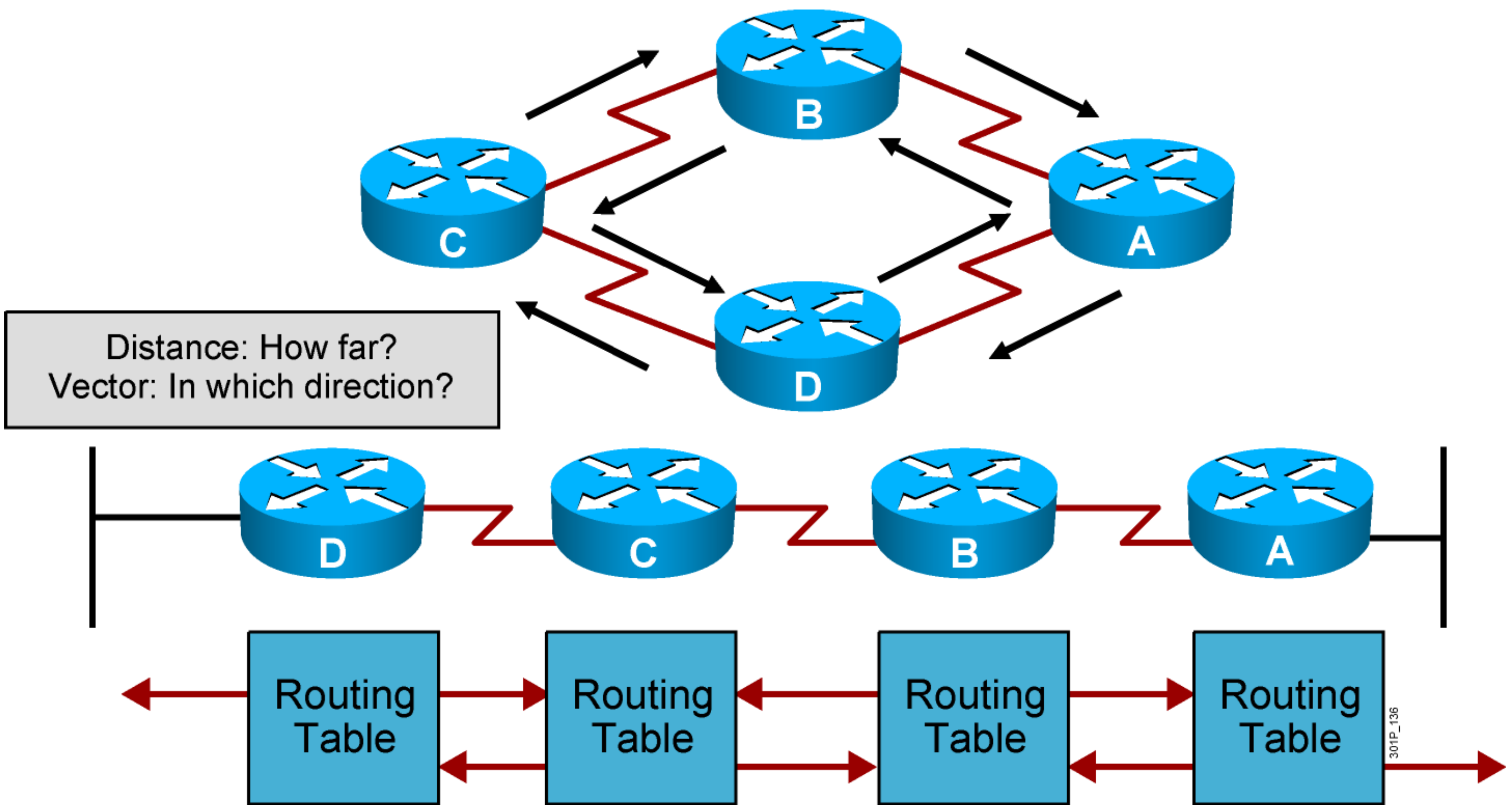
Single-Area OSPF Implementation

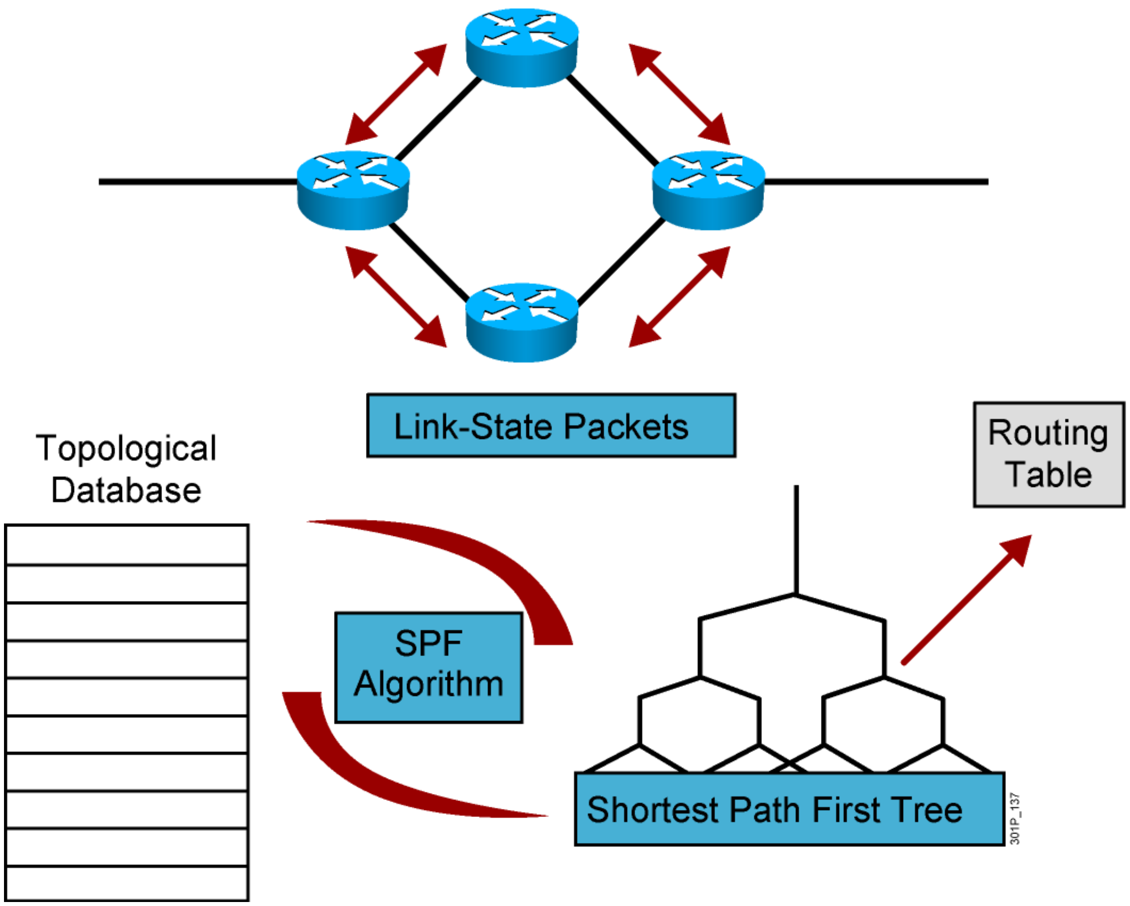
Implementing OSPF

Distance Vector Routing Protocols



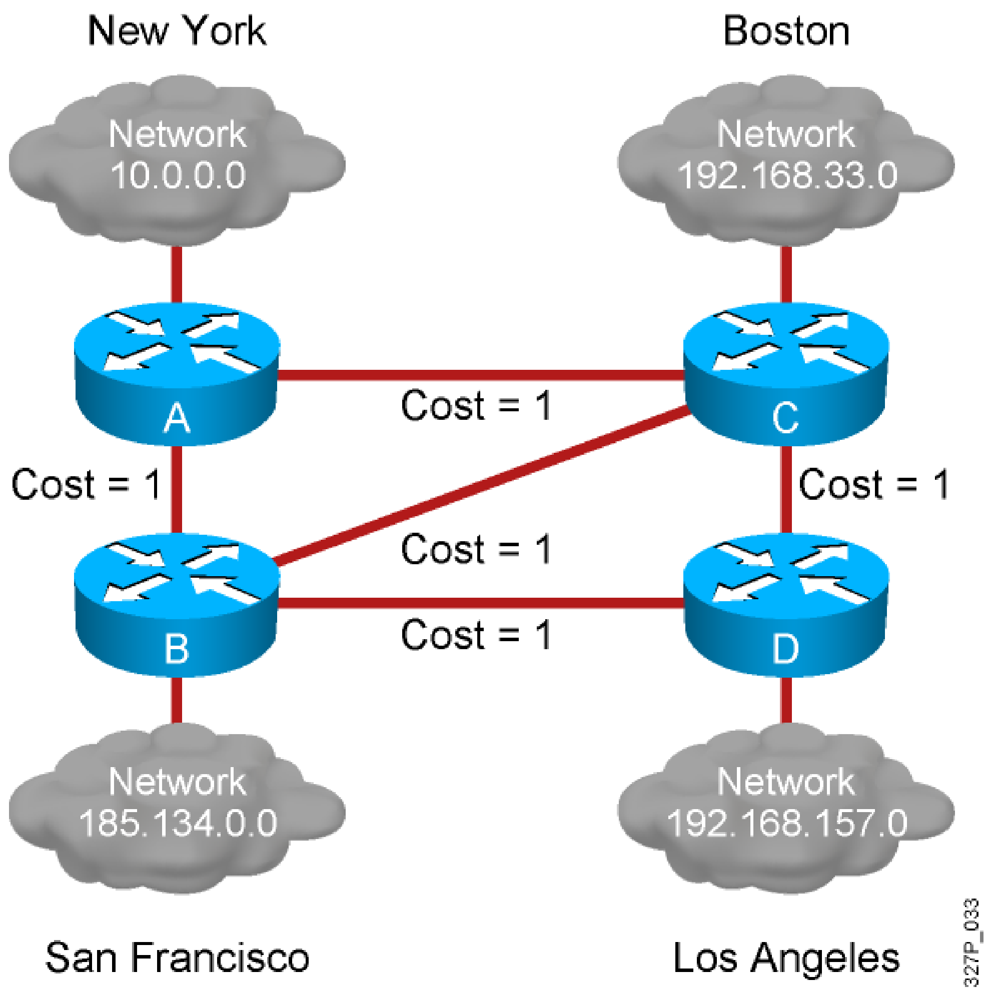
Passes periodic copies of routing table to neighbor routes and accumulates distance vectors

Link-State Routing Protocols



After initial flood, passes small event-triggered link-state updates to all other routers

Link-State Routing Protocol Algorithms



Benefits and Drawbacks of Link-State Routing

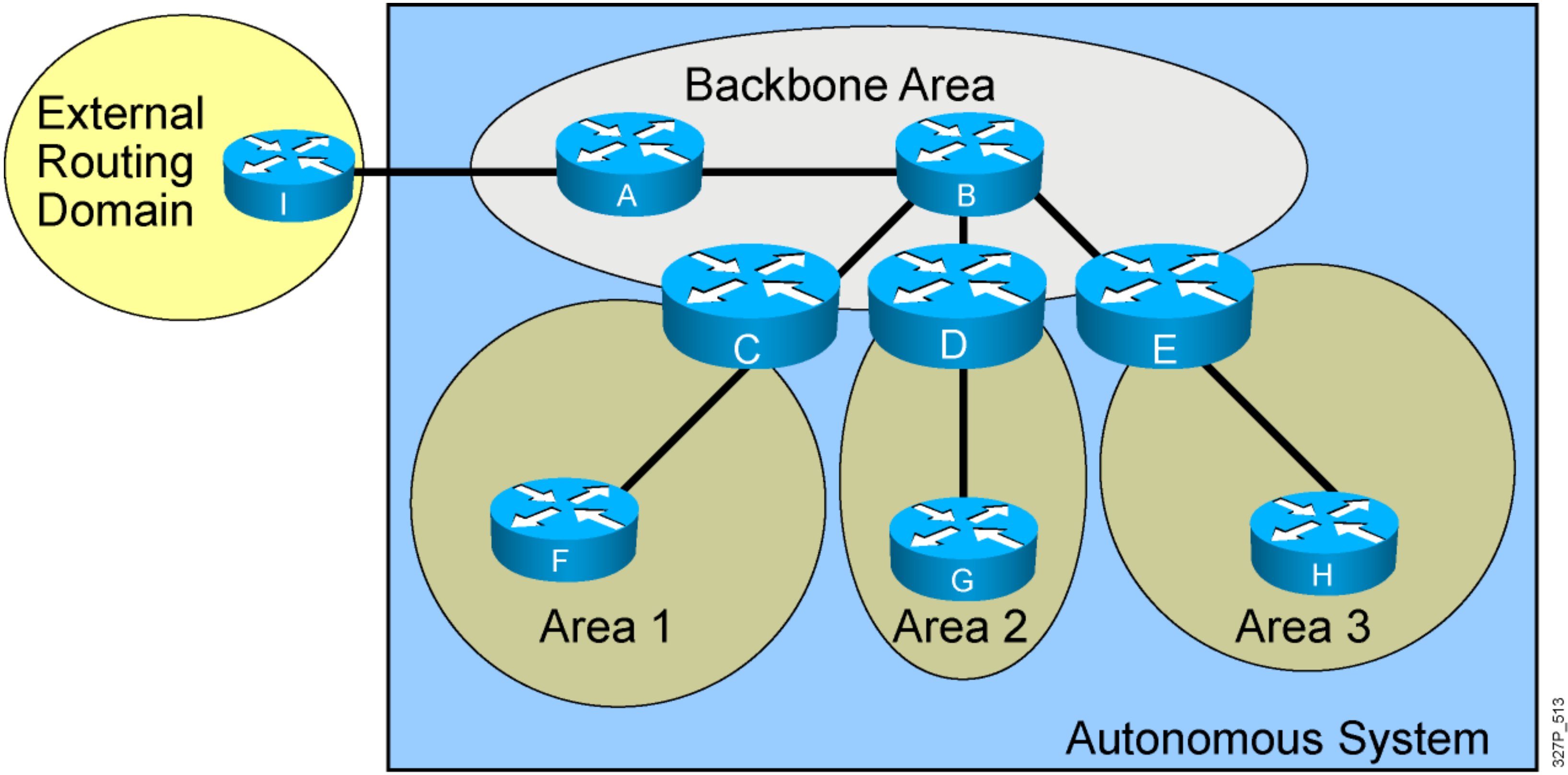
- **Benefits of link-state routing:**
  - **Fast convergence:**
    - **Changes are reported immediately by the affected source**
  - **Robustness against routing loops:**
    - **Routers know the topology**
    - **Link-state packets are sequenced and acknowledged**
  - **Hierarchical network design enables optimization of resources.**

- **Drawbacks of link-state routing:**
  - **Significant demands for resources:**
    - **Memory (three tables: adjacency, topology, forwarding)**
    - **CPU (Dijkstra's algorithm can be intensive, especially when there are many instabilities)**
  - **Requires very strict network design**
  - **Configuration can be complex when tuning various parameters and when design is complex**

OSPF Overview

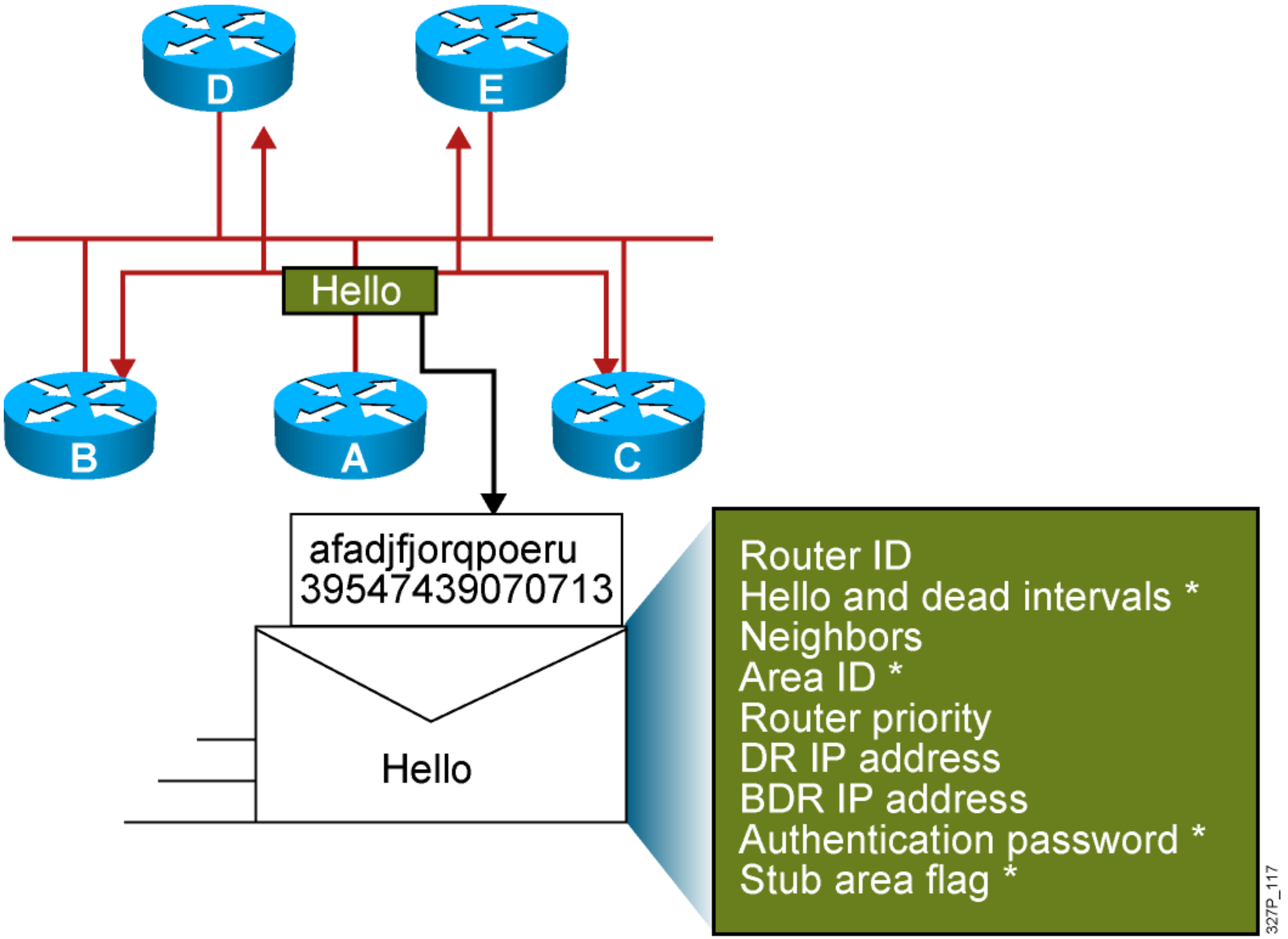
- Creates a neighbor relationship by exchanging hello packets
- Propagates LSAs rather than routing table updates
  - Link: Router interface
  - State: Description of an interface and its relationship to neighboring routers
- Floods LSAs to all OSPF routers in the area, not just directly connected routers
- Pieces together all the LSAs generated by the OSPF routers to create the OSPF link-state database
- Uses the SPF algorithm to calculate the shortest path to each destination and places it in the routing table

OSPF Hierarchy Example



- Minimizes routing table entries
- Localizes the impact of a topology change within an area

Neighbor Adjacencies: The Hello Packet

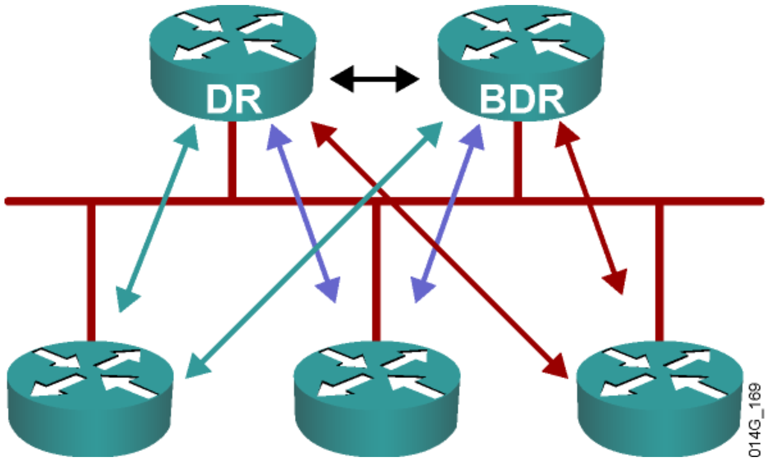


* Entry must match on neighboring routers

Point-to-Point Links

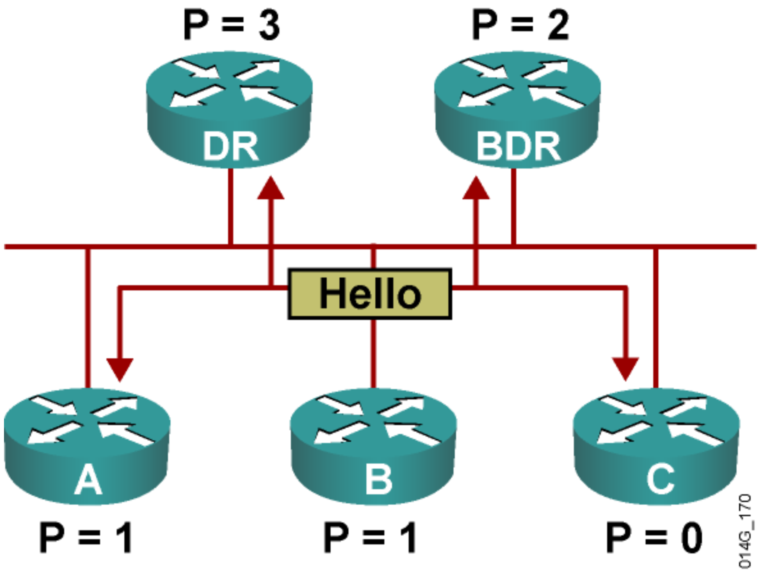
- Usually a serial interface running either PPP or HDLC.
- May also be a point-to-point subinterface running Frame Relay or ATM.
- No DR or BDR election required.
- OSPF autodetects this interface type.
- OSPF packets are sent using multicast 224.0.0.5.

Multiaccess Broadcast Network



- Generally these are, LAN technologies like Ethernet and Token Ring.
- DR and BDR selection are required.
- All neighbor routers form full adjacencies with the DR and BDR only.
- Packets to the DR and the BDR use 224.0.0.6.
- Packets from DR to all other routers use 224.0.0.5.

Electing the DR and BDR



- Hello packets are exchanged via IP multicast.
- The router with the highest OSPF priority is selected as the DR. The router with the second-highest priority value is the BDR.
- Use the OSPF router ID as the tiebreaker.
- The DR election is nonpreemptive.

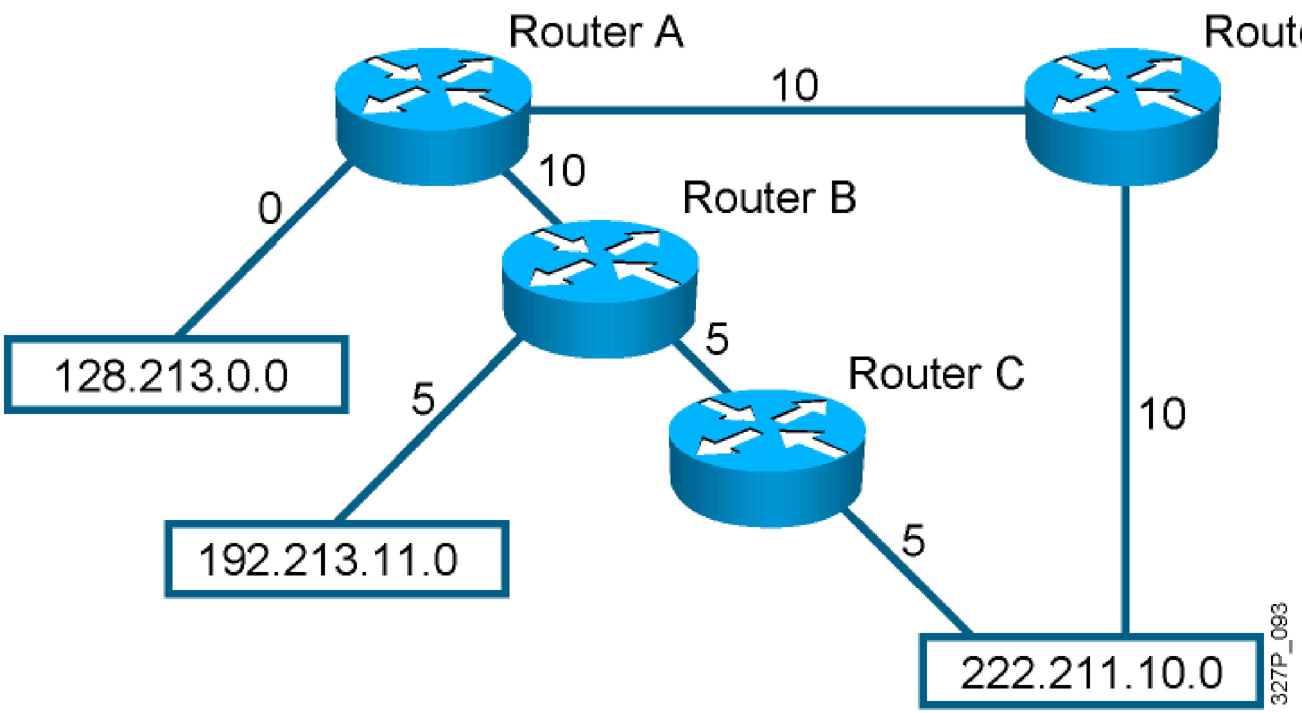
Setting Priority for DR Election

```
Router(config-if)#
```

```
ip ospf priority number
```

- **This interface configuration command assigns the OSPF priority to an interface.**
- **Different interfaces on a router may be assigned different values.**
- **The default priority is 1. The range is from 0 to 255.**
- **0 means the router cannot be the DR or BDR.**
- **A router that is not the DR or BDR is DROTHER.**

SPF Algorithm



- Places each router at the root of a tree and calculates the shortest path to each destination based on the cumulative cost
- Cost = Reference Bandwidth / Interface Bandwidth (b/s)

Configuring Single-Area OSPF

```
RouterX(config)#
```

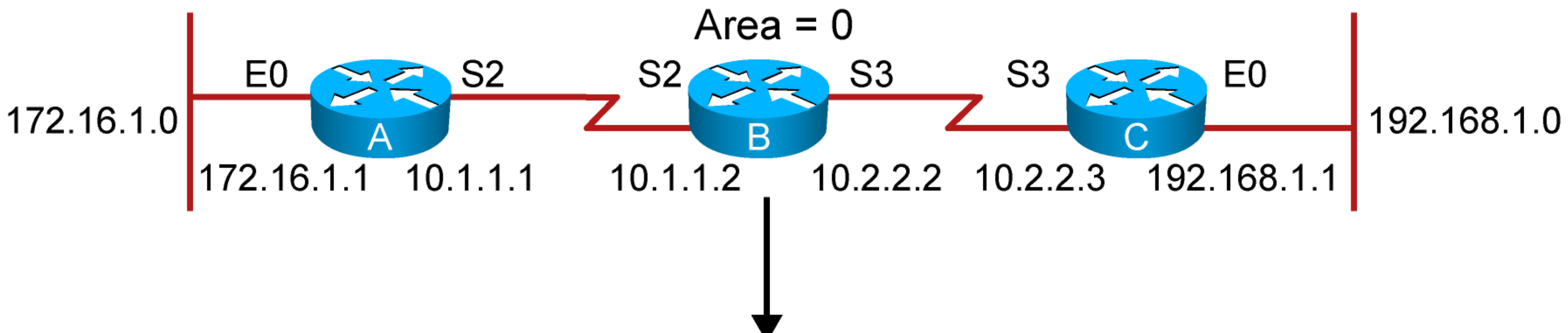
```
router ospf process-id
```

- Defines OSPF as the IP routing protocol

```
RouterX(config-router)#
```

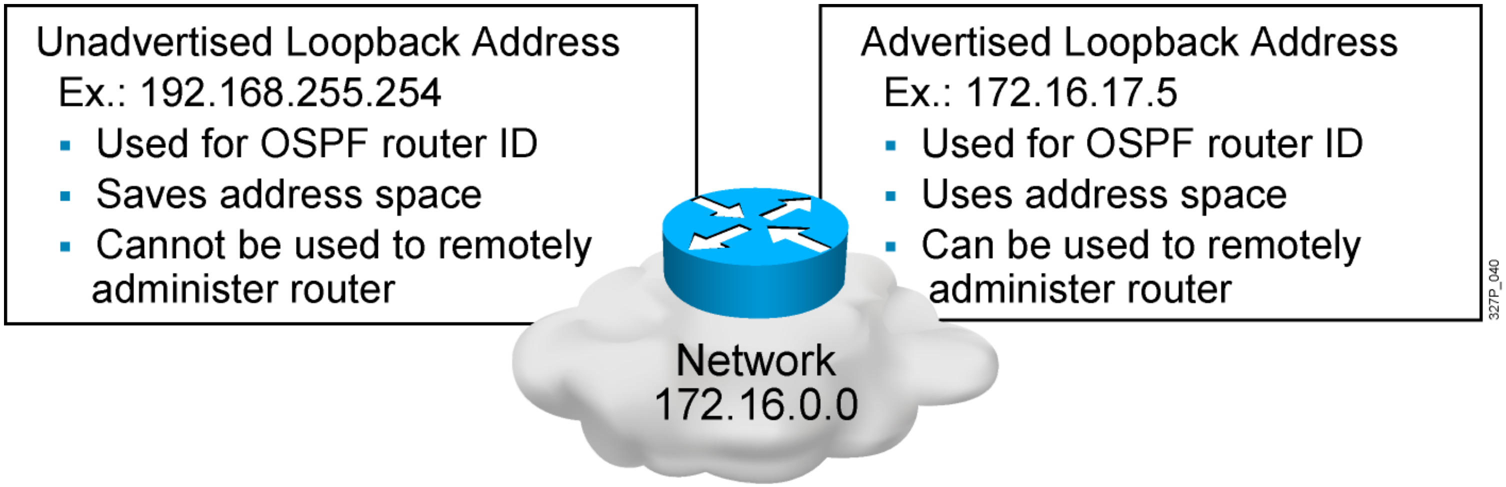
```
network address wildcard-mask area area-id
```

- Assigns networks to a specific OSPF area




```
router ospf 100
network 10.1.1.2 0.0.0.0 area 0
network 10.2.2.2 0.0.0.0 area 0
```

Configuring Loopback Interfaces



Router ID:

- Number by which the router is known to OSPF
- Default: The highest IP address on an active interface at the moment of OSPF process startup
- Can be overridden by a loopback interface: Highest IP address of any active loopback interface
- Can be set manually using the **router-id** command

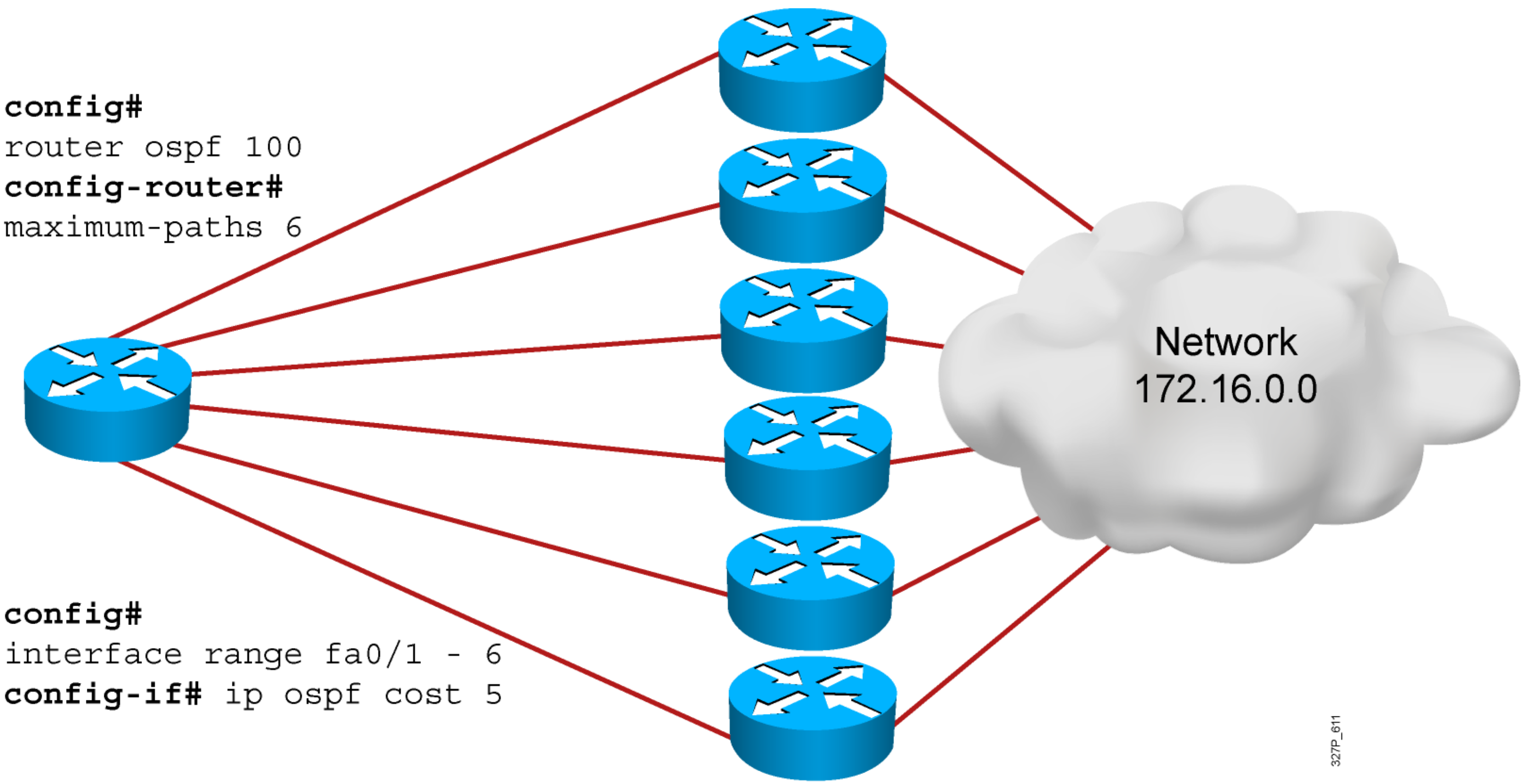
Load Balancing with OSPF

OSPF load balancing:

- Paths must be equal cost
- By default, up to four equal-cost paths can be placed into the routing table
- With a configuration change, up to a maximum of 16 paths can be configured:
  - `(config-router)# maximum-paths <value>`
- To ensure paths are equal cost for load balancing, you can change the cost of a particular link:
  - `(config-if)# ip ospf cost <value>`

Load Balancing with OSPF

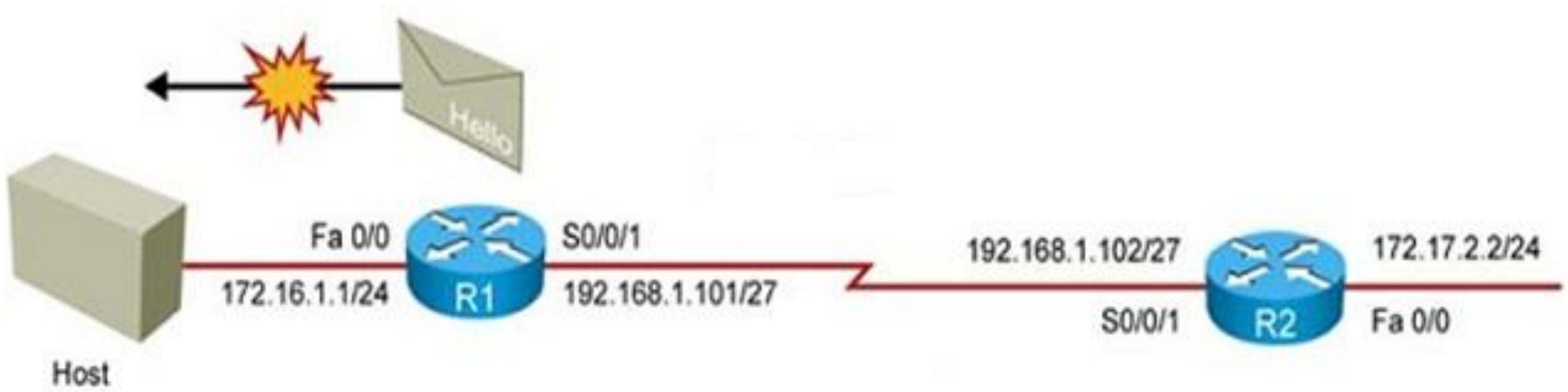
```
config#
router ospf 100
config-router#
maximum-paths 6
```



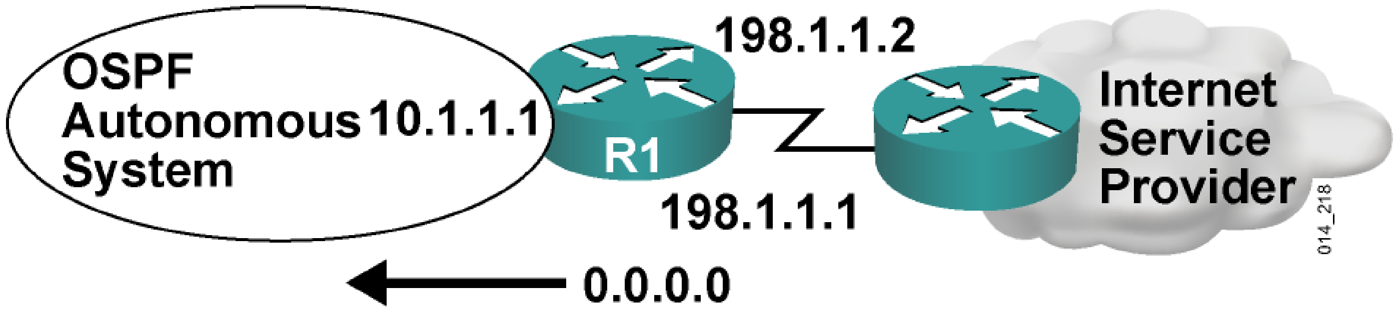

```
config#
interface range fa0/1 - 6
config-if# ip ospf cost 5
```

Using passive-interface command

- No need to talk to host by OSPF
- Disables OSPF on selected interfaces.
- Still advertise subnet on the selected interfaces.



Default Routes in OSPF



- **A default route is injected into OSPF as an external LSA type 5.**
- **Default route distribution is not on by default; use the** default-information originate **command under the OSPF routing process.**

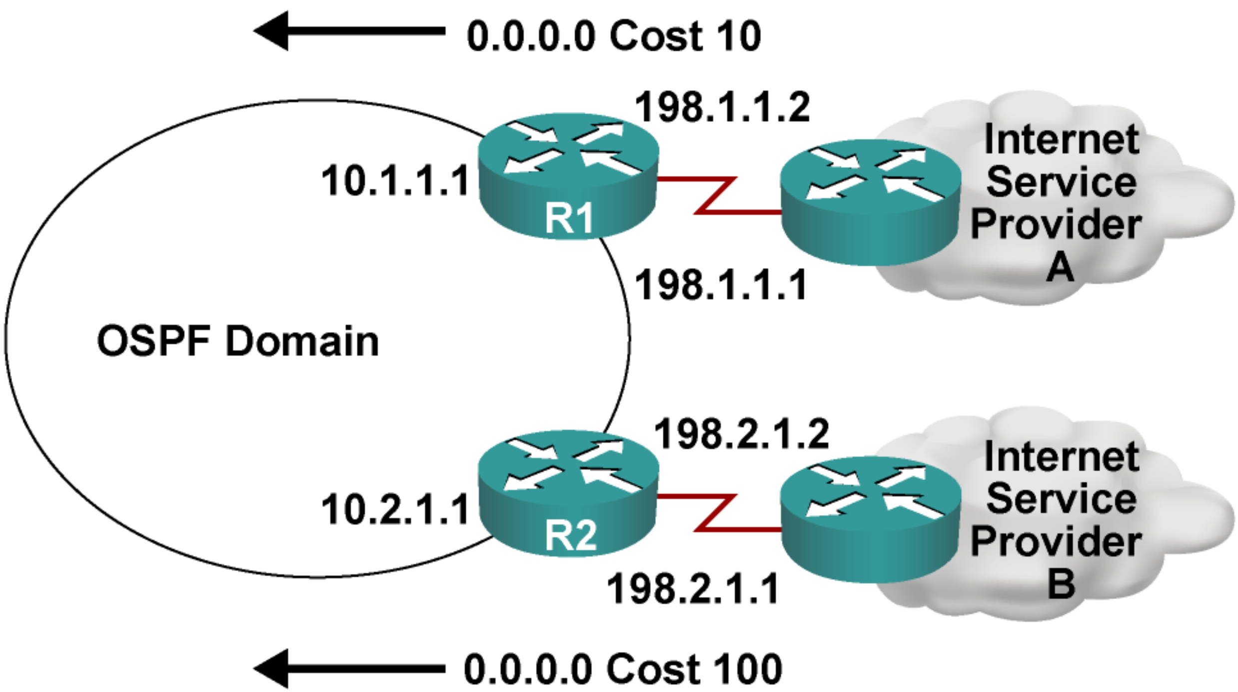
Configuring OSPF Default Routes

`Router(config-router)#`

`default-information originate [always] [metric` *`metric-value`***`] [metric-type`** *`type-value`***`] [route-map`** *`map-name`***`]`**

- **Normally, this command advertises a 0.0.0.0 default into the OSPF network only if the default route already exists in the routing table.**
- **The** always **keyword allows the 0.0.0.0 default to be advertised even when the default route does not exist in the routing table.**

Default Route Configuration Example




```
R1#
router ospf 100
network 10.1.1.1  0.0.0.0 area 0
default-information originate metric 10

ip route 0.0.0.0 0.0.0.0 198.1.1.2
```

```
R2#
router ospf 100
network 10.2.1.1  0.0.0.0 area 0
default-information originate metric 100

ip route 0.0.0.0 0.0.0.0 198.2.1.2
```

Verifying the OSPF Configuration

```
RouterX# show ip protocols
```

- Verifies that OSPF is configured

```
RouterX# show ip route
```

- Displays all the routes learned by the router

```
RouterX# show ip route

Codes: I - IGRP derived, R - RIP derived, O - OSPF derived,
C - connected, S - static, E - EGP derived, B - BGP derived,
E2 - OSPF external type 2 route, N1 - OSPF NSSA external type 1 route,
N2 - OSPF NSSA external type 2 route

Gateway of last resort is 10.119.254.240 to network 10.140.0.0

O 10.110.0.0 [110/5] via 10.119.254.6, 0:01:00, Ethernet2
O IA 10.67.10.0 [110/10] via 10.119.254.244, 0:02:22, Ethernet2
O 10.68.132.0 [110/5] via 10.119.254.6, 0:00:59, Ethernet2
O 10.130.0.0 [110/5] via 10.119.254.6, 0:00:59, Ethernet2
O E2 10.128.0.0 [170/10] via 10.119.254.244, 0:02:22, Ethernet2
```

Verifying the OSPF Configuration (Cont.)

```
RouterX# show ip ospf
```

- Displays the OSPF router ID, timers, and statistics

```
RouterX# show ip ospf
 Routing Process "ospf 50" with ID 10.64.0.2
<output omitted>

 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 Number of areas transit capable is 0
 External flood list length 0
    Area BACKBONE(0)
    Area BACKBONE(0)
        Area has no authentication
        SPF algorithm last executed 00:01:25.028 ago
        SPF algorithm executed 7 times
<output omitted>
```

Verifying the OSPF Configuration (Cont.)

```
RouterX# show ip ospf interface
```

- Displays the area ID and adjacency information

```
RouterX# show ip ospf interface ethernet 0

Ethernet 0 is up, line protocol is up
Internet Address 192.168.254.202, Mask 255.255.255.0, Area 0.0.0.0
AS 201, Router ID 192.168.99.1, Network Type BROADCAST, Cost: 10
Transmit Delay is 1 sec, State OTHER, Priority 1
Designated Router id 192.168.254.10, Interface address 192.168.254.10
Backup Designated router id 192.168.254.28, Interface addr 192.168.254.28
Timer intervals configured, Hello 10, Dead 60, Wait 40, Retransmit 5
Hello due in 0:00:05
Neighbor Count is 8, Adjacent neighbor count is 2
  Adjacent with neighbor 192.168.254.28 (Backup Designated Router)
  Adjacent with neighbor 192.168.254.10 (Designated Router)
```

Verifying the OSPF Configuration (Cont.)

```
RouterX# show ip ospf neighbor
```

- Displays the OSPF neighbor information on a per-interface basis

```
RouterX# show ip ospf neighbor

ID               Pri State          Dead Time   Address         Interface
10.199.199.137   1   FULL/DR         0:00:31    192.168.80.37   FastEthernet0/0
172.16.48.1      1   FULL/DROTHER    0:00:33    172.16.48.1     FastEthernet0/1
172.16.48.200    1   FULL/DROTHER    0:00:33    172.16.48.200   FastEthernet0/1
10.199.199.137   5   FULL/DR         0:00:33    172.16.48.189   FastEthernet0/1
```

Verifying the OSPF Configuration (Cont.)

```
RouterX# show ip ospf neighbor 10.199.199.137
Neighbor 10.199.199.137, interface address 192.168.80.37
In the area 0.0.0.0 via interface Ethernet0
Neighbor priority is 1, State is FULL
Options 2
Dead timer due in 0:00:32
Link State retransmission due in 0:00:04
Neighbor 10.199.199.137, interface address 172.16.48.189
In the area 0.0.0.0 via interface Fddi0
Neighbor priority is 5, State is FULL
Options 2
Dead timer due in 0:00:32
Link State retransmission due in 0:00:03
```

OSPF debug Commands

```
RouterX# debug ip ospf events

OSPF:hello with invalid timers on interface Ethernet0
hello interval received 10 configured 10
net mask received 255.255.255.0 configured 255.255.255.0
dead interval received 40 configured 30

OSPF: rcv. v:2 t:1 l:48 rid:200.0.0.117
      aid:0.0.0.0 chk:6AB2 aut:0 auk:

RouterX# debug ip ospf packet

OSPF: rcv. v:2 t:1 l:48 rid:200.0.0.116
      aid:0.0.0.0 chk:0 aut:2 keyid:1 seq:0x0
```

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