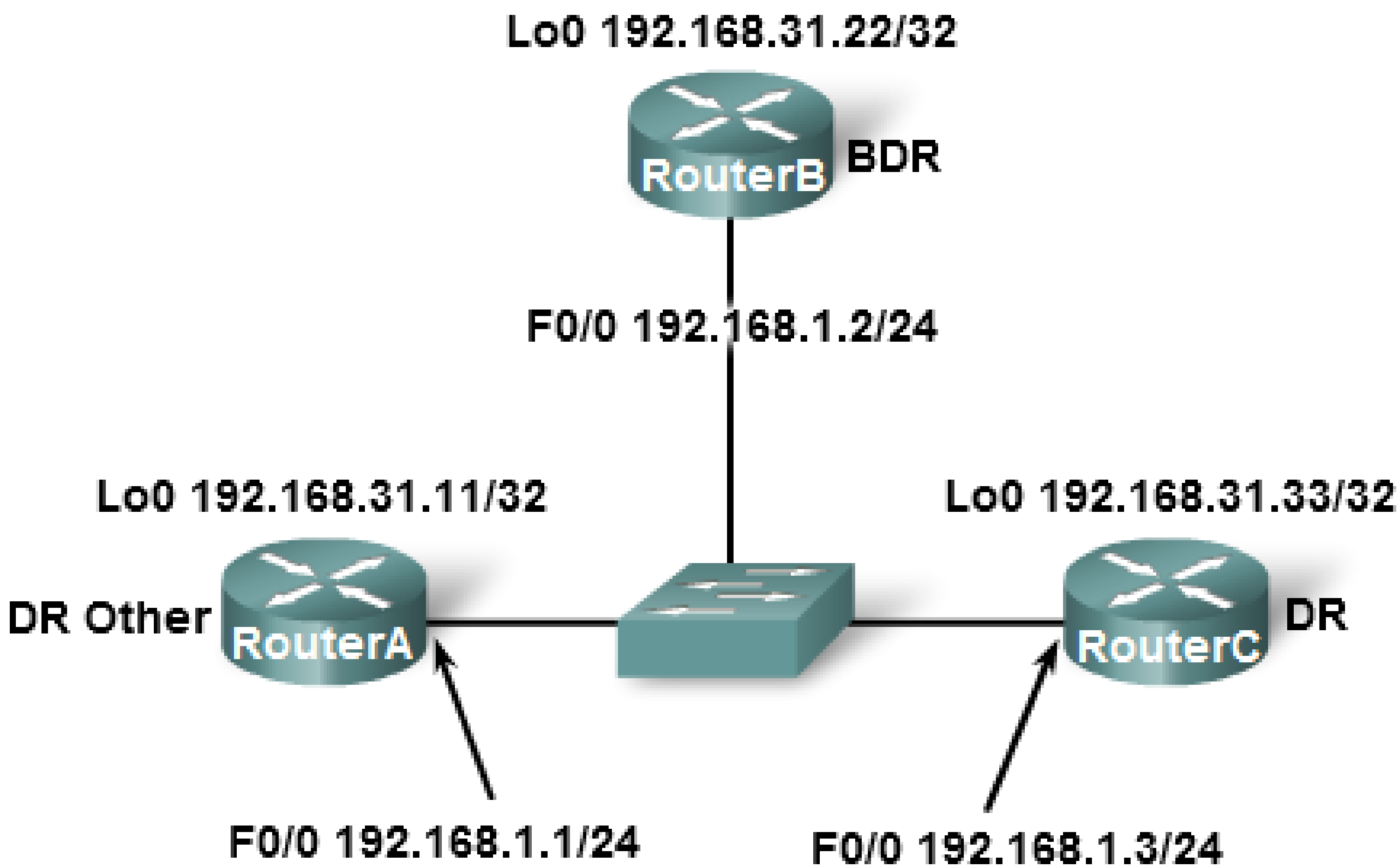
Both DR and BDR fail, highest router IDs become new DR and BDR.

Ensuring your DR



What options can you configure that will ensure that R2 will be the DR of the LAN segment?

Multiaccess Topology



```
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)
```

All routers currently have the default OSPF Interface Priority of 1

Changing OSPF Interface Priority

```
RouterA(config)#interface fastethernet 0/0
RouterA(config-if)#ip ospf priority 200
```

```
RouterB(config)#interface fastethernet 0/0
RouterB(config-if)#ip ospf priority 100
```

```
#interface fastethernet 0/0
-if)#shutdown
-if)#no shutdown
-if)#end
```

```
RouterA(config-if)#end
RouterA#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.31.22   100   FULL/BDR        00:00:30    192.168.1.2     FastEthernet0/0
192.168.31.33     1   FULL/DROTHER    00:00:30    192.168.1.3     FastEthernet0/0
```

```
RouterB(config-if)#end
RouterB#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.31.11   200   FULL/DR         00:00:37    192.168.1.1     FastEthernet0/0
192.168.31.33     1   FULL/DROTHER    00:00:38    192.168.1.3     FastEthernet0/0
```

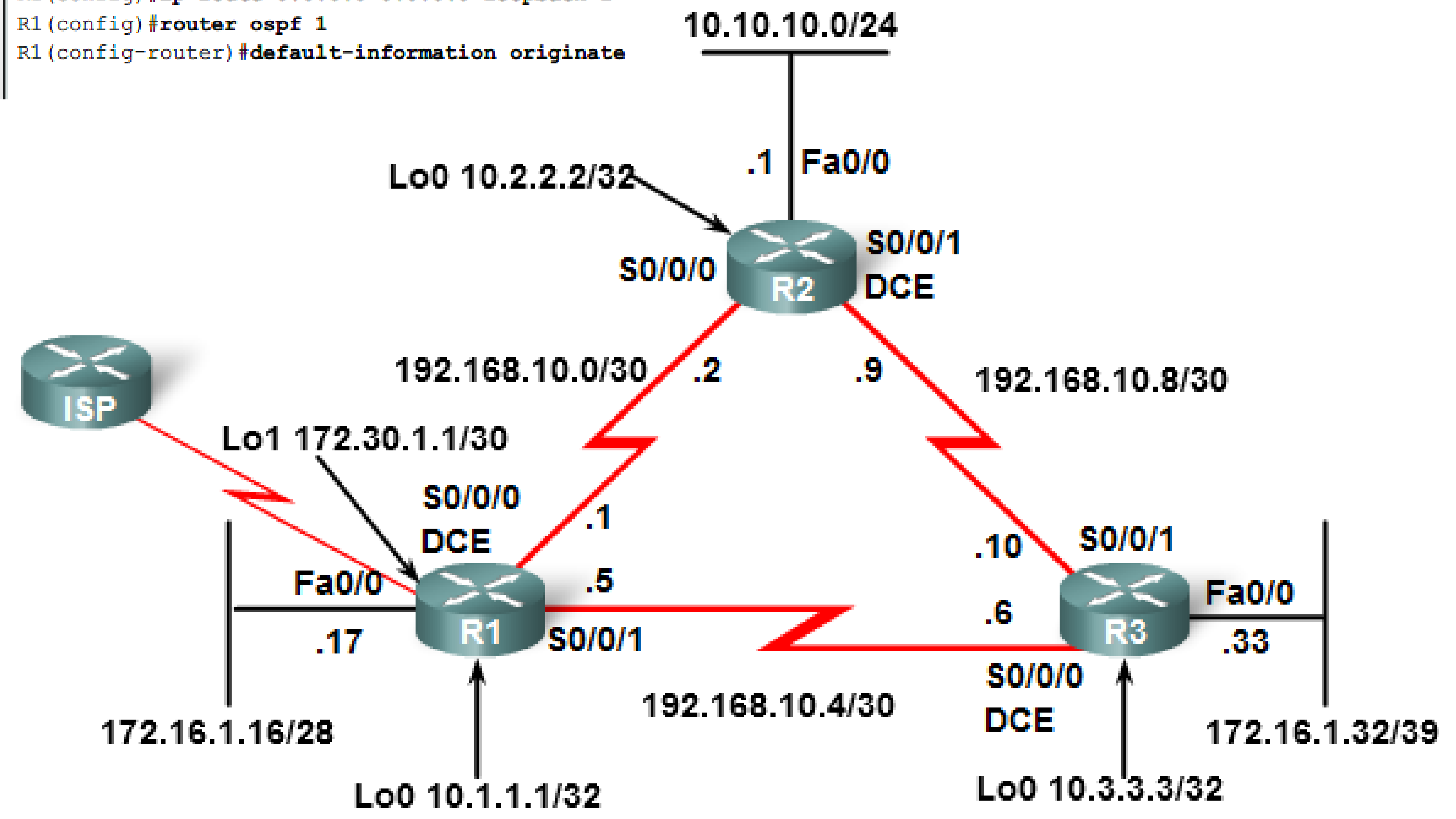
```
RouterC(config-if)#end
RouterC#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.31.22   100   FULL/BDR        00:00:32    192.168.1.2     FastEthernet0/0
192.168.31.11   200   FULL/DR         00:00:31    192.168.1.1     FastEthernet0/0
```

DR and BDR roles change

Practice 03

Topology with ISP Connection

```
R1(config)#interface loopback 1
R1(config-if)#ip add 172.30.1.1 255.255.255.252
R1(config-if)#exit
R1(config)#ip route 0.0.0.0 0.0.0.0 loopback 1
R1(config)#router ospf 1
R1(config-router)#default-information originate
```



```
R1#show ip route
Codes: <some code output omitted>
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       E1 - OSPF external type 1, E2 - OSPF external type 2

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

     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 [110/1171] via 192.168.10.6, 00:00:58, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O       172.16.1.32/29 [110/391] via 192.168.10.6, 00:00:58, Serial0/0/1
C       172.16.1.16/28 is directly connected, FastEthernet0/0
     172.30.0.0/30 is subnetted, 1 subnets
C       172.30.1.0 is directly connected, Loopback1
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
O       10.10.10.0/24 [110/1172] via 192.168.10.6, 00:00:58, Serial0/0/1
C       10.1.1.1/32 is directly connected, Loopback0
```

```
R2#show ip route
Codes: <some code output omitted>
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       E1 - OSPF external type 1, E2 - OSPF external type 2

Gateway of last resort is 192.168.10.10 to network 0.0.0.0

     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/0/0
O       192.168.10.4 [110/1171] via 192.168.10.10, 00:00:25, Serial0/0/1
C       192.168.10.8 is directly connected, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O       172.16.1.32/29 [110/782] via 192.168.10.10, 00:00:25, Serial0/0/1
O       172.16.1.16/28 [110/1172] via 192.168.10.10, 00:00:25, Serial0/0/1
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.2.2.2/32 is directly connected, Loopback0
C       10.10.10.0/24 is directly connected, FastEthernet0/0
O*E2     0.0.0.0/0 [110/1] via 192.168.10.10, 00:00:13, Serial0/0/1
```

```
R3#show ip route
Codes: <some code output omitted>
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       E1 - OSPF external type 1, E2 - OSPF external type 2

Gateway of last resort is 192.168.10.10 to network 0.0.0.0

     192.168.10.0/30 is subnetted, 3 subnets
O       192.168.10.0 [110/1952] via 192.168.10.5, 00:00:38, Serial0/0/0
C       192.168.10.4 is directly connected, Serial0/0/0
C       192.168.10.8 is directly connected, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.1.32/29 is directly connected, FastEthernet0/0
O       172.16.1.16/28 [110/391] via 192.168.10.5, 00:00:38, Serial0/0/0
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.3.3.3/32 is directly connected, Loopback0
O       10.10.10.0/24 [110/782] via 192.168.10.9, 00:00:38, Serial0/0/1
O*E2     0.0.0.0/0 [110/1] via 192.168.10.5, 00:00:27, Serial0/0/0
```

Changing the Reference Bandwidth

```
R1(config-if)#router ospf 1
R1(config-router)#auto-cost reference-bandwidth ?
  <1-4294967>  The reference bandwidth in terms of Mbits per second

R1(config-router)#auto-cost reference-bandwidth  10000
% OSPF: Reference bandwidth is changed.
```

```
R2(config-if)#router ospf 1
R2(config-router)#auto-cost reference-bandwidth  10000
% OSPF: Reference bandwidth is changed.
        Please ensure reference bandwidth is consistent across all routers.
```

```
R3(config-if)#router ospf 1
R3(config-router)#auto-cost reference-bandwidth  10000
% OSPF: Reference bandwidth is changed.
        Please ensure reference bandwidth is consistent across all routers.
```

```
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       E1 - OSPF external type 1, E2 - OSPF external type 2

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

     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 [110/1171] via 192.168.10.6, 00:00:58, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O       172.16.1.32/29 [110/391] via 192.168.10.6, 00:00:58, Serial0/0/1
C       172.16.1.16/28 is directly connected, FastEthernet0/0
     172.30.0.0/30 is subnetted, 1 subnets
C       172.30.1.0 is directly connected, Loopback1
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
O       10.10.10.0/24 [110/1172] via 192.168.10.6, 00:00:58, Serial0/0/1
C       10.1.1.1/32 is directly connected, Loopback0
S*   0.0.0.0/0 is directly connected, Loopback1
```

R1 Before

R1 After

```
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       E1 - OSPF external type 1, E2 - OSPF external type 2

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

     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 [110/104597] via 192.168.10.6, 00:01:33, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O       172.16.1.32/29 [110/39162] via 192.168.10.6, 00:01:33, Serial0/0/1
C       172.16.1.16/28 is directly connected, FastEthernet0/0
     172.30.0.0/30 is subnetted, 1 subnets
C       172.30.1.0 is directly connected, Loopback1
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
O       10.10.10.0/24 [110/65635] via 192.168.10.2, 00:01:33, Serial0/0/0
C       10.1.1.1/32 is directly connected, Loopback0
S*   0.0.0.0/0 is directly connected, Loopback1
```

Modifying Timers

```
R1#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.3.3.3          0   FULL/  -        00:00:35    192.168.10.6    Serial0/0/1
10.2.2.2          0   FULL/  -        00:00:36    192.168.10.2    Serial0/0/0
```

R1 Neighbors
1

Modifying Timers

```
R1(config)#interface serial 0/0/0
R1(config-if)#ip ospf hello-interval 5
R1(config-if)#ip ospf dead-interval 20
R1(config-if)#end

<Wait 20 seconds for IOS message>

%OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/0/0 from FULL to DOWN, Neighbor Down:
Dead timer expired
```

Modify R1 Timers

Modifying Timers

```
R1#show ip ospf neighbor

Neighbor ID      Pri   State           Dead Time   Address         Interface
10.3.3.3           0   FULL/  -        00:00:35    192.168.10.6    Serial0/0/1
```

R1 Neighbors
2

Modifying Timers

```
R2#show ip ospf interface serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Internet Address 192.168.10.2/30, Area 0
  Process ID 1, Router ID 10.2.2.2, Network Type POINT_TO_POINT, Cost: 65535
  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 00:00:09
  Supports Link-local Signaling (LLS)
  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 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

R2 Timers

Modifying Timers

```
R2(config)#interface serial 0/0/0
R2(config-if)#ip ospf hello-interval 5
R2(config-if)#ip ospf dead-interval 20
R2(config-if)#end
%OSPF-5-ADJCHG: Process 1, Nbr 10.1.1.1 on Serial0/0/0 from LOADING to FULL, Loading
Done
```

Modify R2 Timers

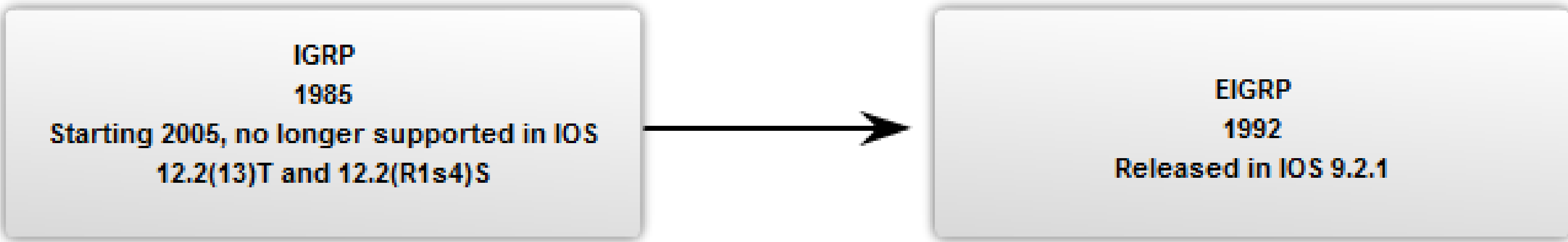
Modifying Timers

```
R1#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.3.3.3          0   FULL/  -        00:00:36    192.168.10.6    Serial0/0/1
10.2.2.2          0   FULL/  -        00:00:17    192.168.10.2    Serial0/0/0
```

R1 Neighbors
3

Practice 04

IGRP to EIGRP



Summary of Operations

Traditional Distance Vector Routing Protocols

- Use the Bellman-Ford or Ford-Fulkerson algorithm.
- Age out routing entries and uses periodic updates.
- Keep track of only the best routes; the best path to a destination network.
- When a route becomes unavailable, the router must wait for a new routing update.
- Slower convergence due to holddown timers.

Enhanced Distance Vector Routing Protocol: EIGRP

- Uses the Diffusing Update Algorithm (DUAL).
- Does not age out routing entries nor uses periodic updates.
- Maintains a topology table separate from the routing table, which includes the best path and any loop-free backup paths.
- When a route becomes unavailable, DUAL will use a backup path if one exists in the topology table.
- Faster convergence due to the absence of holddown timers and a system of coordinated route calculations.

Encapsulated EIGRP Message

Data Link Frame Header	IP Packet Header	EIGRP Packet Header	Type/Length/Values Types

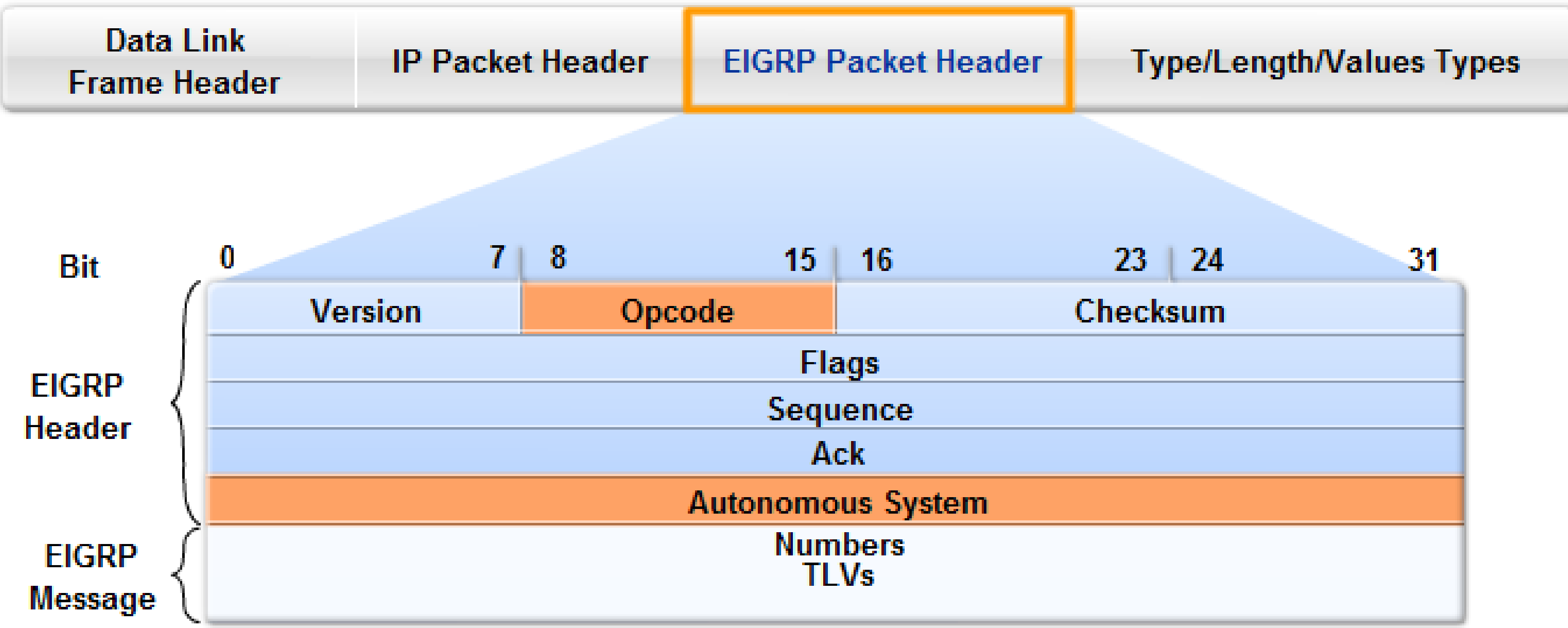
Data Link Frame
MAC Source Address = Address of sending interface
MAC Destination Address = Multicast: 01-00-5E-00-00-0A

IP Packet
IP Source Address = Address of sending interface
IP Destination Address = Multicast: 224.0.0.10
Protocol field = 88 for EIGRP

EIGRP Packet Header
Opcode for EIGRP packet type
AS Number

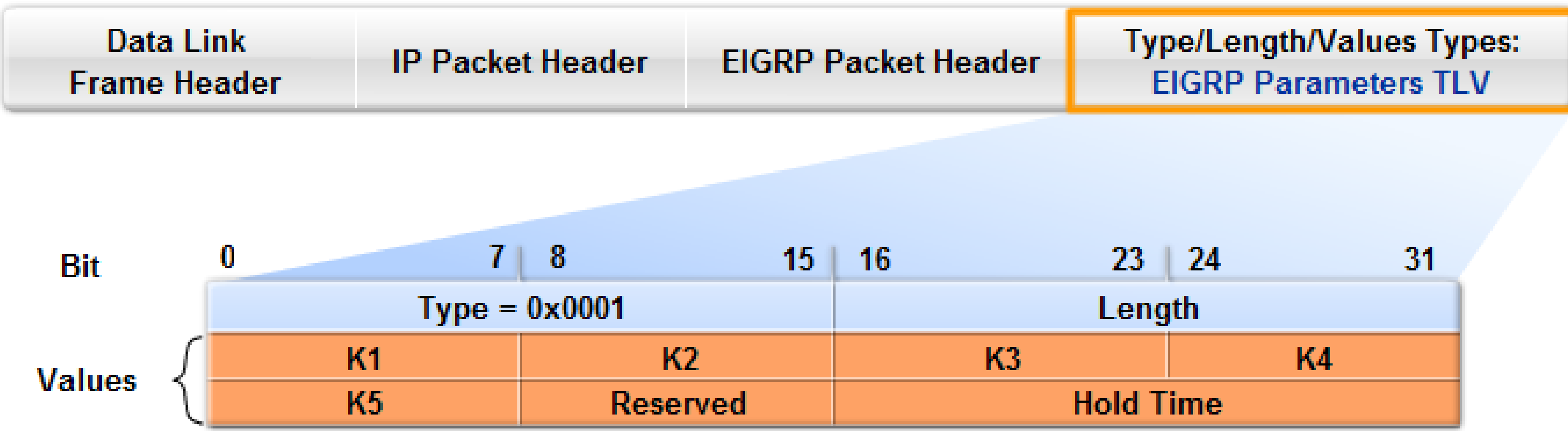
TLV Types
Some types include:
0x0001 EIGRP Parameters
0x0102 IP Internal Routes
0x0103 IP External Routes

Encapsulated EIGRP Message

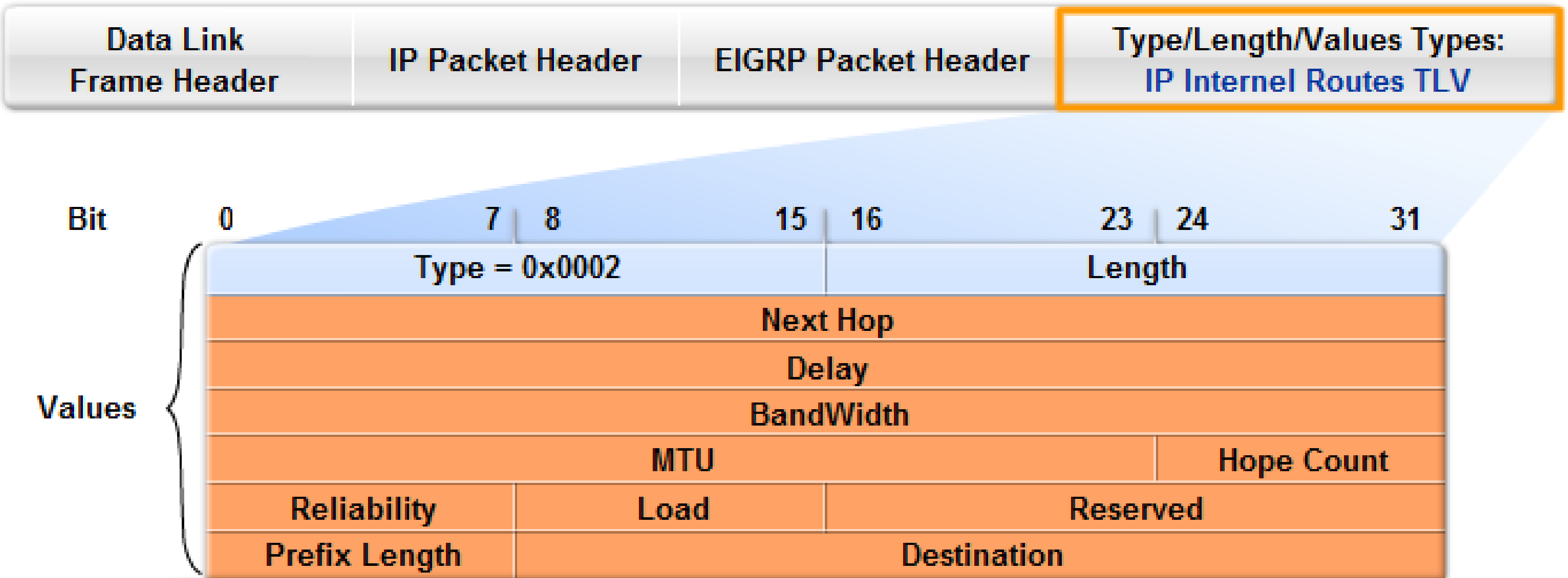


- **Opcode:** EIGRP Packet Type: Update (1),Query (3),Reply(4),Hello (5)
- **Autonomous System Number:** ID for this EIGRP routing process

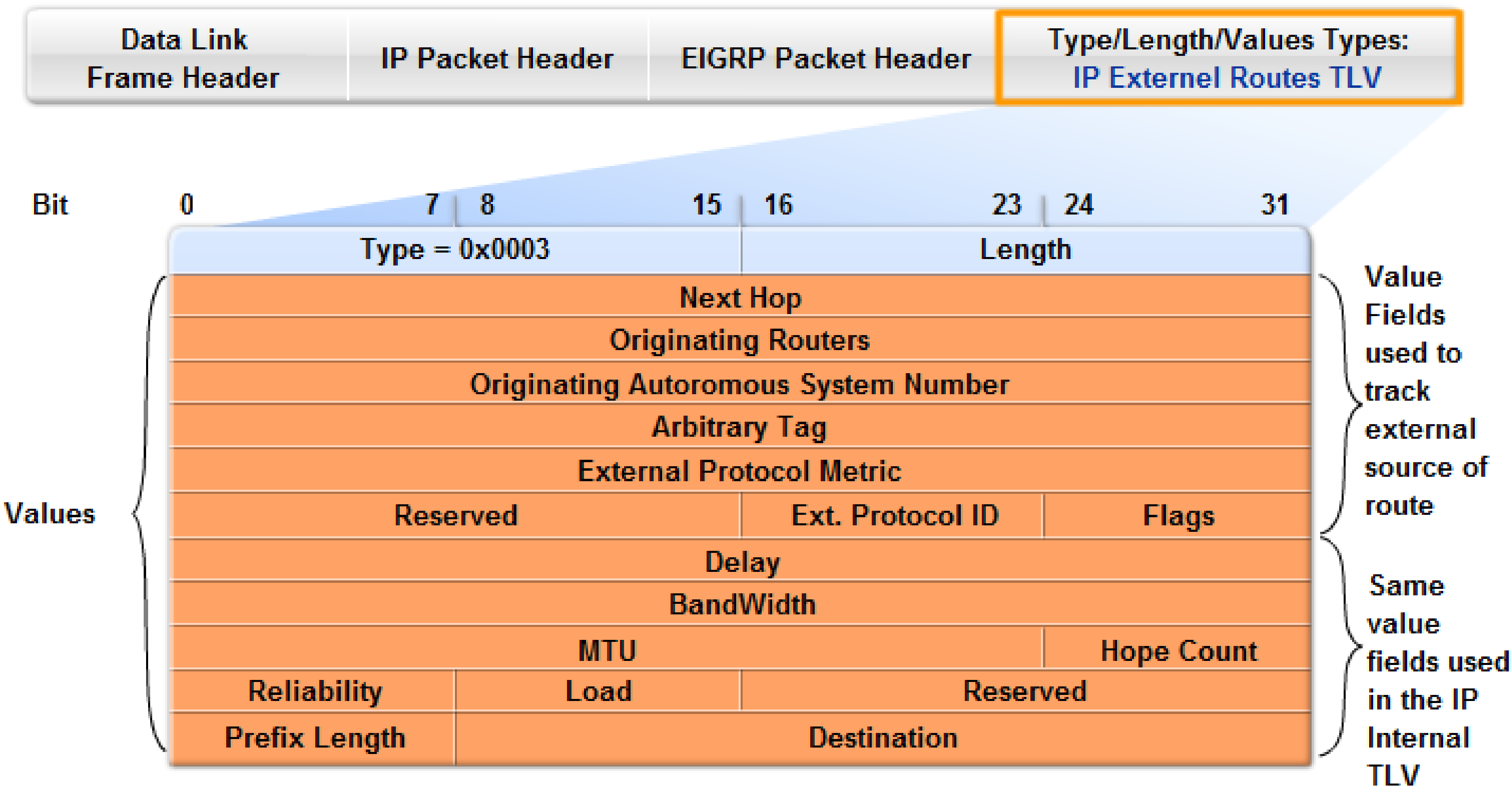
Encapsulated EIGRP Message



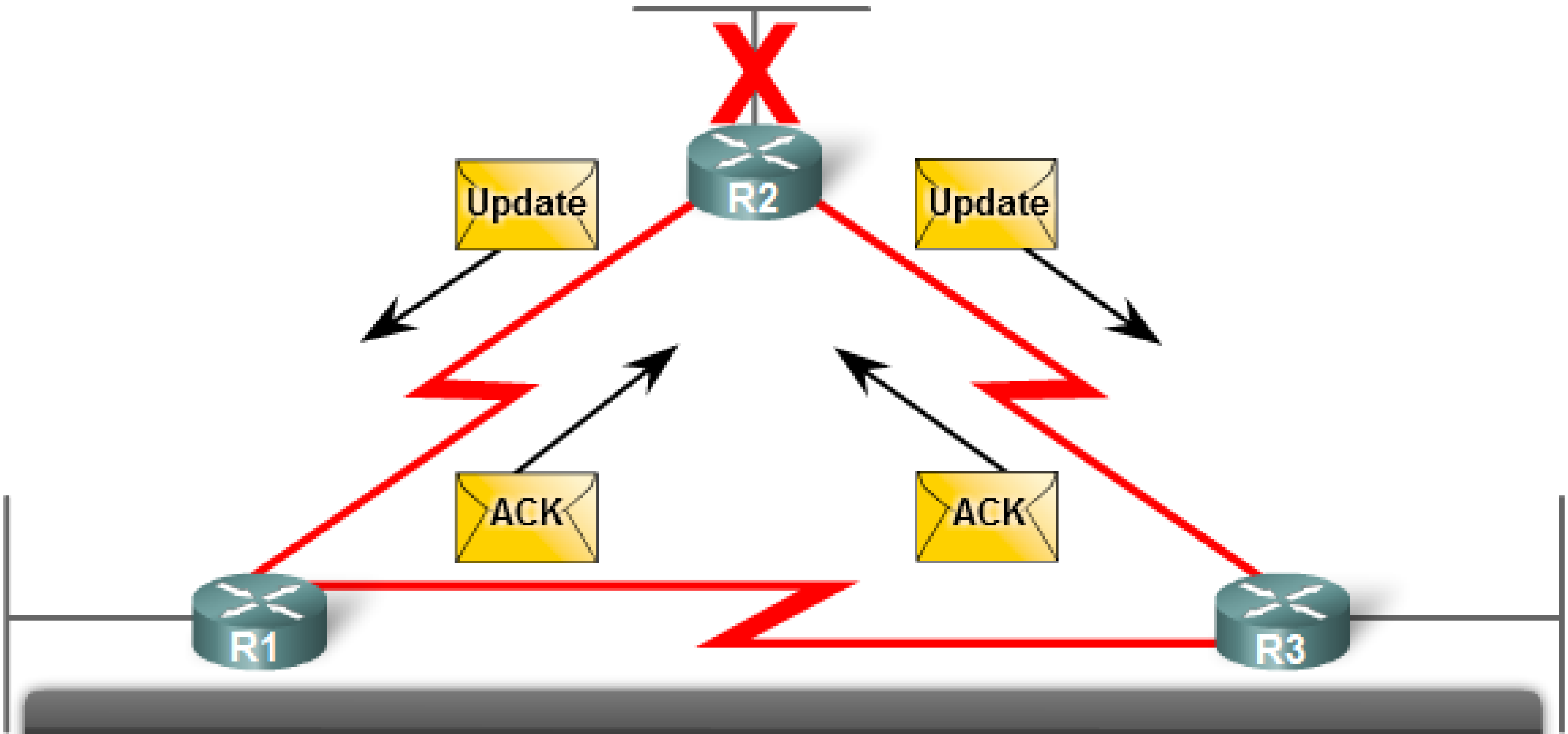
- **K1** and **K3:** Weights for bandwidth and delay; set to 1
- **Hold Time:** Maximum time router should wait for the next hello



- **Delay:** Sum of delays in units of 10 microseconds from source to destination; 0xFFFFFFFF indicates unreachable route
- **Bandwidth:** Lowest configured bandwidth of any interface along the route
- **Prefix Length:** Specifies the number of network bits in the subnet mask
- **Destination:** The destination address of the route

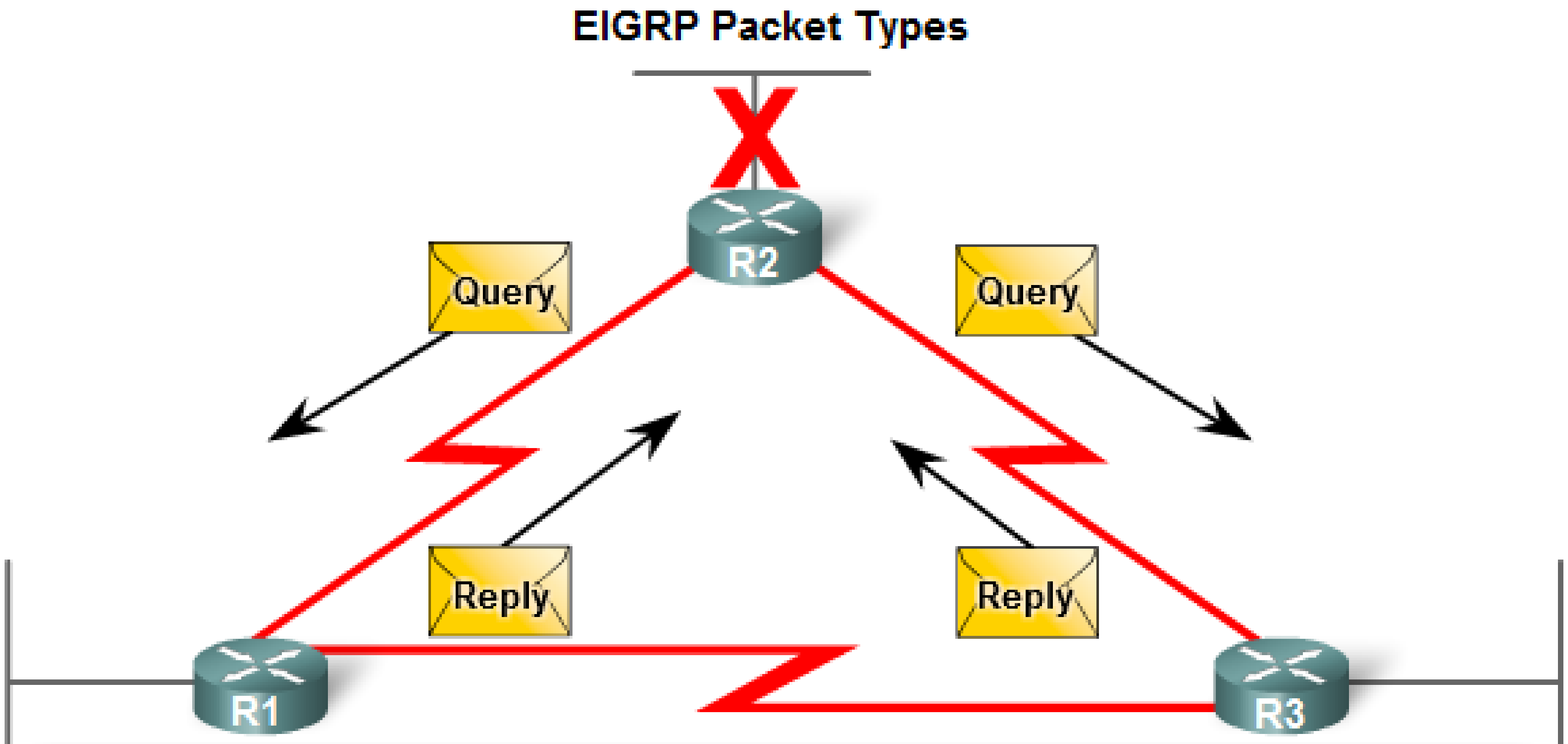

Data Link Frame Header
IP Packet Header
EIGRP Packet Header
Type/Length/Values Types:
IP Externel Routes TLV
Bit
0
7
8
15
16
23
24
31
Type = 0x0003
Length
Next Hop
Originating Routers
Originating Autoromous System Number
Arbitrary Tag
External Protocol Metric
Reserved
Ext. Protocol ID
Flags
Delay
BandWidth
MTU
Hope Count
Reliability
Load
Reserved
Prefix Length
Destination
Values
Value Fields used to track external source of route
Same value fields used in the IP Internal TLV

EIGRP Packet Types



Update packet

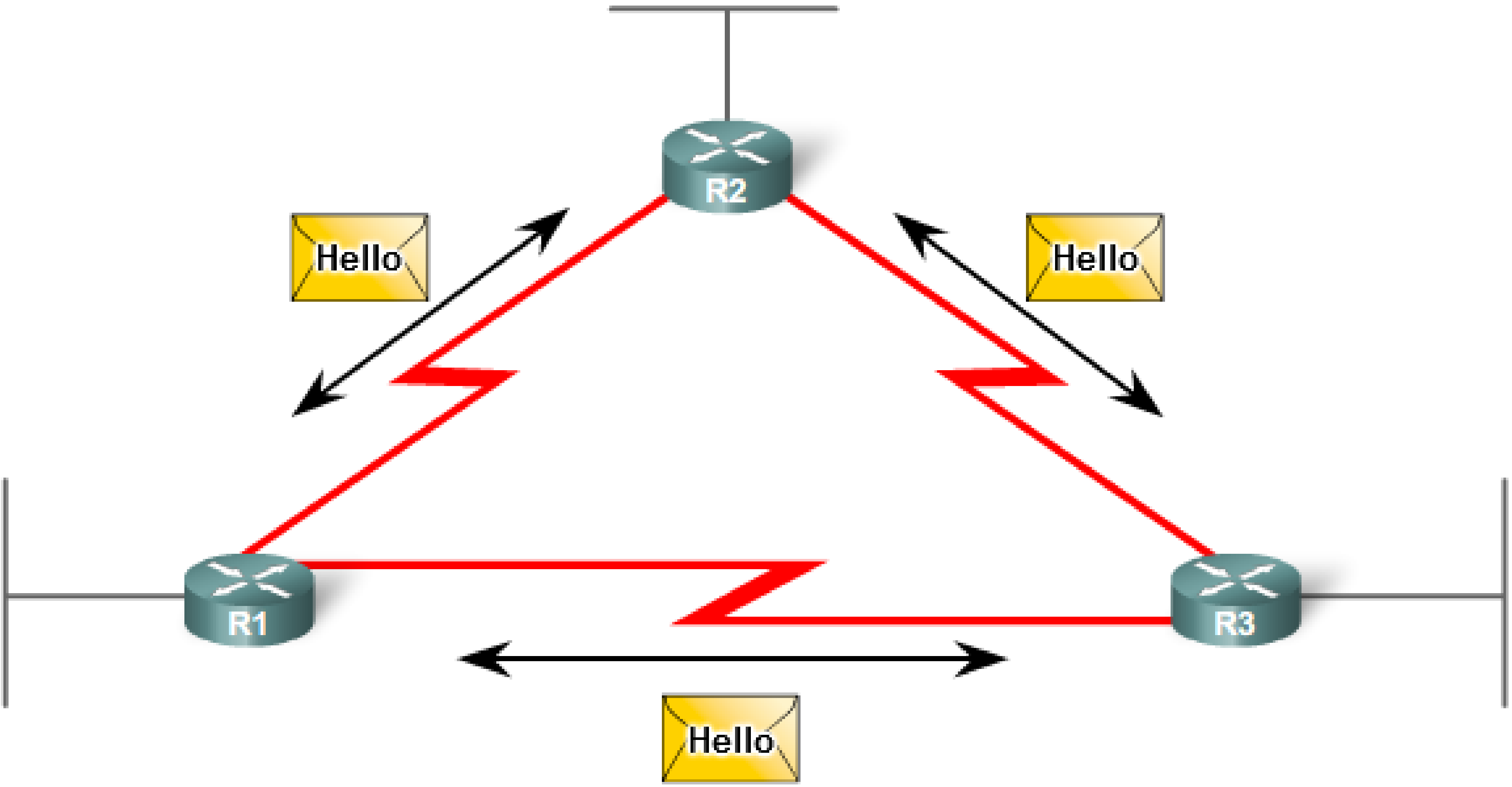
- Used to propagate routing information after a change Acknowledgement (ACK) packet
- Automatically sent back when reliable RTP is used



Query packet

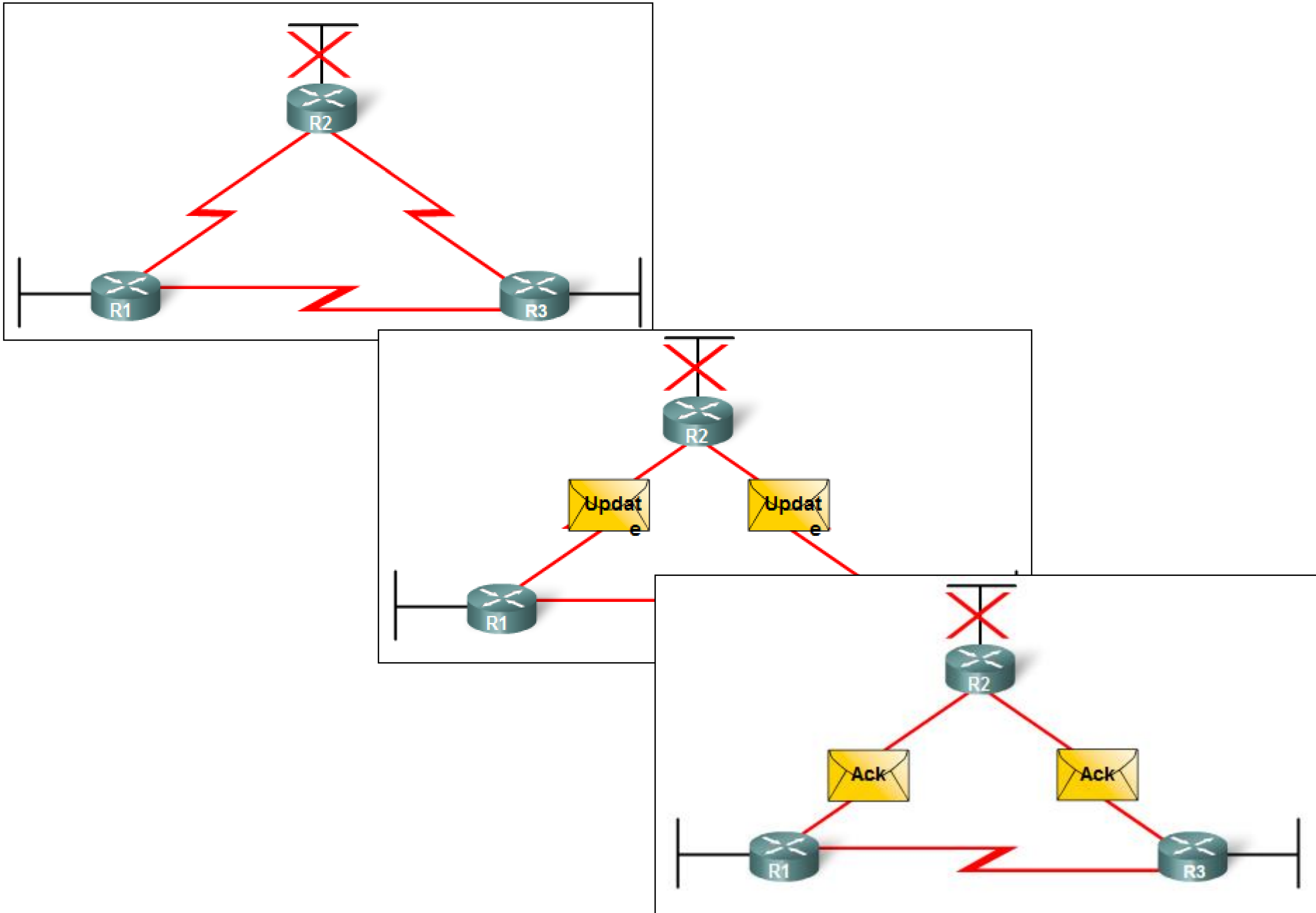
- Used by DUAL when searching for networks or other tasks.Reply packet
- Automatically sent in response to Query packet Acknowledgement (ACK) packet
- Automatically sent back when reliable RTP is used

Default Hello Intervals and Hold Times for EIGRP

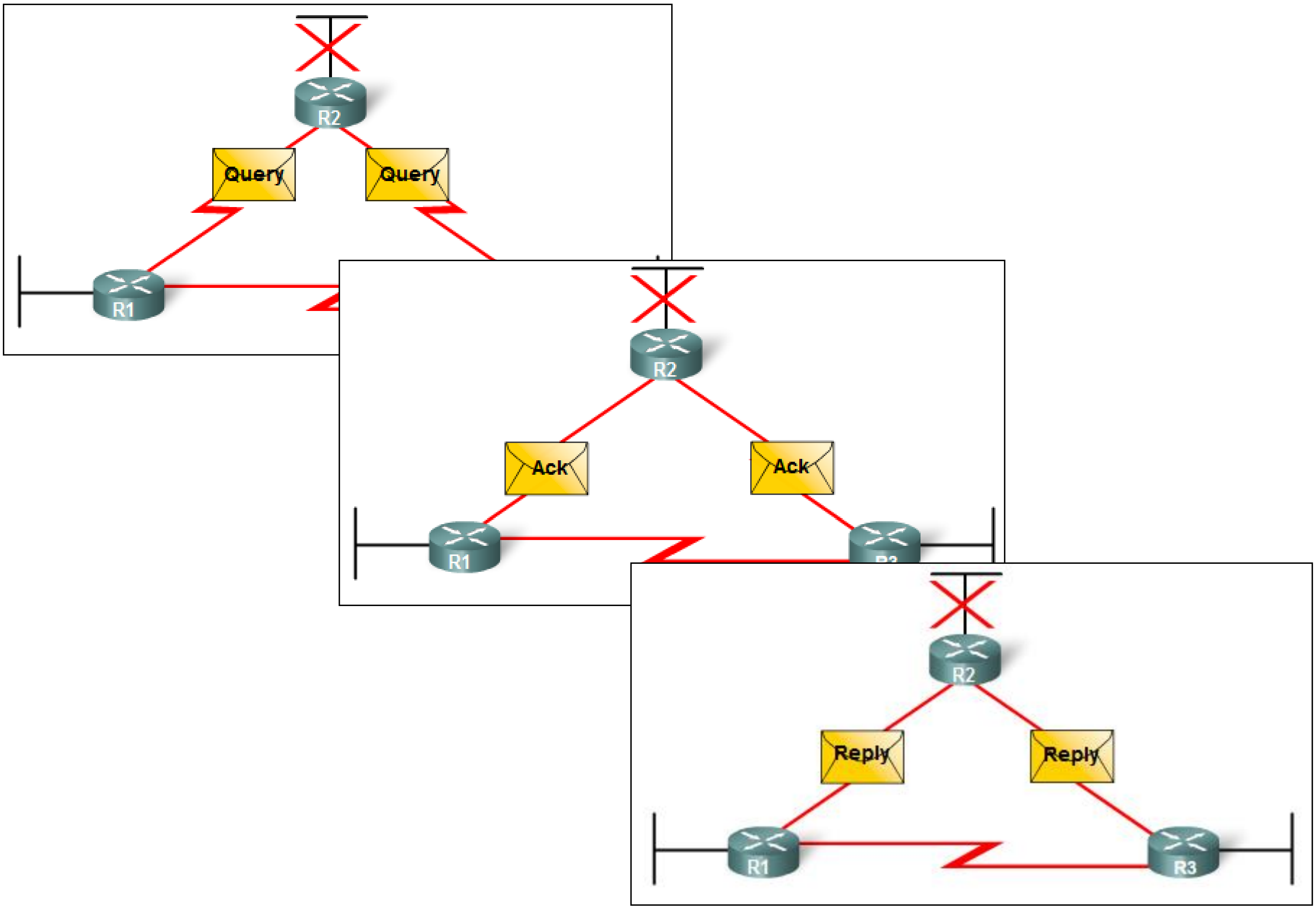


Bandwidth	Example Link	Default Hello Interval	Default Hold Time
1.544 Mbps	Multipoint Frame Relay	60 seconds	180 seconds
Greater than 1.544 Mbps	T1, Ethernet	5 seconds	15 seconds

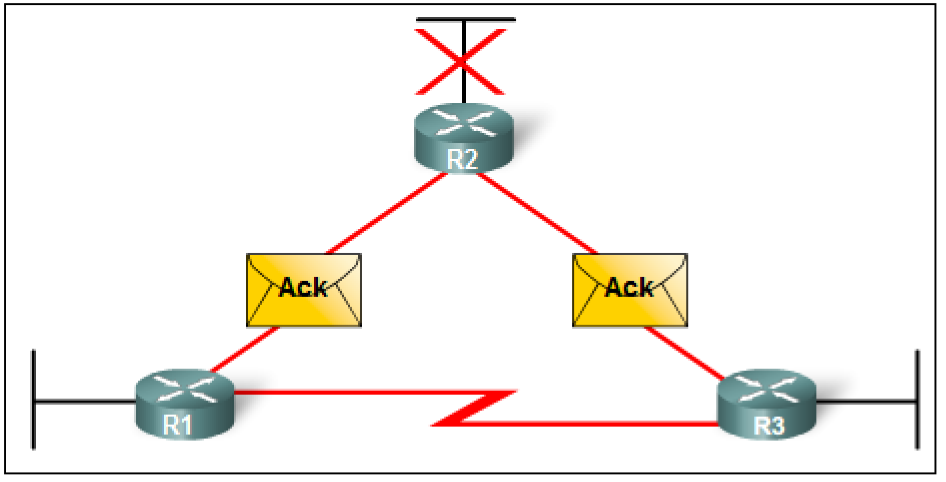
DUAL



DUAL

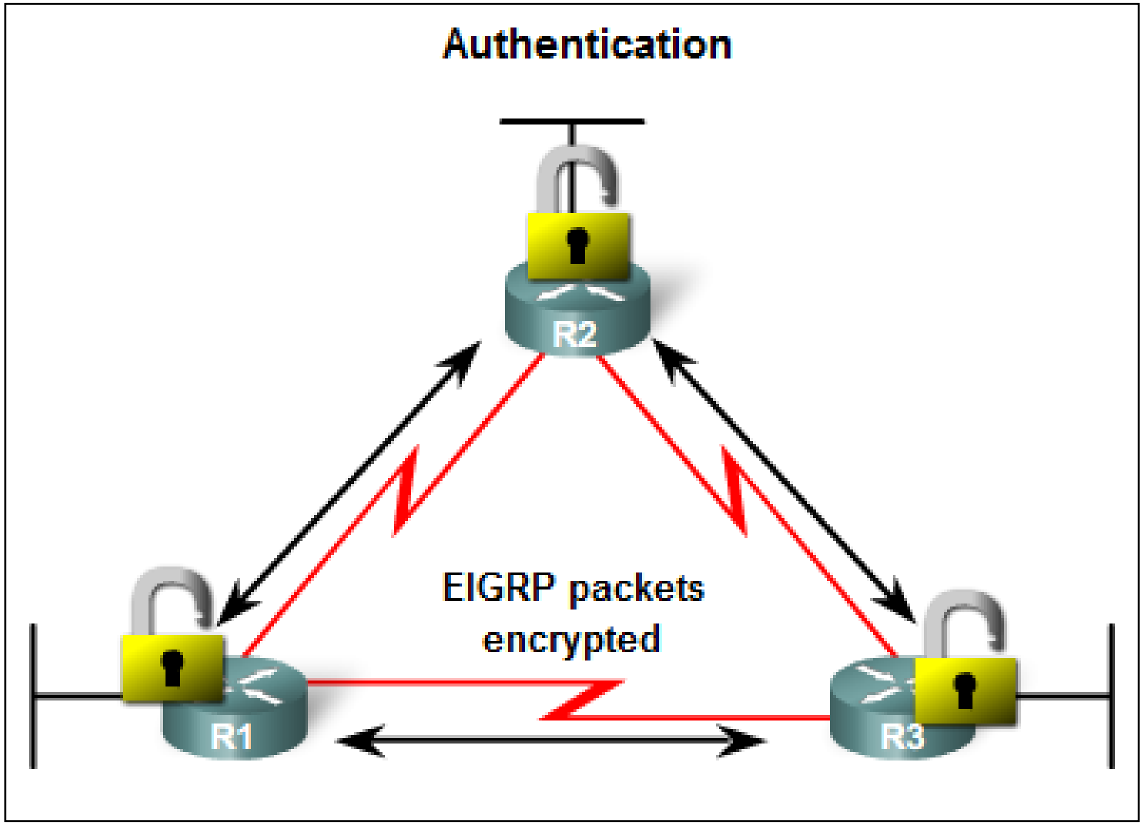


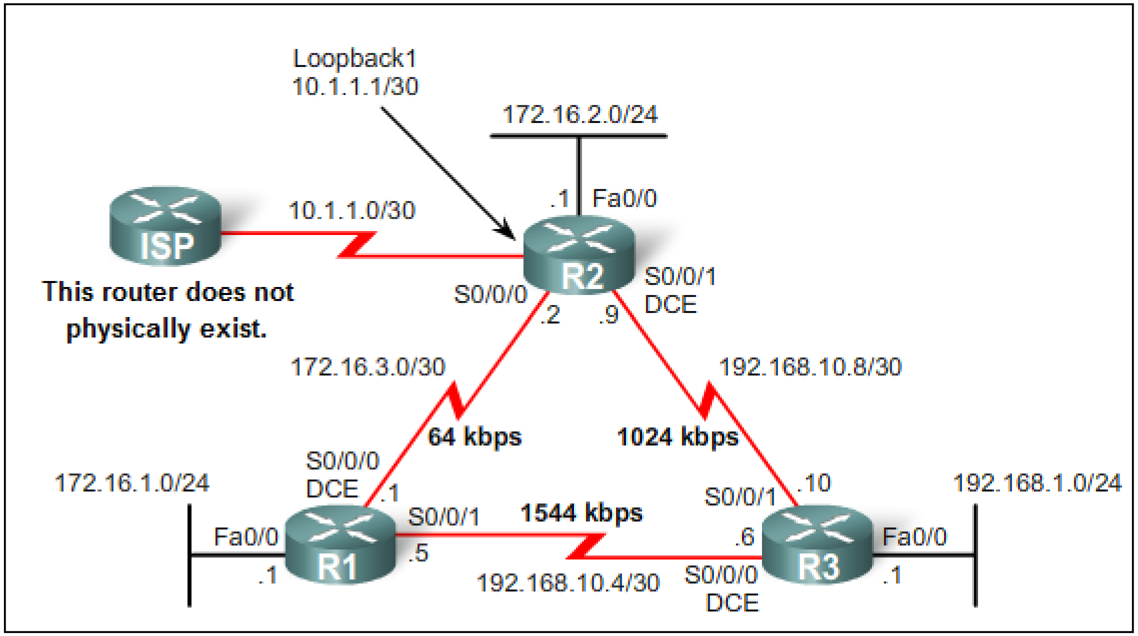
DUAL



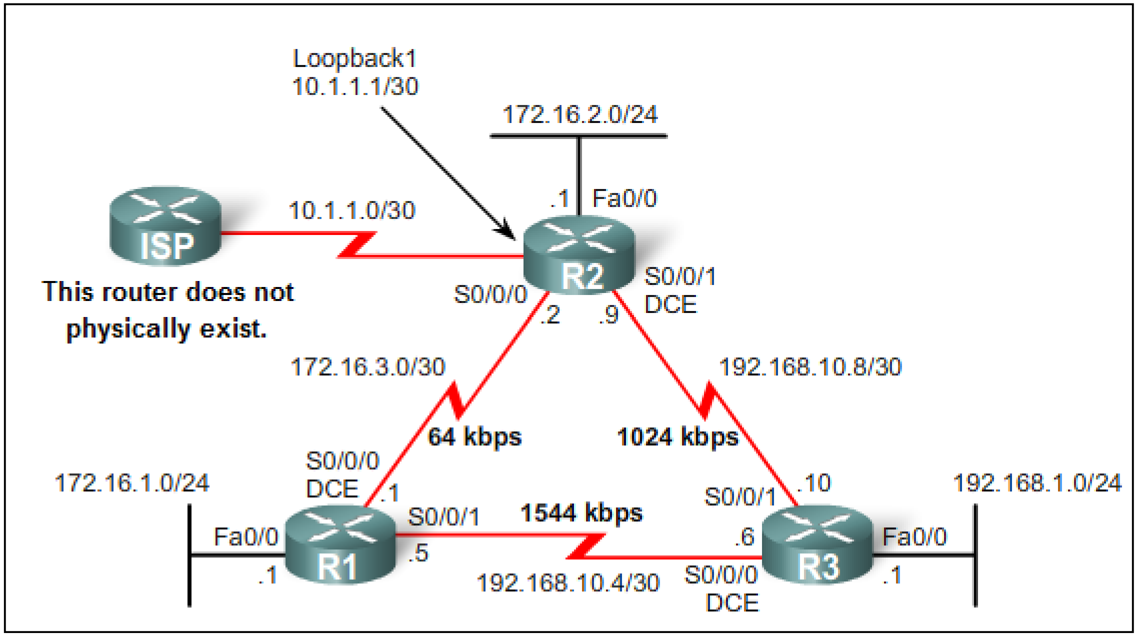
Default Administrative Distances

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


Authentication
R2
R1
R3
EIGRP packets encrypted



Device	Interface	IP Address	Subnet Mask
R1	Fa0/0	172.16.1.1	255.255.255.0
	S0/0/0	172.16.3.1	255.255.255.252
	S0/0/1	192.168.10.5	255.255.255.252
R2	Fa0/0	172.16.2.1	255.255.255.0
	S0/0/0	172.16.3.2	255.255.255.252
	S0/0/1	192.168.10.9	255.255.255.252
	Lo1	10.1.1.1	255.255.255.252
R3	Fa0/0	192.168.1.1	255.255.255.0
	S0/0/0	192.168.10.6	255.255.255.252
	S0/0/1	192.168.10.10	255.255.255.252

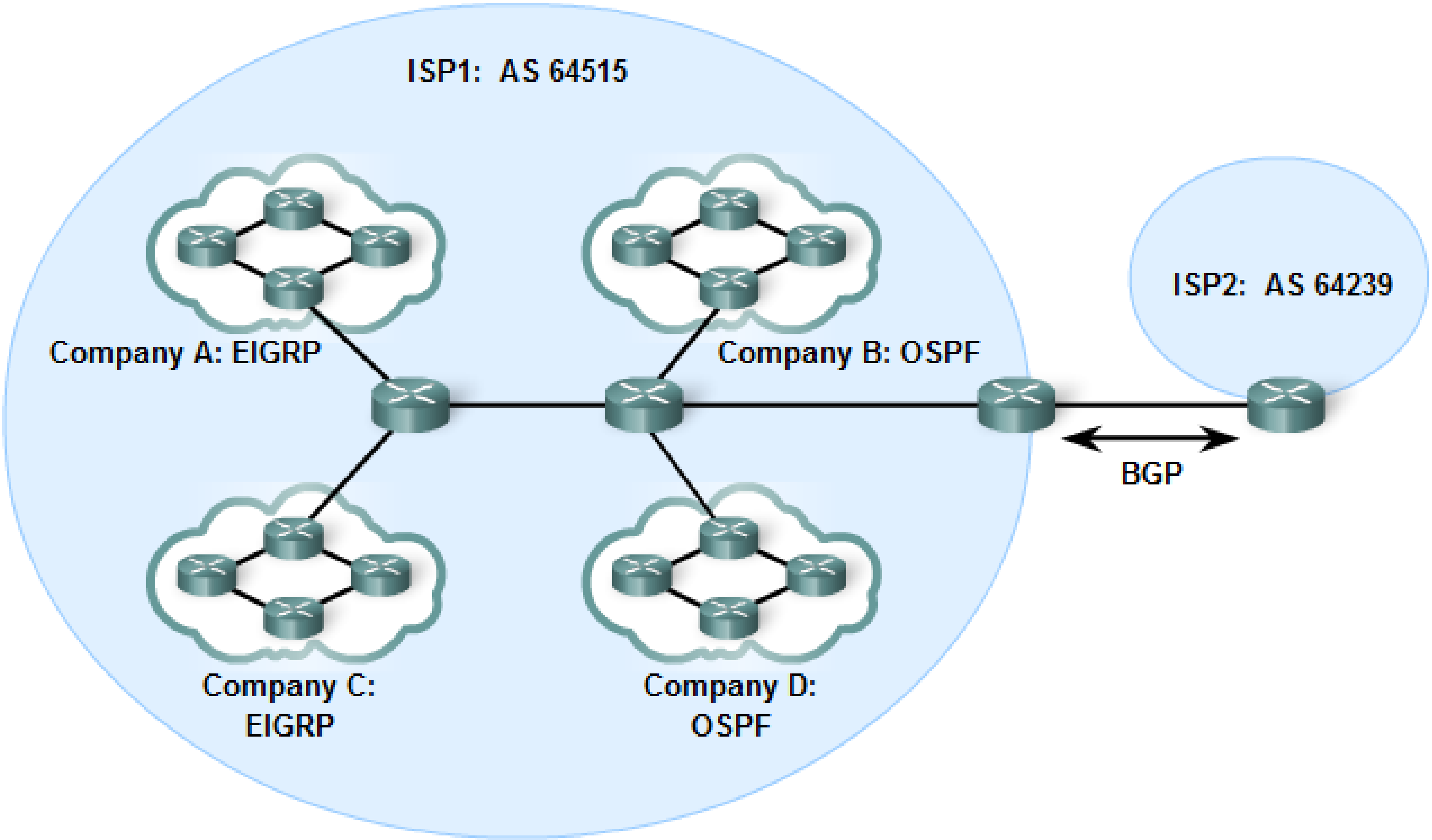



```
R1#show startup-config

<some output omitted>
!
hostname R1
!
interface FastEthernet0/0
 ip address 172.16.1.1 255.255.255.0
!
interface Serial0/0/0
 ip address 172.16.3.1 255.255.255.252
 clock rate 64000
!
interface Serial0/0/1
 description Link to R3
 ip address 192.168.10.5 255.255.255.252
!
end
```

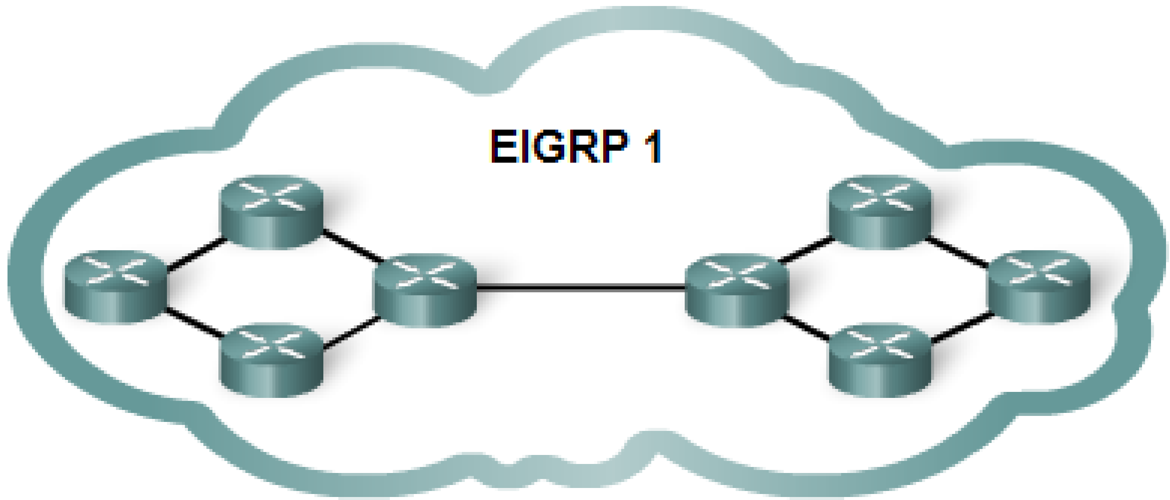
```
R2#show startup-config

<some output omitted>
!
hostname R2
!
interface Loopback1
 ip address 10.1.1.1 255.255.255.252
 description Simulated ISP
!
interface FastEthernet0/0
 ip address 172.16.2.1 255.255.255.0
!
interface Serial0/0/0
 ip address 172.16.3.2 255.255.255.252
!
interface Serial0/0/1
 ip address 192.168.10.9 255.255.255.252
 clockrate 64000
!
end
```

```
R3#show startup-config

<some output omitted>
!
hostname R3
!
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
!
interface Serial0/0/0
 ip address 192.168.10.6 255.255.255.252
 clockrate 64000
!
interface Serial0/0/1
 ip address 192.168.10.10 255.255.255.252
!
end
```

Autonomous Systems

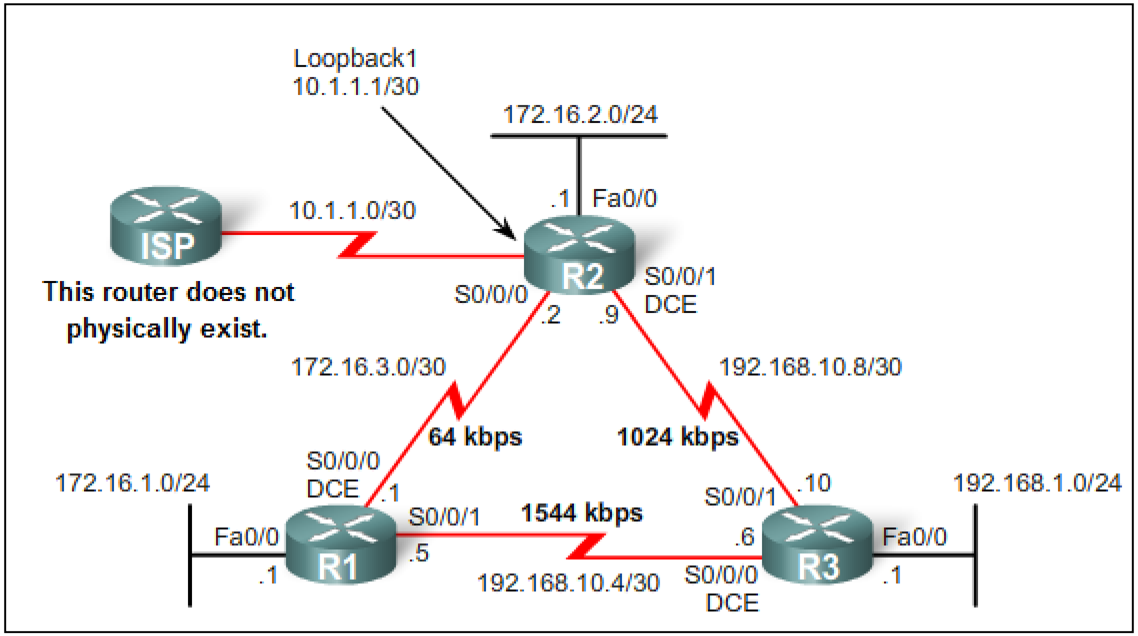


Single Process IDs




```
R1(config)#router eigrp ?
  <1-65535>  Autonomous system number
R1(config)#router eigrp 1
```

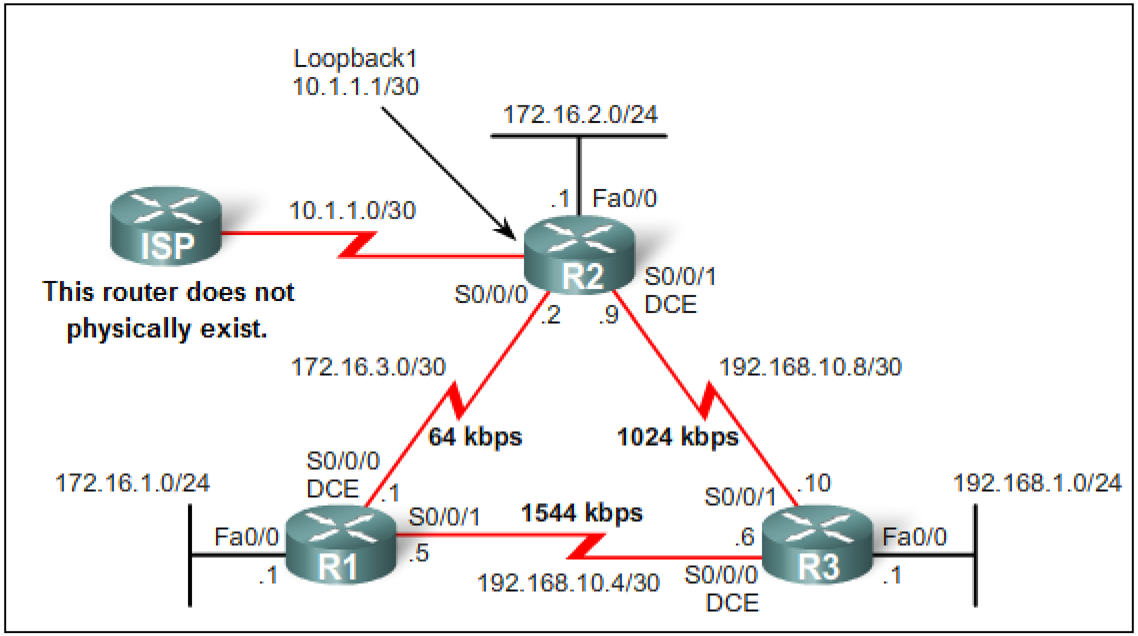
Although the Cisco IOS refers to the router eigrp parameter as an "Autonomous system number", this parameter configures an EIGRP process-an instance of EIGRP running on the router-and has nothing to do with AS configurations in ISP routers.




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

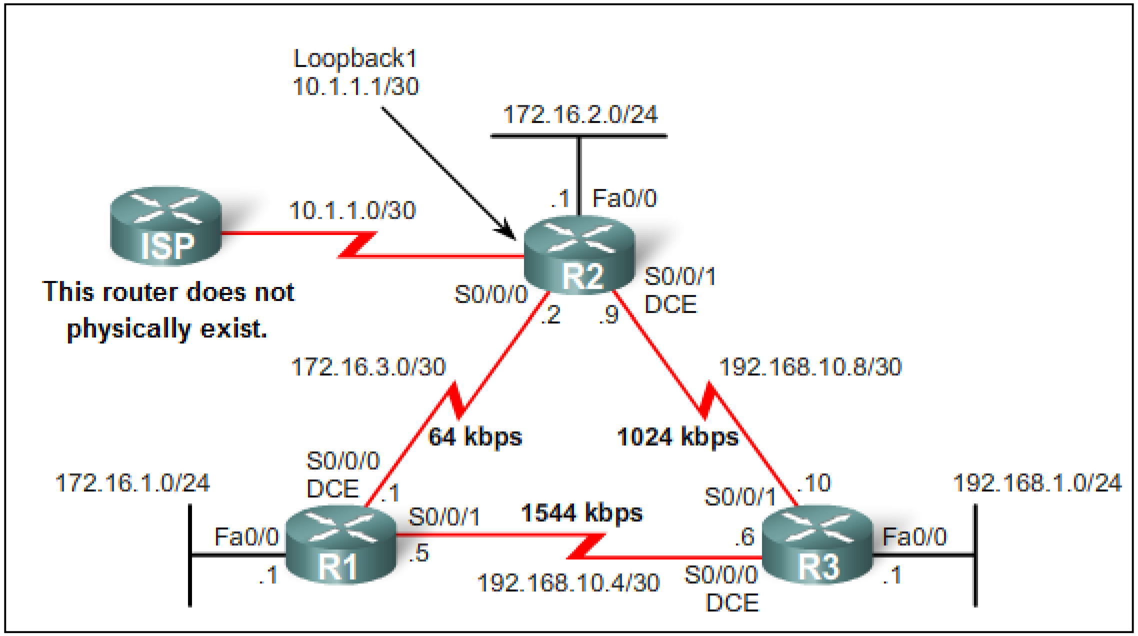
```
R2(config)#router eigrp 1
R2(config-router)#
```

```
R3(config)#router eigrp 1
R3(config-router)#
```




```
R1(config)#router eigrp 1
R1(config-router)#network 172.16.0.0
R1(config-router)#network 192.168.10.0
```

```
R2(config)#router eigrp 1
R2(config-router)#network 172.16.0.0
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 172.16.3.1 (Serial0/0/0) is up: new adjacency
```




```
R1(config)#router eigrp 1
R1(config-router)#network 172.16.0.0
R1(config-router)#network 192.168.10.0
```

```
R2(config)#router eigrp 1
R2(config-router)#network 172.16.0.0
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 172.16.3.1 (Serial0/0/0) is up: new adjacency
R2(config-router)#network 192.168.10.8 0.0.0.3
```

```
R3(config)#router eigrp 1
R3(config-router)#network 192.168.10.0
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 192.168.10.5 (Serial0/0/0) is up: new adjacency
R3(config-router)#
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 192.168.10.9 (Serial0/0/1) is up: new adjacency
R3(config-router)#network 192.168.1.0
```

The Neighbor Table

```
R2#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                  Interface    Hold Uptime   SRTT   RTO  Q   Seq Type
                                          (sec)         (ms)        Cnt Num
1   192.168.10.10            Se0/0/1        10 00:01:41   20   200  0   7
0   172.16.3.1               Se0/0/0        10 00:09:49   25   200  0   28
```

Address of neighbors

Interface connected to neighbor

Amount of time left before neighbor is considered "down"

Amount of time since adjacency was established

```
R1#show ip protocols
Routing Protocol is "eigrp 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 1
  Automatic network summarization is in effect
  Automatic address summarization:
    192.168.10.0/24 for FastEthernet0/0, Serial0/0/0
      Summarizing with metric 2169856
    172.16.0.0/16 for Serial0/0/1
      Summarizing with metric 28160
  Maximum path: 4
  Routing for Networks:
    172.16.0.0
    192.168.10.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    (this router)         90      00:03:29
    192.168.10.6          90      00:02:09
    Gateway         Distance      Last Update
    172.16.3.2            90      00:02:12
  Distance: internal 90 external 170
```

```
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
<Output omitted>

Gateway of last resort is not set

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:03:50, Null0
C       192.168.10.4/30 is directly connected, Serial0/0/1
D       192.168.10.8/30 [90/2681856] via 192.168.10.6, 00:02:43, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:10:52, Null0
C       172.16.1.0/24 is directly connected, FastEthernet0/0
D       172.16.2.0/24 [90/2172416] via 172.16.3.2, 00:10:47, Serial0/0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
D    192.168.1.0/24 [90/2172416] via 192.168.10.6, 00:02:31, Serial0/0/1
```

```
R2#show ip route
<Output omitted>

Gateway of last resort is not set

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:04:13, Null0
D       192.168.10.4/30 [90/2681856] via 192.168.10.10, 00:03:05, Serial0/0/1
C       192.168.10.8/30 is directly connected, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:04:07, Null0
D       172.16.1.0/24 [90/2172416] via 172.16.3.1, 00:11:11, Serial0/0/0
C       172.16.2.0/24 is directly connected, FastEthernet0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
     10.0.0.0/30 is subnetted, 1 subnets
C       10.1.1.0 is directly connected, Loopback1
D    192.168.1.0/24 [90/2172416] via 192.168.10.10, 00:02:54, Serial0/0/1
```

```
R3#show ip route
<Output omitted>

Gateway of last resort is not set

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:03:11, Null0
C       192.168.10.4/30 is directly connected, Serial0/0/0
C       192.168.10.8/30 is directly connected, Serial0/0/1
D    172.16.0.0/16 [90/2172416] via 192.168.10.5, 00:03:23, Serial0/0/0
                   [90/2172416] via 192.168.10.9, 00:03:23, Serial0/0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/0
```

```
R2#show ip route
<Output omitted>

Gateway of last resort is not set

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:04:13, Null0
D       192.168.10.4/30 [90/2681856] via 192.168.10.10, 00:03:05, Serial0/0/1
C       192.168.10.8/30 is directly connected, Serial0/0/1
     172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D       172.16.0.0/16 is a summary, 00:04:07, Null0
D       172.16.1.0/24 [90/2172416] via 172.16.3.1, 00:11:11, Serial0/0/0
C       172.16.2.0/24 is directly connected, FastEthernet0/0
C       172.16.3.0/30 is directly connected, Serial0/0/0
     10.0.0.0/30 is subnetted, 1 subnets
C       10.1.1.0 is directly connected, Loopback1
D    192.168.1.0/24 [90/2172416] via 192.168.10.10, 00:02:54, Serial0/0/1
```

Summary Routes to Null0

```
R3#show ip route
<Output omitted>

Gateway of last resort is not set

     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D       192.168.10.0/24 is a summary, 00:03:11, Null0
C       192.168.10.4/30 is directly connected, Serial0/0/0
C       192.168.10.8/30 is directly connected, Serial0/0/1
D    172.16.0.0/16 [90/2172416] via 192.168.10.5, 00:03:23, Serial0/0/0
                   [90/2172416] via 192.168.10.9, 00:03:23, Serial0/0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/0
```

Equal cost routes to 172.16.0.0/16

EIGRP Composite Metric

Default Composite Formula:
metric = **[K1*bandwidth + K3*delay]**

Complete Composite Formula:
metric = **[K1*bandwidth + (K2*bandwidth)/(256 - load) + K3*delay] * [K5/(reliability + K4)]**

(Not used if "K" values are 0)

Default values:
K1 (bandwidth) = 1
K2 (load) = 0
K3 (delay) = 1
K4 (reliability) = 0
K5 (reliability) = 0

"K" values can be changed with the `metric weights` command.

```
Router(config-router)#metric weights tos k1 k2 k3 k4 k5
```

```
R1#show ip protocols
Routing Protocol is "eigrp 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 1
  Automatic network summarization is in effect
  Automatic address summarization:
    192.168.10.0/24 for FastEthernet0/0, Serial0/0/0
      Summarizing with metric 2169856
    172.16.0.0/16 for Serial0/0/1
      Summarizing with metric 28160
  Maximum path: 4
  Routing for Networks:
    172.16.0.0
    192.168.10.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    (this router)         90      00:03:29
    192.168.10.6          90      00:02:09
    Gateway         Distance      Last Update
    172.16.3.2            90      00:02:12
  Distance: internal 90 external 170
```

Use show interface to Verify Metri

```
R1#show interface serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Hardware is GT96K Serial
  Description: Link to R2
  Internet address is 172.16.3.1/30
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:00, output 00:00:01, output hang nev
  Last clearing of "show interface" counters 3d22h
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     112522 packets input, 7303722 bytes, 0 no buffer
     Received 40016 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     112601 packets output, 7280131 bytes, 0 underruns
     0 output errors, 0 collisions, 2 interface resets
     0 output buffer failures, 0 output buffers swapped out
     12 carrier transitions
     DCD=up  DSR=up  DTR=up  RTS=up  CTS=up
```

Delay Values in Microseconds

Media	Delay
100M ATM	100 µS
Fast Ethernet	100 µS
FDDI	100 µS
1HSSI	20,000 µS
16M Token Ring	630 µS
Ethernet	1,000 µS
T1 (Serial Default)	20,000 µS
512K	20,000 µS
DSO	20,000 µS
56K	20,000 µS

usec = microsecond or 1 millionth of a second

Access Control List (ACL)

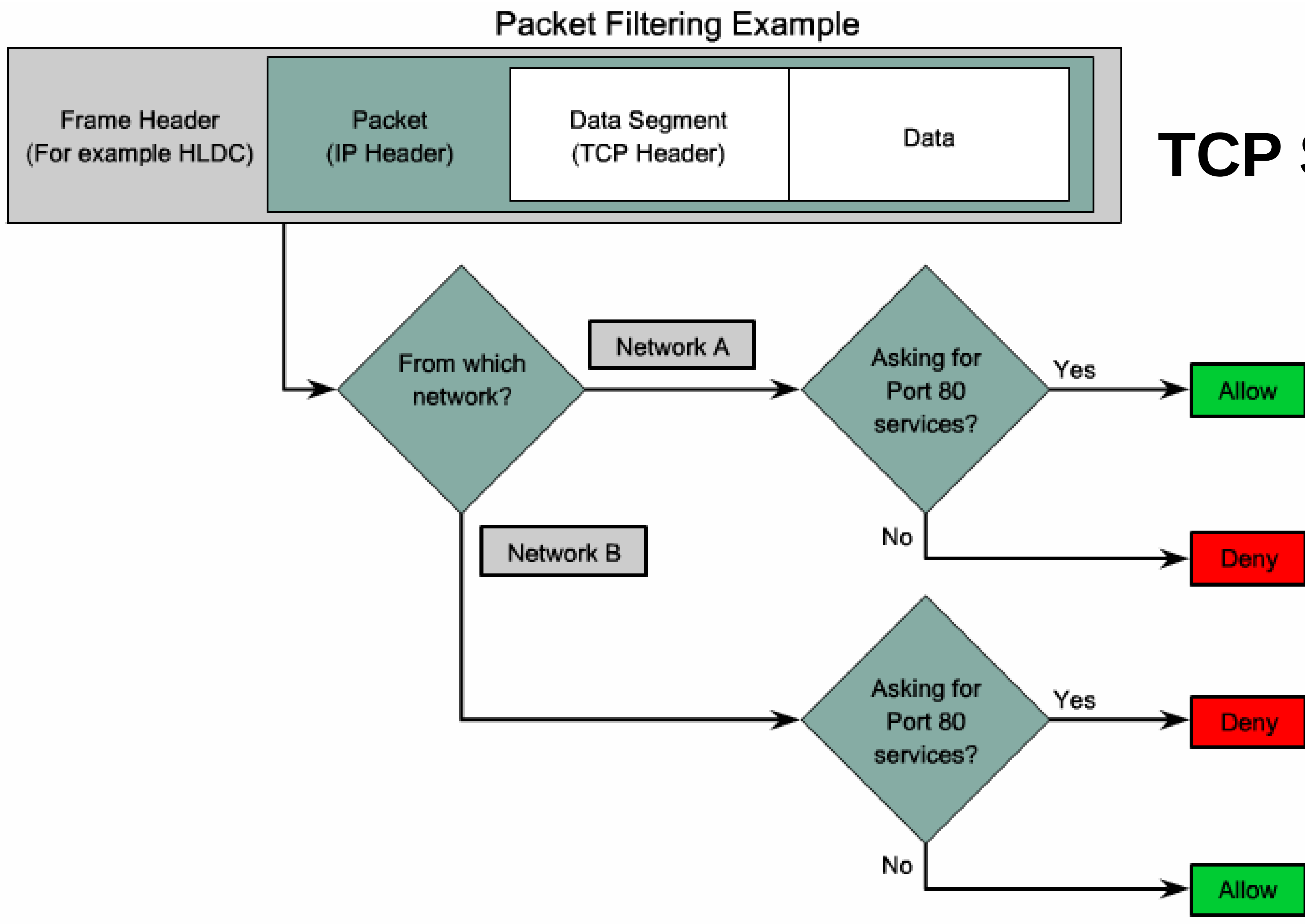
- كيف يمكن تحقيق أمن الشبكة؟
  - الحد الأدنى هو استخدام جدار ناري
- هناك عدة أنواع من الجدران النارية، ما هو النوع الأنسب؟
  - في حال كان الاهتمام فقط بتحديد من يحق له الوصول إلى الشبكة ومنع من لا يحق له ذلك على مستوى العناوين المنطقية وعناوين المنافذ فيمكن استخدام Packet Filtering firewall.
- ألا يمكن تحقيق هذا النمط من الجدران النارية ضمن المسير (لأن كلفة الجدار الناري عالية جداً)؟
  - يمكن ذلك باستخدام ACL بشرط ألا تزيد حركة المرور عن حد معين.

عرف قوائم التحكم بالوصول

- هي عبارة عن جدار ناري من نمط packet Filtering يتم تأهيلها ضمن المسير في حال كانت حركة المرور أقل من حد معين، بهدف منع عناوين منطقية محددة من الوصول إلى الشبكة أو الخروج منها ويمكن أن تتعدى العناوين المنطقية بحيث تمنع مجموعات من أجهزة المضيف من الوصول إلى تطبيقات محددة أو التعامل معها.
- توضع هذه القوائم على دخل أي منفذ من منافذ المسير وعلى الخرج (قائمة الدخل مستقلة عن قائمة الخرج) وتستخدم أحد أمرين إما deny أو permit

ما هو عدد قوائم التحكم بالوصول التي يمكن أن توضع في آن واحد ضمن المسير؟

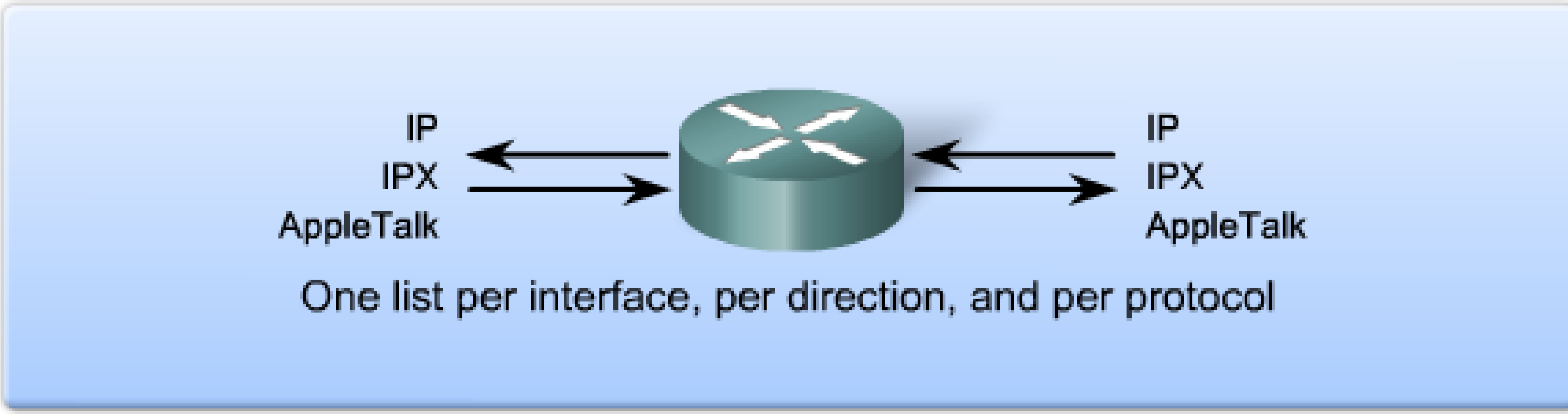
- يمكن أن يتم وضع قائمتين ضمن كل منفذ أحدها على الدخل والأخرى على الخرج (على اعتبار أنك ضمن المسير)
- ويحقق ما سبق على أي بروتوكول طبقة ثالثة متاح ضمن المسير (في CCNA نهتم فقط بالبروتوكول IP)



Packet Filtering Example
Frame Header
(For example HLDC)
Packet
(IP Header)
Data Segment
(TCP Header)
Data
From which
network?
Network A
Network B
Asking for
Port 80
services?
Yes
No
Allow
Deny
Asking for
Port 80
services?
Yes
No
Deny
Allow

TCP SY

ACL Traffic Filtering on a Router



With two interfaces and three protocols running, this router could have a total of 12 separate ACLs applied.

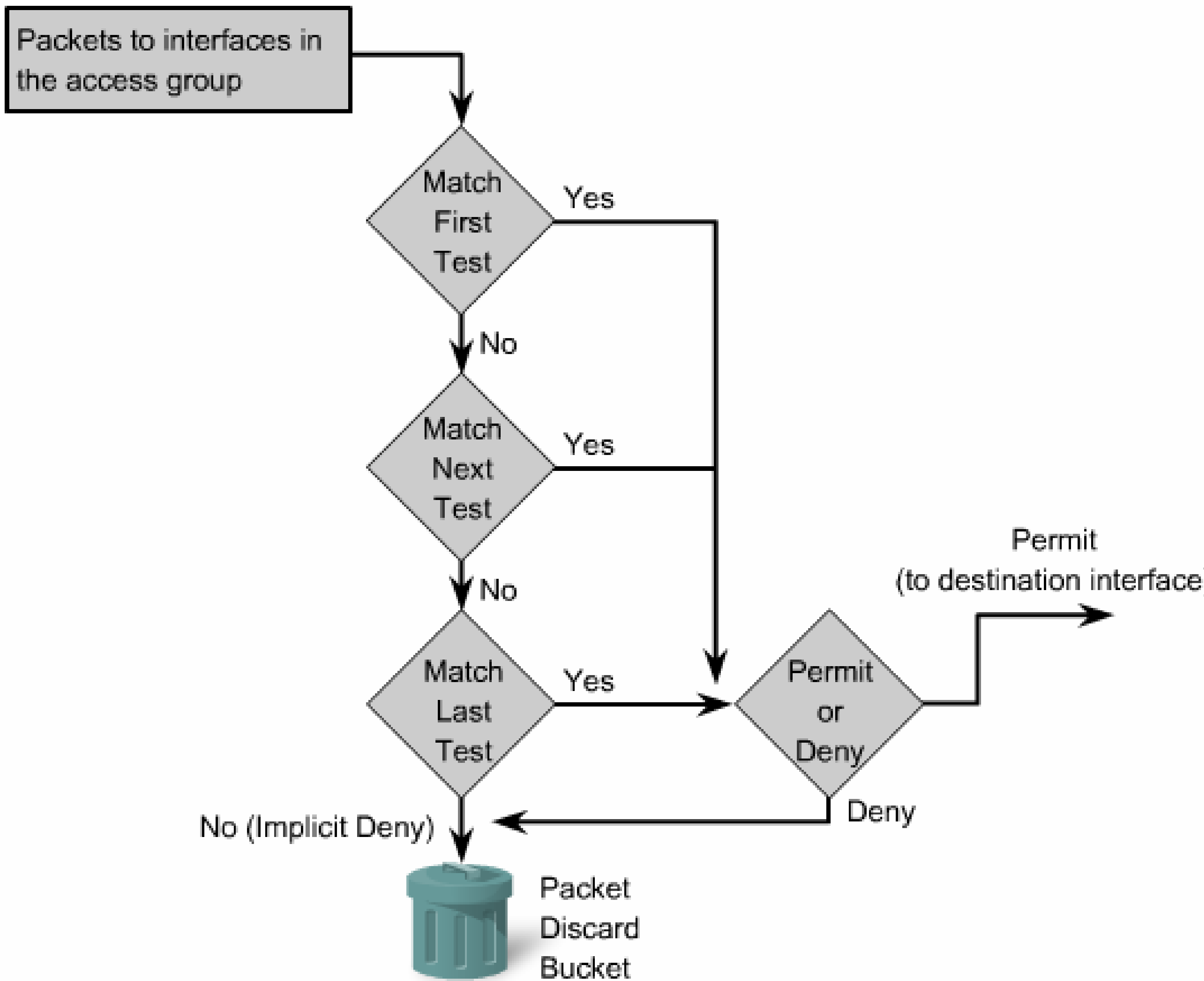
The three Ps for using ACLs

You can only have one ACL per protocol, per interface, and per direction:

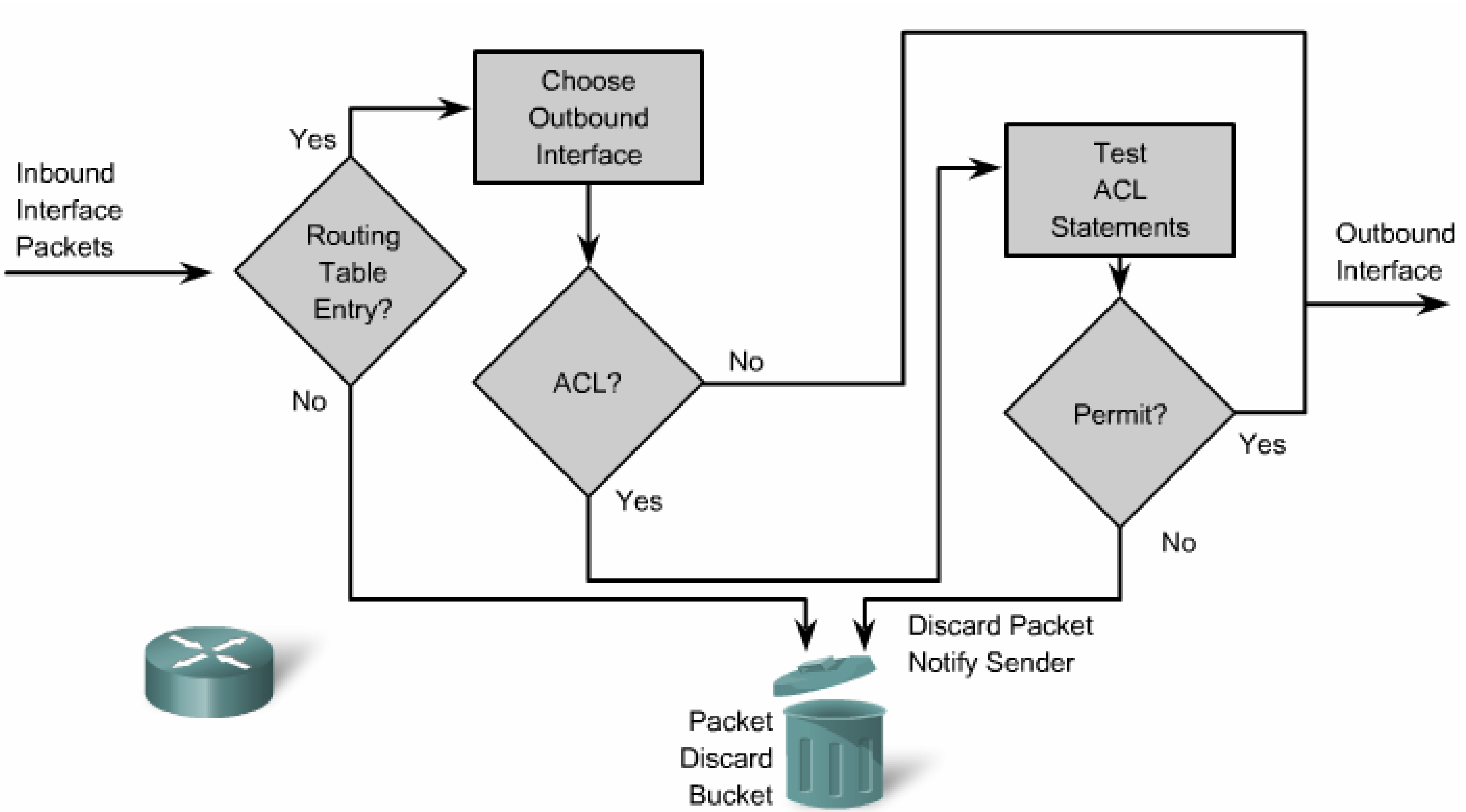
- One ACL per protocol (e.g., IP or IPX)
- One ACL per interface (e.g., FastEthernet0/0)
- One ACL per direction (i.e., IN or OUT)

Inbound ACLs

How ACLs Work



Outbound ACLs



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Deny All Traffic

- At the end of every access list is an implied "deny all traffic" criteria statement.
- It is also sometimes referred to as the "implicit deny any" statement.
- Therefore, if a packet does not match any of the ACL entries, it is automatically blocked.
- The implied "deny all traffic" is the default behavior of ACLs and cannot be changed.
- For most protocols, if you define an inbound access list for traffic filtering, you should include explicit access list criteria statements to permit routing updates.

Types of ACLs

Standard ACLs filter IP packets based on the source address only.

```
access-list 10 permit 192.168.30.0 0.0.0.255
```

Extended ACLs filter IP packets based on several attributes, including the following:

- Source and destination IP addresses
- Source and destination TCP and UDP ports
- Protocol type (IP, ICMP, UDP, TCP, or protocol number)

```
access-list 103 permit tcp 192.168.30.0 0.0.0.255 any eq 80
```