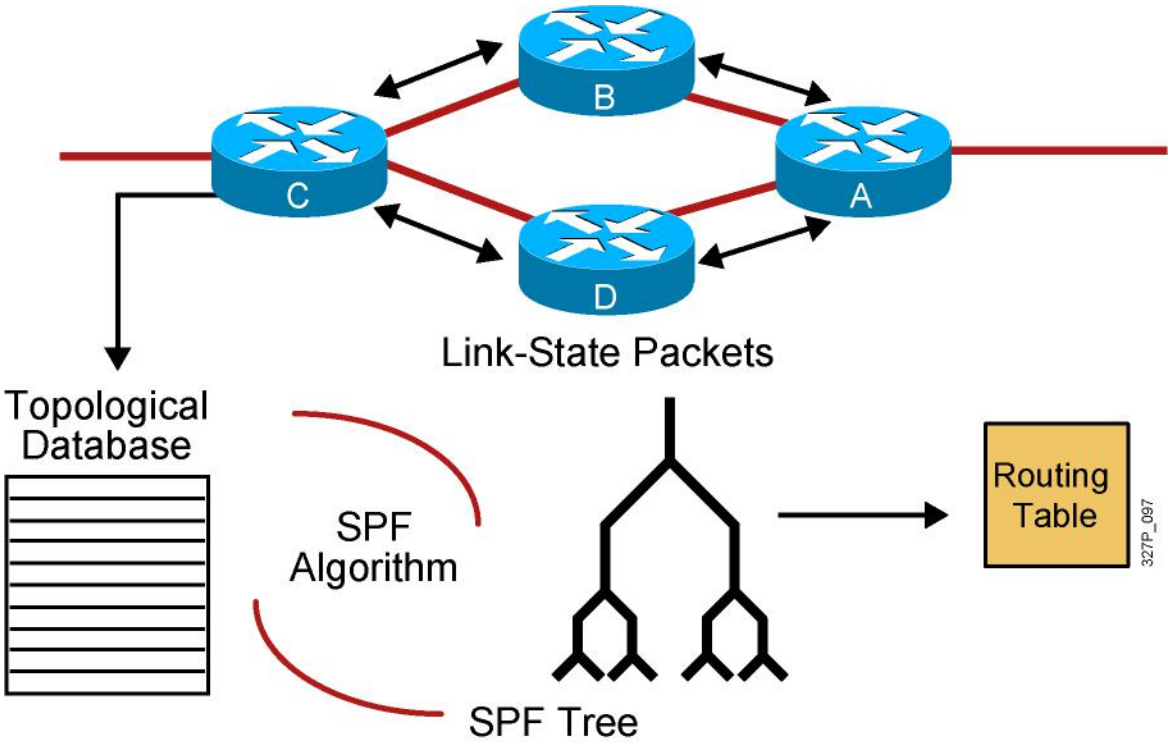
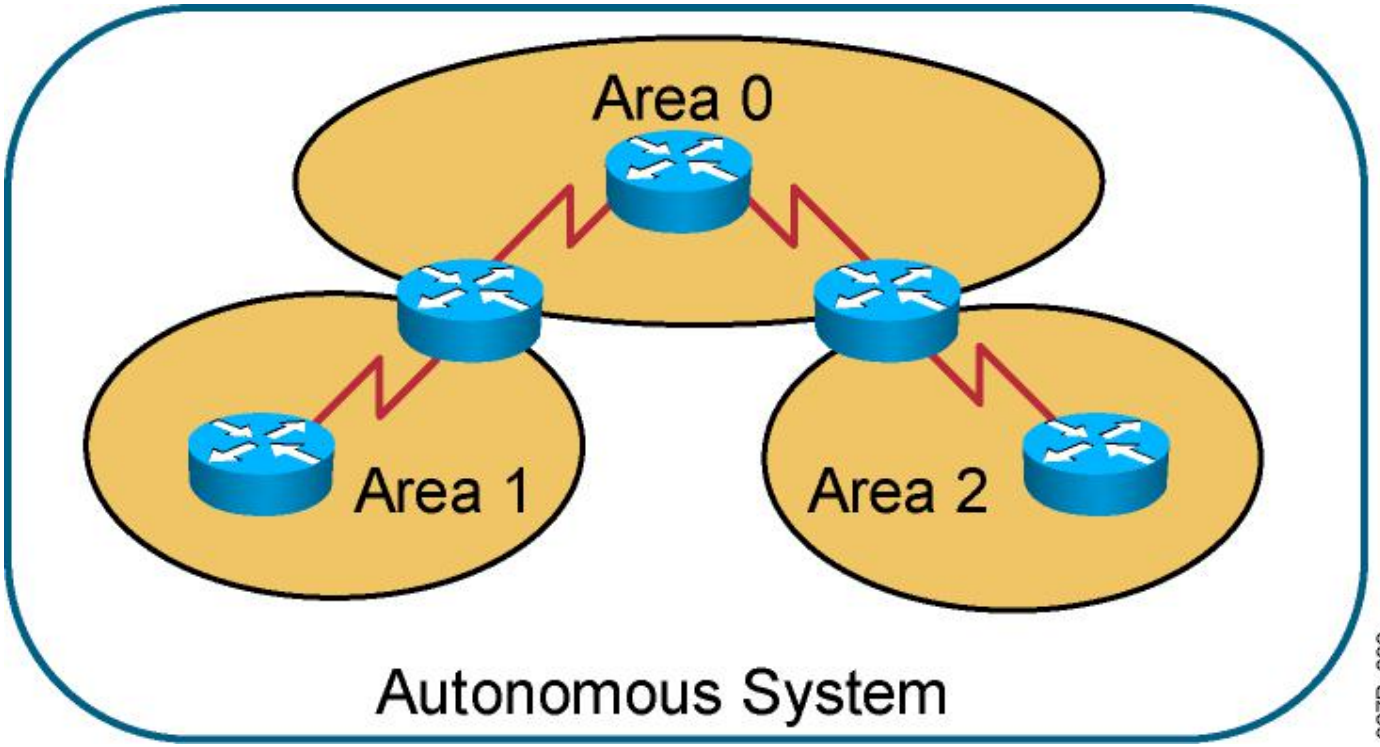
Link State Routing Protocol

Link-State Routing Protocols



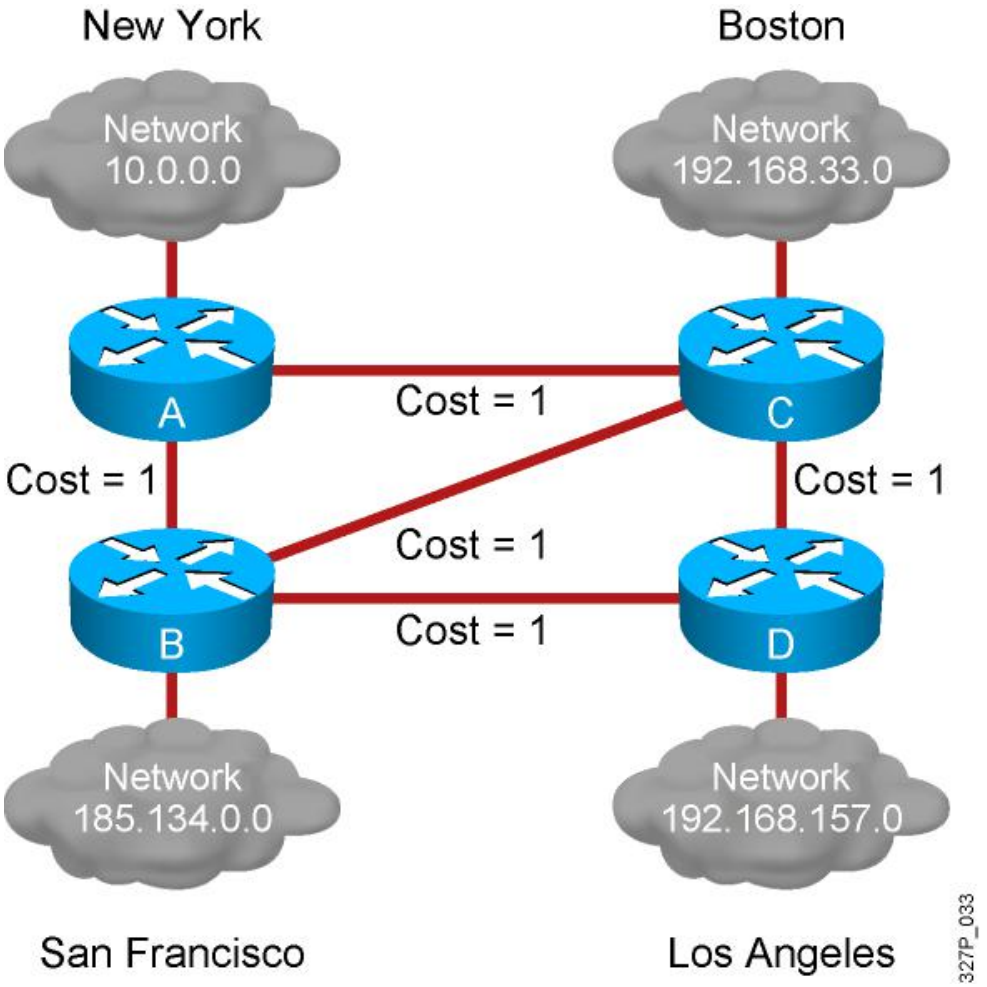
- After an initial flood of LSAs, link-state routers pass small, event-triggered link-state updates to all other routers.

OSPF Hierarchical Routing



- Consists of areas and autonomous systems
- Minimizes routing update traffic

Link-State Routing Protocol Algorithms



Benefits and Drawbacks of Link-State Routing

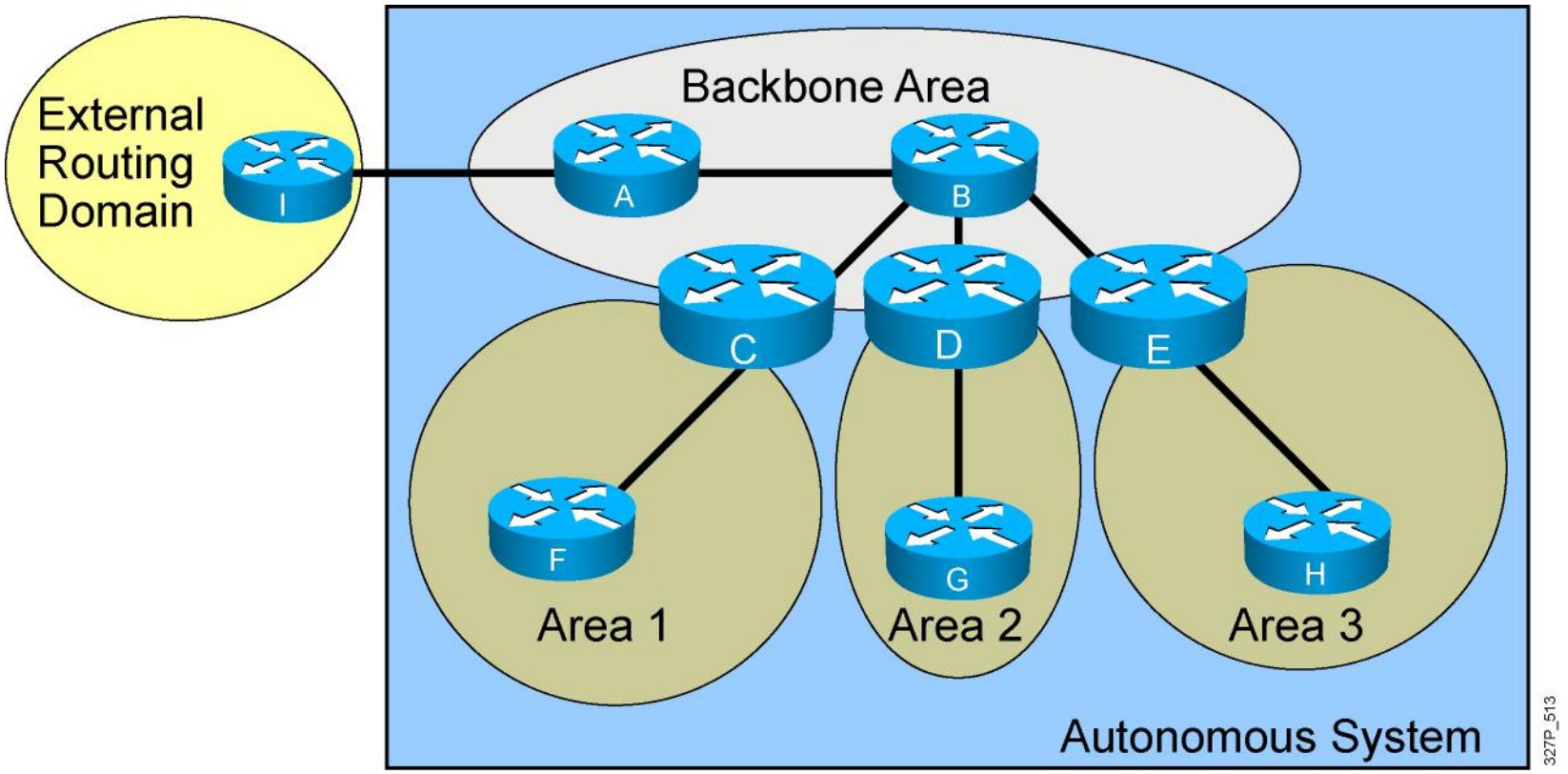
- Benefits of link-state routing:
  - Fast convergence:
    - Changes are reported immediately by the affected source
  - Robustness against routing loops:
    - Routers know the topology
    - Link-state packets are sequenced and acknowledged
  - Hierarchical network design enables optimization of resources.

- 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

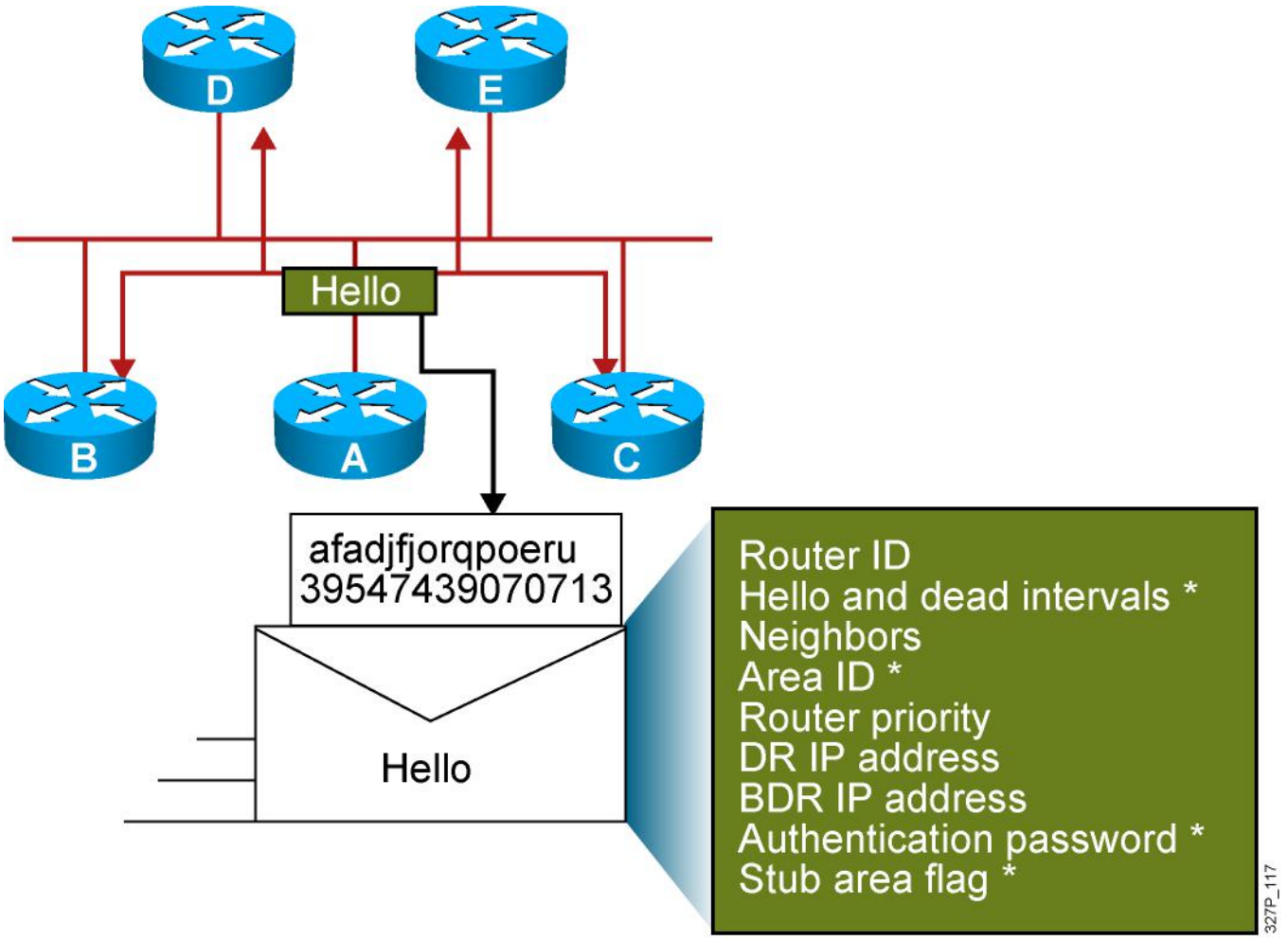
- Creates a neighbor relationship by exchanging hello packets
- Propagates LSAs rather than routing table updates
  - Link: Router interface
  - State: Description of an interface and its relationship to neighboring routers
- Floods LSAs to all OSPF routers in the area, not just directly connected routers
- 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



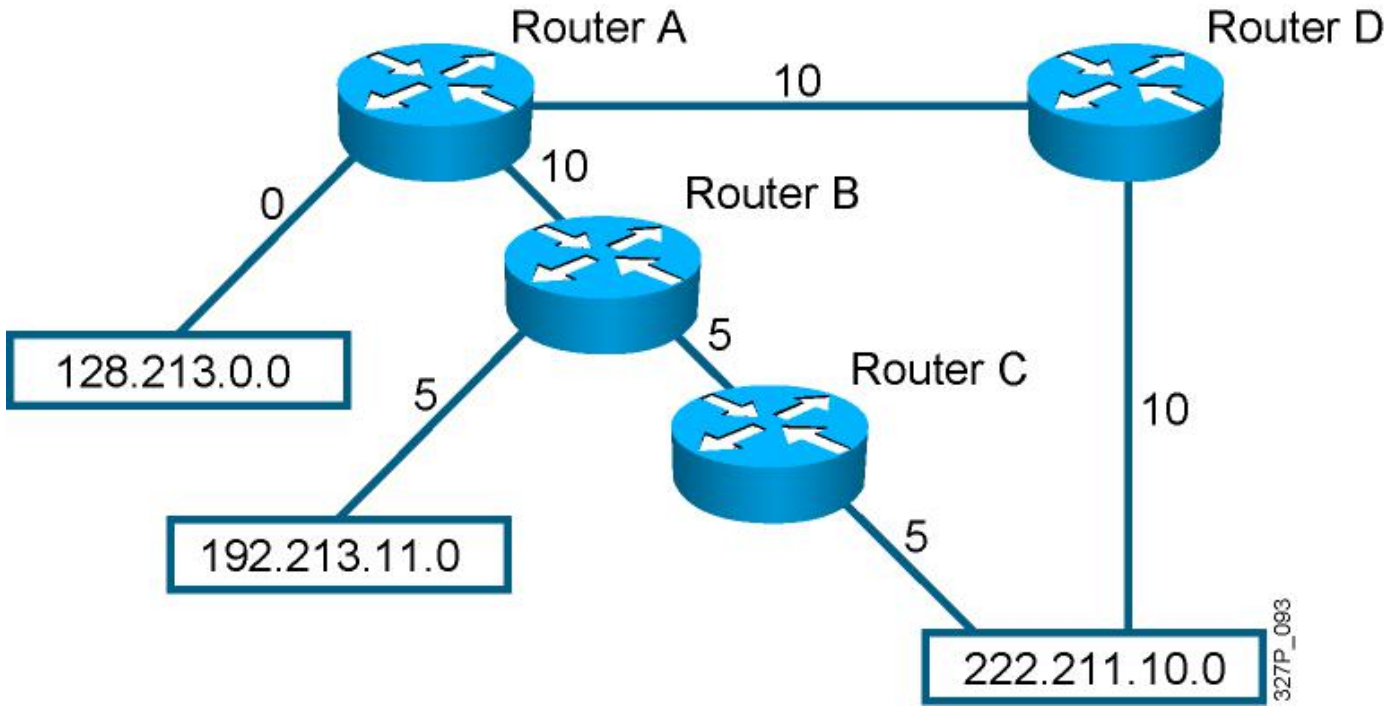
- Minimizes routing table entries
- Localizes the impact of a topology change within an area

Neighbor Adjacencies: The Hello Packet



* Entry must match on neighboring routers

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)#

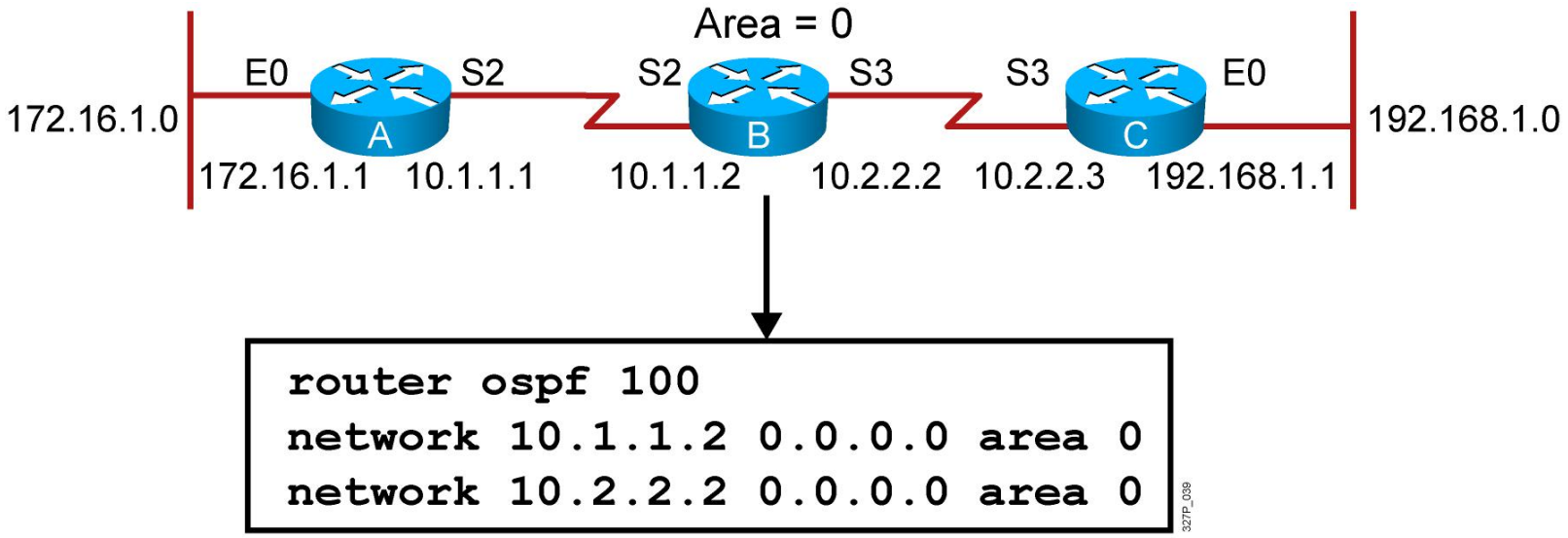
```
router ospf process-id
```

- Defines OSPF as the IP routing protocol

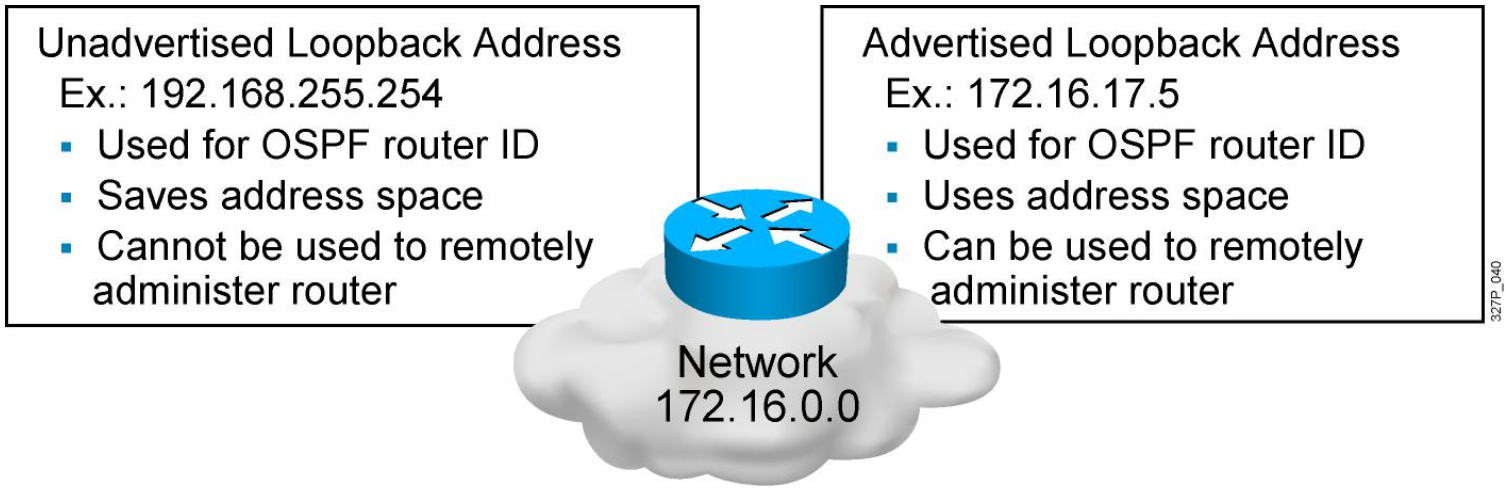
RouterX(config-router)#

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

- Assigns networks to a specific OSPF area



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

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

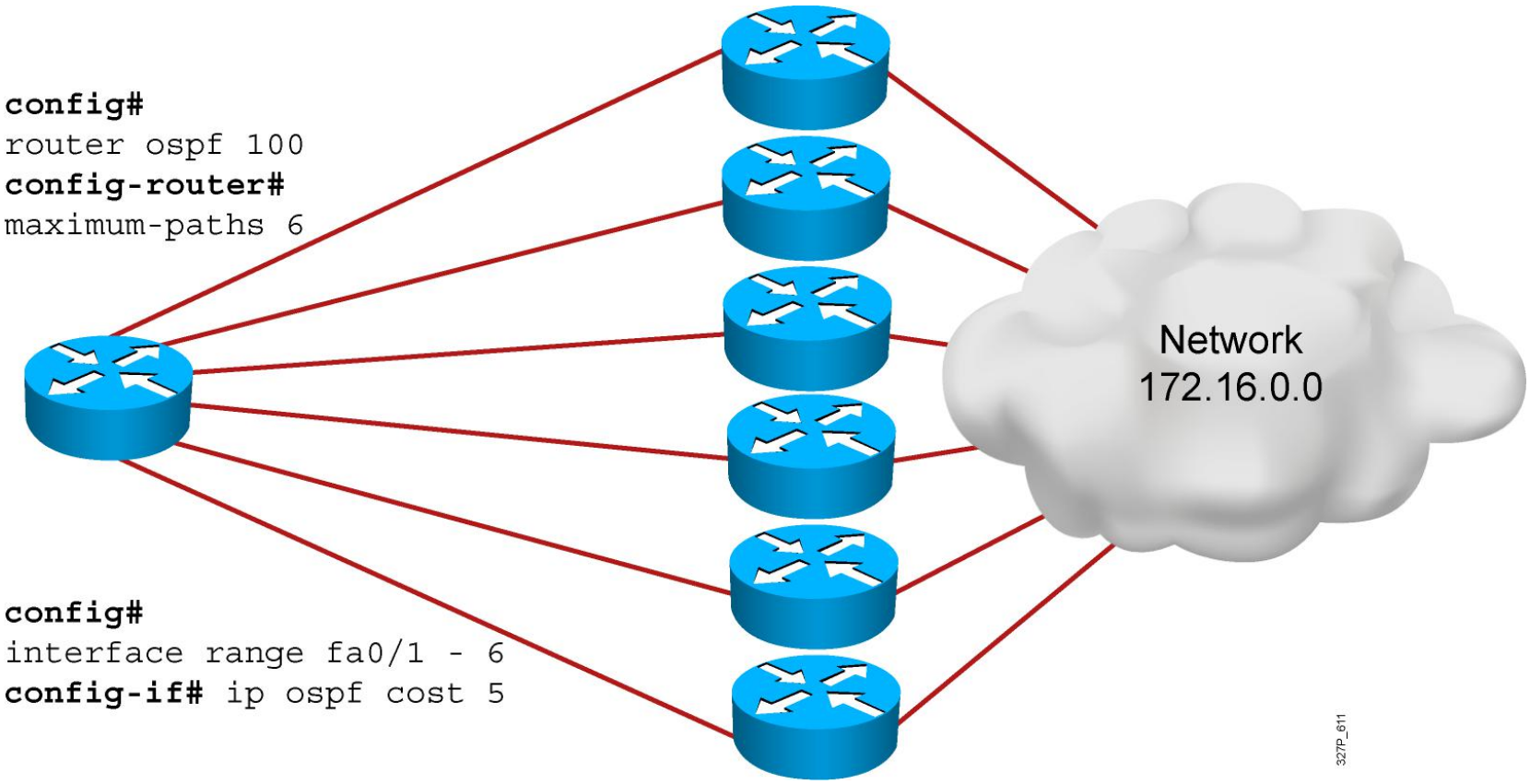
```
RouterX# debug ip ospf events

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
```

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



OSPF Authentication

- OSPF supports two types of authentication:
  - Plaintext (or simple) password authentication
  - MD5 authentication
- The router generates and checks every OSPF packet.
- The router authenticates the source of each routing update packet that it receives.
- Configure a “key” (password); each participating neighbor must have the same key configured.

Configuring OSPF Plaintext Password Authentication

```
RouterX(config-if)#
ip ospf authentication-key password
```

- Assigns a password to use with neighboring routers

```
RouterX(config-if)#
ip ospf authentication [message-digest | null]
```

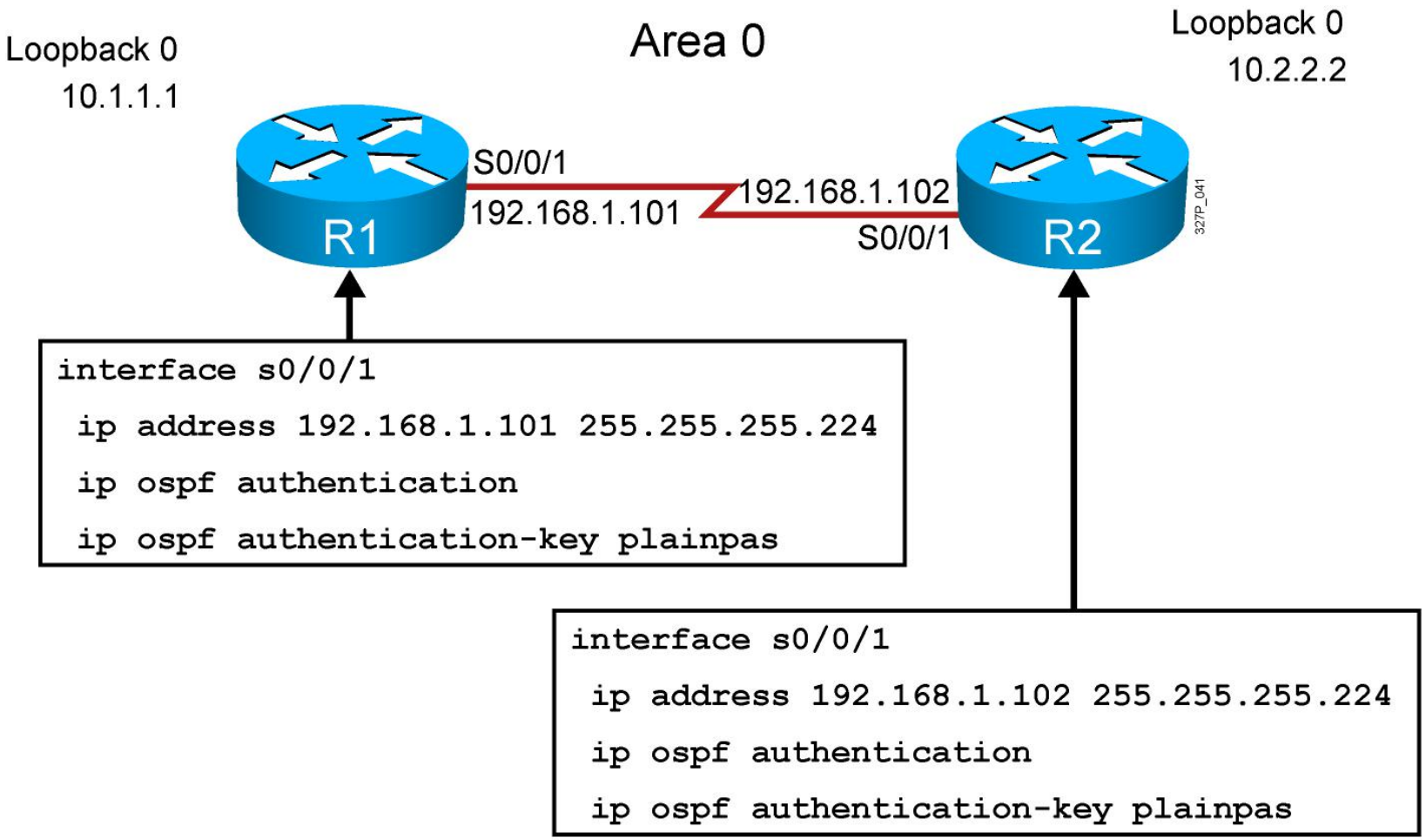
- Specifies the authentication type for an interface (as of Cisco IOS Release 12.0)

OR

```
RouterX(config-router)#
area area-id authentication [message-digest]
```

- Specifies the authentication type for an area

Plaintext Password Authentication Configuration Example



Verifying Plaintext Password Authentication

```
RouterX#show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
10.2.2.2          0   FULL/  -        00:00:32    192.168.1.102   Serial0/0/1

RouterX#show ip route
<output omitted>
Gateway of last resort is not set
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
O       10.2.2.2/32 [110/782] via 192.168.1.102, 00:01:17, Serial0/0/1
C       10.1.1.0/24 is directly connected, Loopback0
     192.168.1.0/27 is subnetted, 1 subnets
C       192.168.1.96 is directly connected, Serial0/0/1

RouterX#ping 10.2.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.2.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/29/32 ms
```