



OSPF & DHCP

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OSPF

Link-State Routing Protocol & OSPF

OSPF Messages

OSPF Operation

Configuring Single-Area OSPFv2

Verify OSPF

DHCP

DHCPv4 Operation

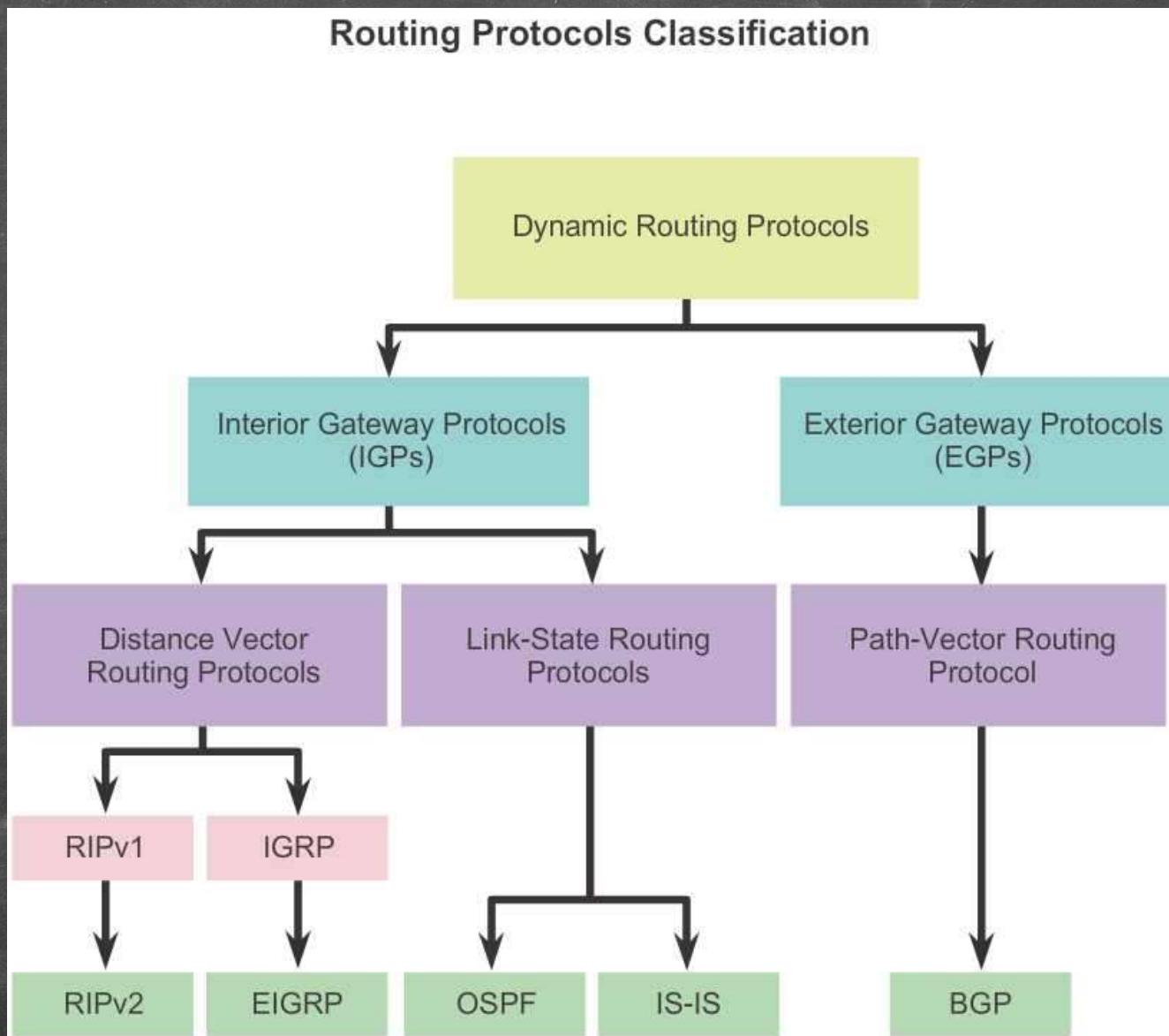
Configuring a DHCPv4 Server

DHCPv4 Relay

Configuring a DHCPv4 client

Troubleshoot DHCPv4

Link-State Routing Protocol



Link-State Routing Protocol

- A link-state routing protocol is like having a complete map of the network topology.
- The sign posts along the way from source to destination are not necessary, because all link-state routers are using an identical map of the network.
- A link-state router uses the link-state information to create a topology map and to select the best path to all destination networks in the topology.

Link-State Routing Protocol

- Link-state protocols work best in situations where:
 - The network design is hierarchical, usually occurring in large networks
 - Fast convergence of the network is crucial
 - The administrators have good knowledge of the implemented link-state routing protocol
- There are two link-state IPv4 IGPs:
 - OSPF - Popular standards based routing protocol
 - IS-IS - Popular in provider networks

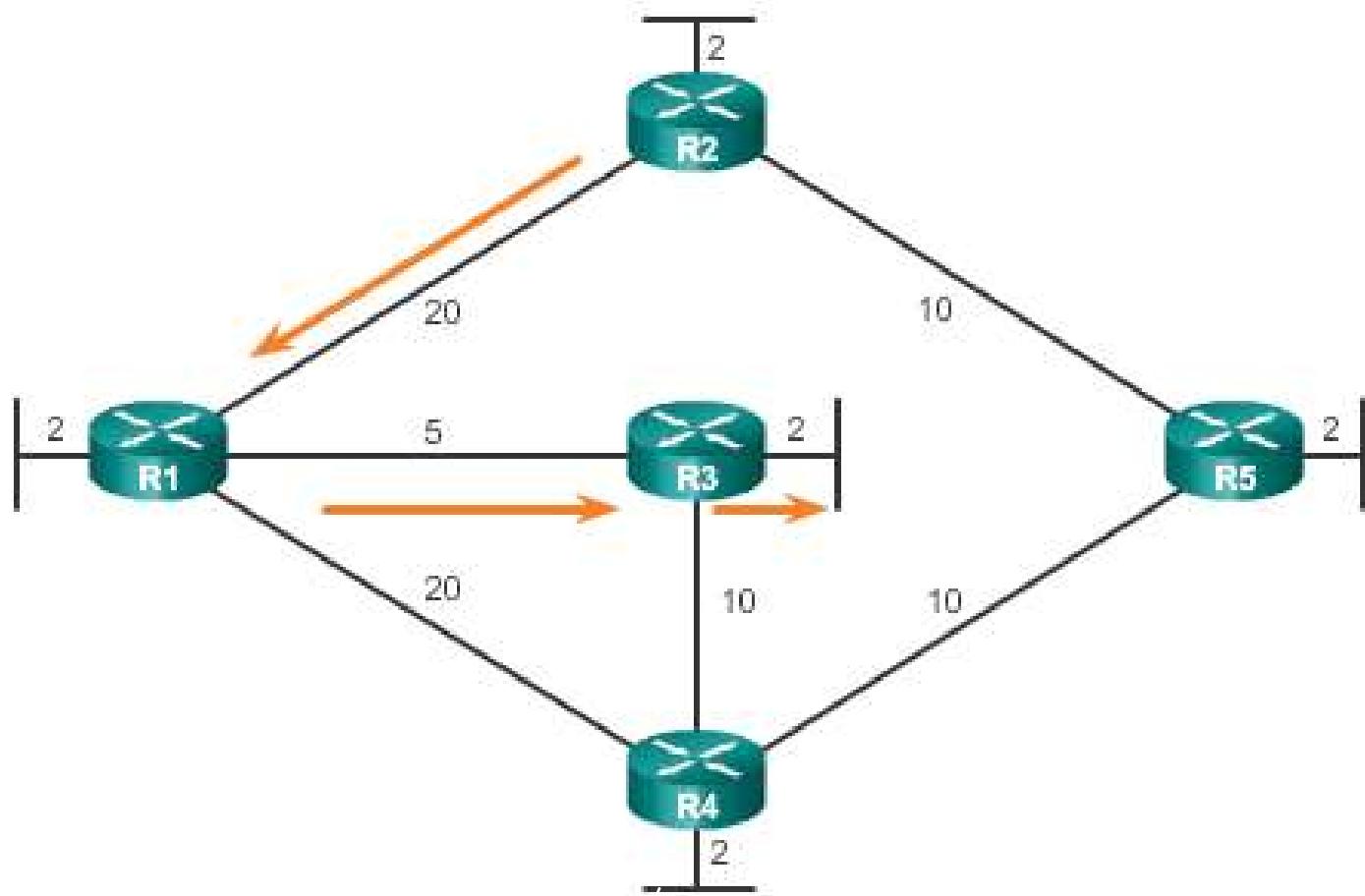
Link-State Routing Protocol

- All link-state routing protocols apply Dijkstra's algorithm to calculate the best path route.
- The algorithm is commonly referred to as the shortest path first (SPF) algorithm.
- This algorithm uses accumulated costs along each path, from source to destination, to determine the total cost of a route.

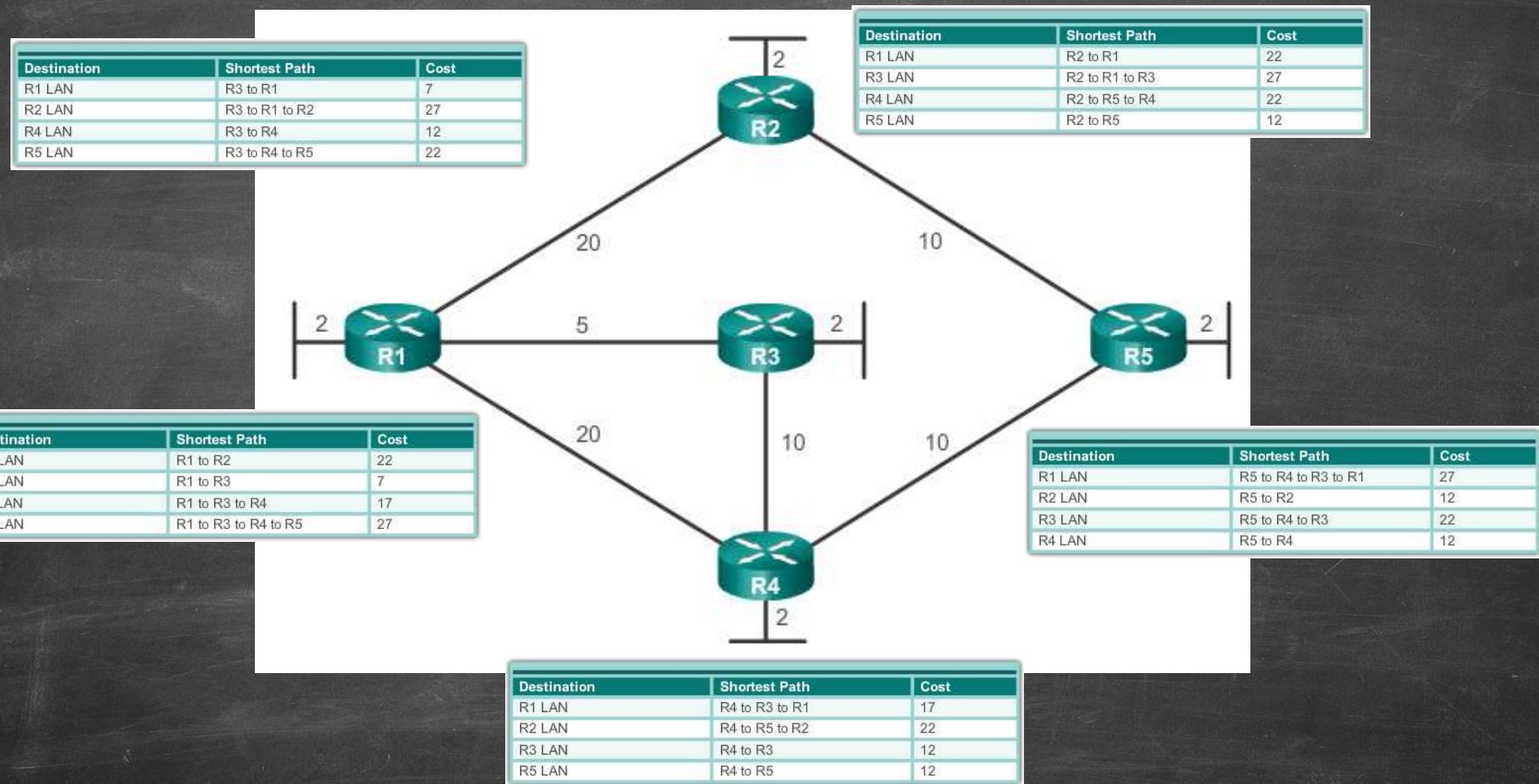
Link-State Routing Protocol

Dijkstra's Shortest Path First Algorithm

Shortest Path for host on R2 LAN to reach host on R3 LAN:
 $R2 \text{ to } R1 \text{ (20)} + R1 \text{ to } R3 \text{ (5)} + R3 \text{ to LAN (2)} = 27$



Link-State Routing Protocol



Link-State Routing Protocol

- Link-State Updates

Link-State Routing Process

- Each router learns about each of its own directly connected networks.
- Each router is responsible for "saying hello" to its neighbors on directly connected networks.
- Each router builds a Link-State Packet (LSP) containing the state of each directly connected link.
- Each router floods the LSP to all neighbors who then store all LSP's received in a database.
- Each router uses the database to construct a complete map of the topology and computes the best path to each destination network.

Link-State Routing Protocol

- Link & Link-State
 - Each router learns about its own links

Link 1

- Network: **10.1.0.0/16**
- IP address: **10.1.0.1**
- Type of network: **Ethernet**
- Cost of that link: **2**
- Neighbors: **None**

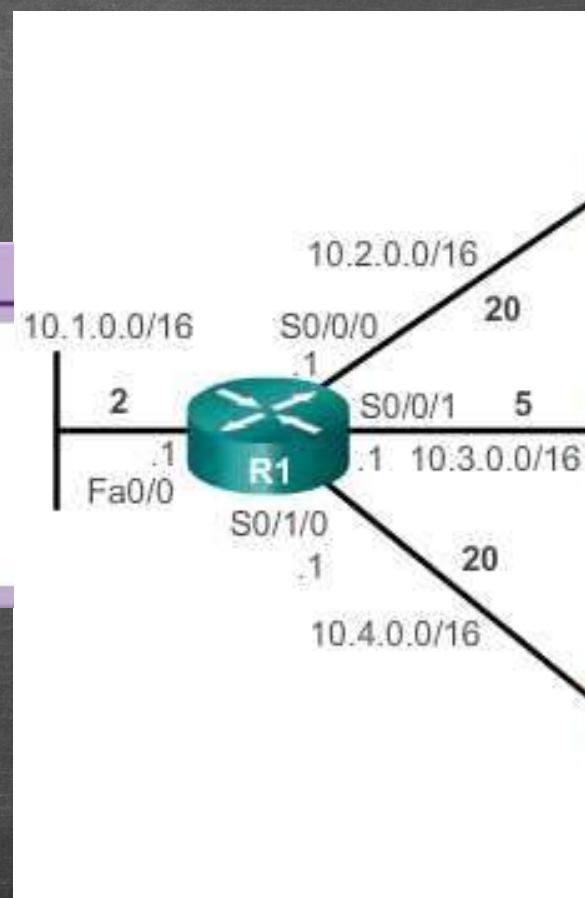
Link & Link-State

Say Hello

Building the Link-State Packet

Flooding LSP & Building Database

Building the SPF Tree & Routing Table



Link 2

- Network: **10.2.0.0/16**
- IP address: **10.2.0.1**
- Type of network: **Serial**
- Cost of that link: **20**
- Neighbors: **R2**

Link 3

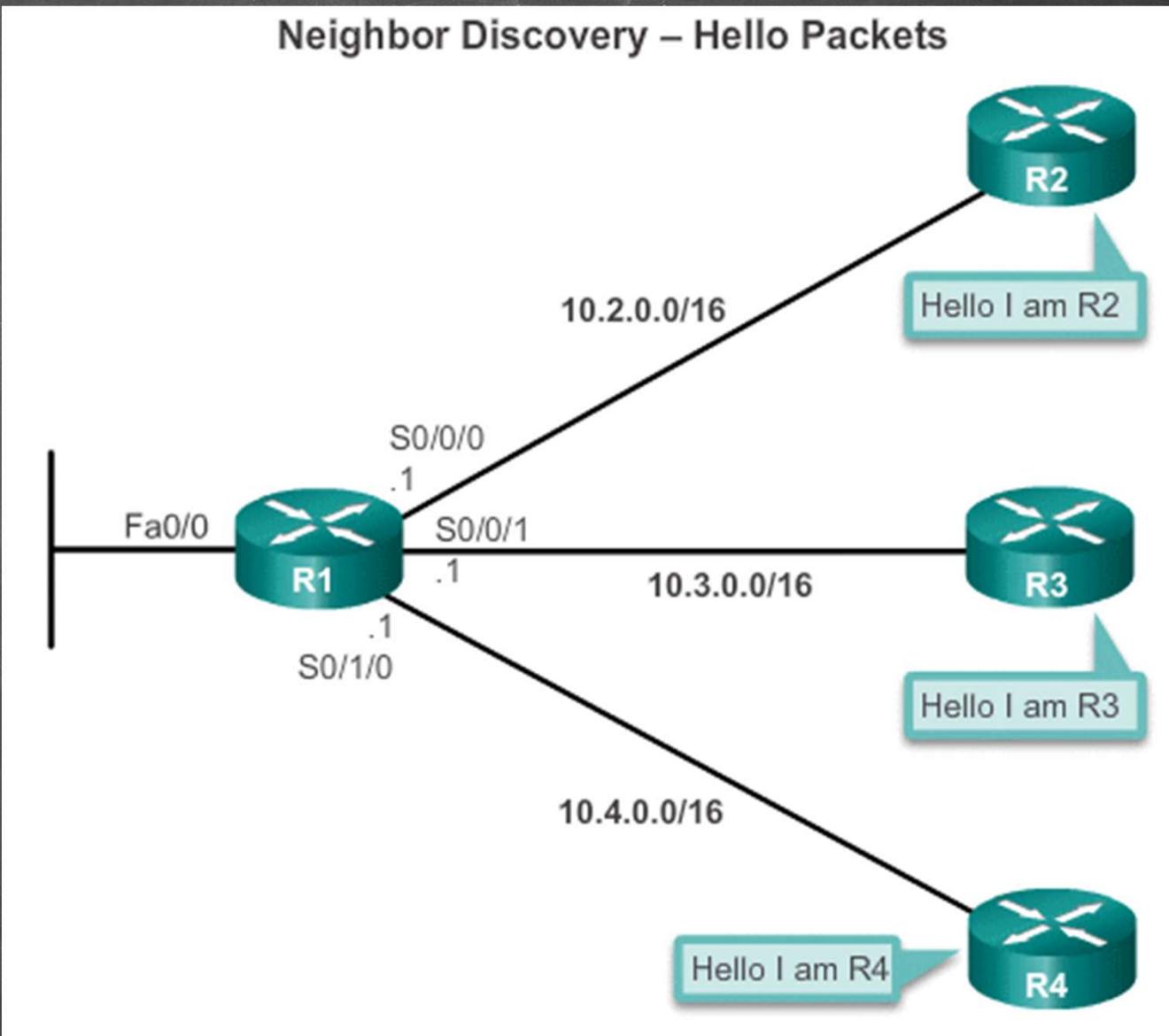
- Network: **10.3.0.0/16**
- IP address: **10.3.0.1**
- Type of network: **Serial**
- Cost of that link: **5**
- Neighbors: **R3**

Link 4

- Network: **10.4.0.0/16**
- IP address: **10.4.0.1**
- Type of network: **Serial**
- Cost of that link: **20**
- Neighbors: **R4**

Link-State Routing Protocol

- Say Hello
 - Exchanging Hello packets with other link-state routers



Link & Link-State

Say Hello

Building the Link-State Packet

Flooding LSP & Building Database

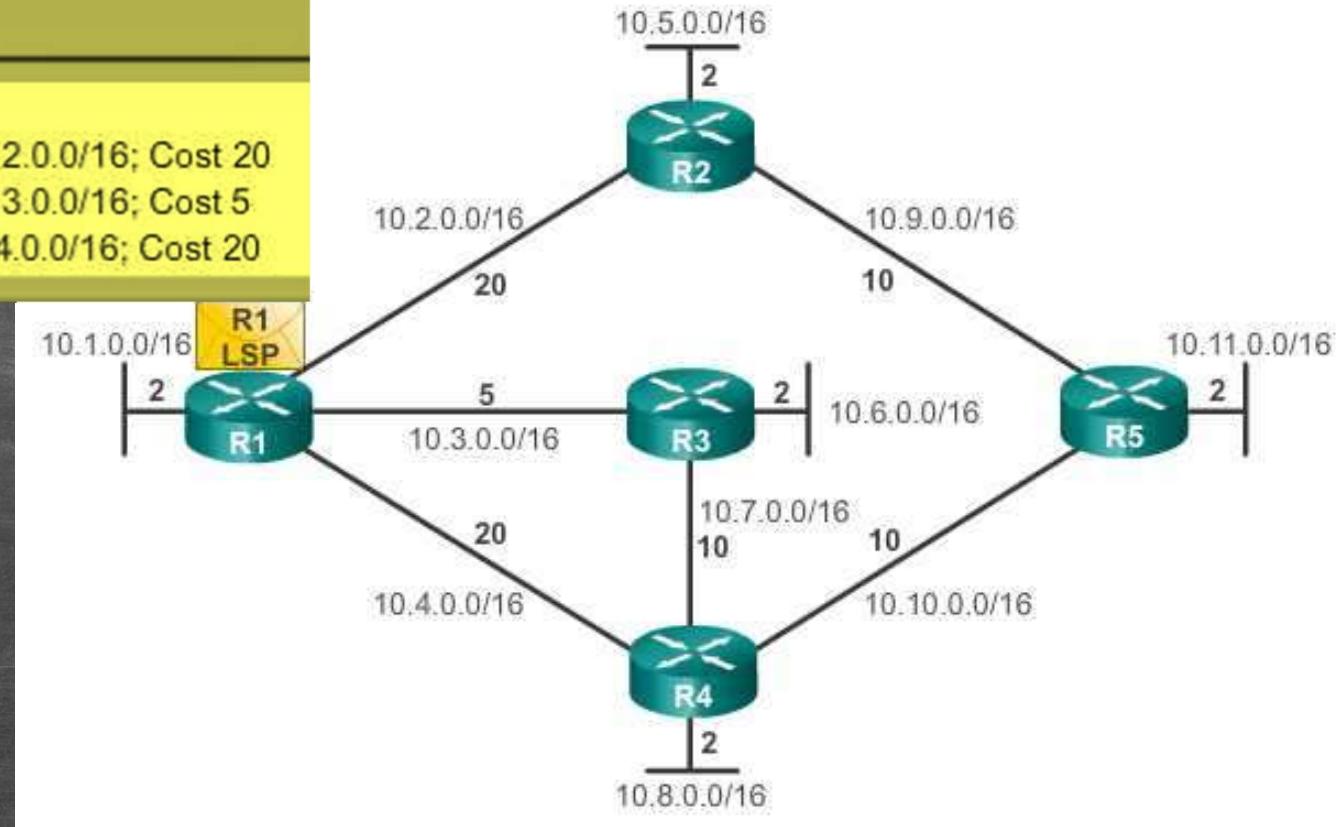
Building the SPF Tree & Routing Table

Link-State Routing Protocol

- Building the Link-State Packet (LSP)

R1 Link State Contents

- R1; Ethernet network; 10.1.0.0/16; Cost 2
- R1 -> R2; Serial point-to-point network; 10.2.0.0/16; Cost 20
- R1 -> R3; Serial point-to-point network; 10.3.0.0/16; Cost 5
- R1 -> R4; Serial point-to-point network; 10.4.0.0/16; Cost 20



Link & Link-State

Say Hello

Building the Link-State Packet

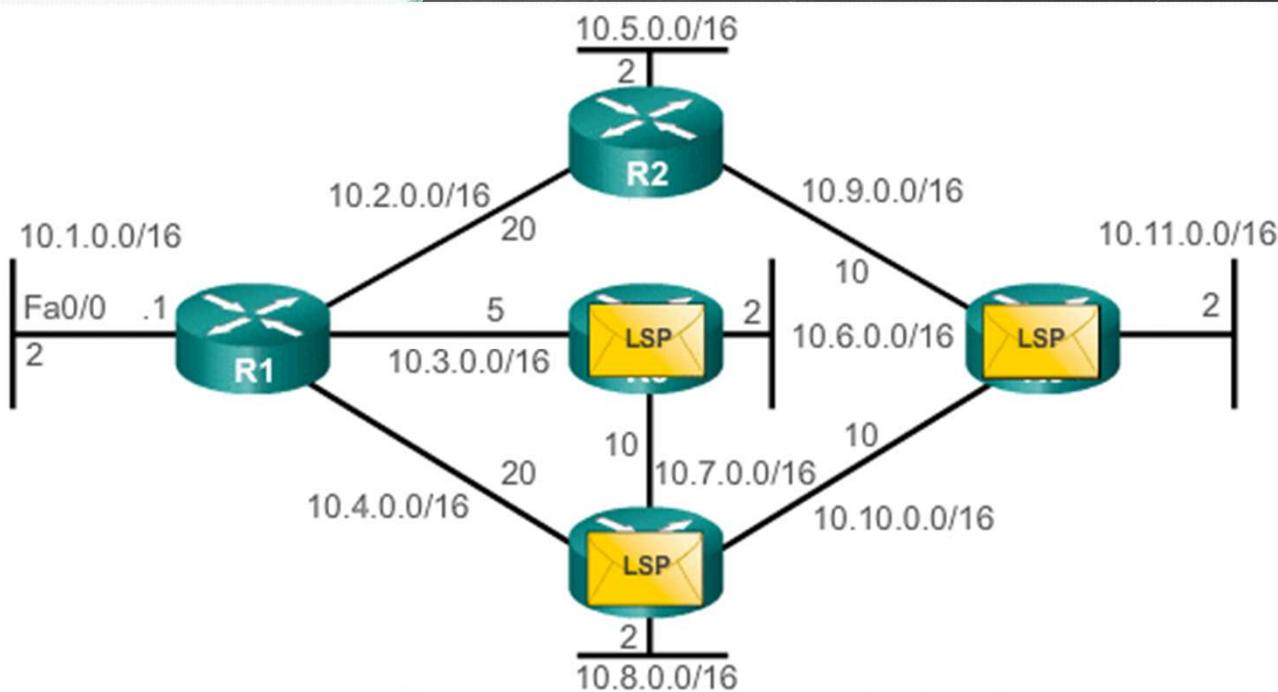
Flooding LSP & Building Database

Building the SPF Tree & Routing Table

Link-State Routing Protocol

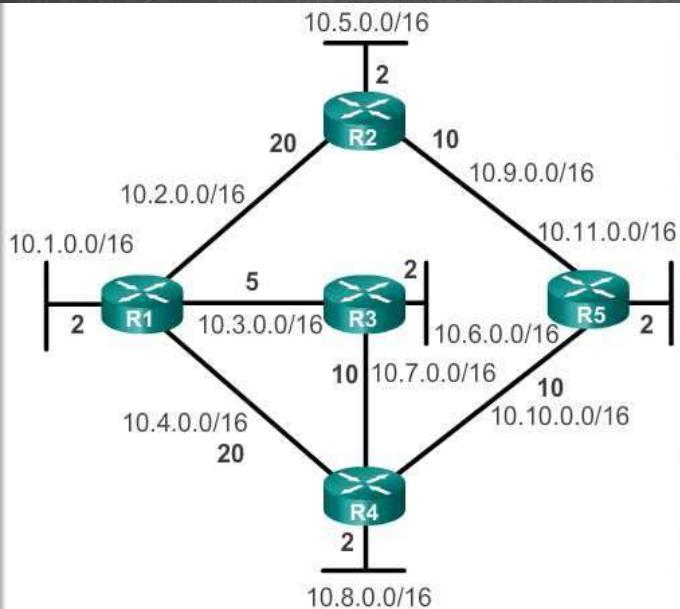
- Flooding the LSP
- Building the Link-State Database

R1 Link-State Database	
R1 Link-states:	
• Connected to network 10.1.0.0/16, cost = 2	
• Connected to R2 on network 10.2.0.0/16, cost = 20	
• Connected to R3 on network 10.3.0.0/16, cost = 5	
• Connected to R4 on network 10.4.0.0/16, cost = 20	
R2 Link-states:	
• Connected to network 10.5.0.0/16, cost = 2	
• Connected to R1 on network 10.2.0.0/16, cost = 20	
• Connected to R5 on network 10.9.0.0/16, cost = 10	
R3 Link-states:	
• Connected to network 10.6.0.0/16, cost = 2	
• Connected to R1 on network 10.3.0.0/16, cost = 5	
• Connected to R4 on network 10.7.0.0/16, cost = 10	
R4 Link-states:	
• Connected to network 10.8.0.0/16, cost = 2	
• Connected to R1 on network 10.4.0.0/16, cost = 20	
• Connected to R3 on network 10.7.0.0/16, cost = 10	
• Connected to R5 on network 10.10.0.0/16, cost = 10	
R5 Link-states:	
• Connected to network 10.11.0.0/16, cost = 2	
• Connected to R2 on network 10.9.0.0/16, cost = 10	
• Connected to R4 on network 10.10.0.0/16, cost = 10	



Link-State Routing Protocol

- Building the SPF Tree
- Adding OSPF Routes to the Routing Table



Link & Link-State

Say Hello

Building the Link-State Packet

Flooding LSP & Building Database

Building the SPF Tree & Routing Table

Destination	Shortest Path	Cost
10.5.0.0/16	R1 → R2	22
10.6.0.0/16	R1 → R3	7
10.7.0.0/16	R1 → R3	15
10.8.0.0/16	R1 → R3 → R4	17
10.9.0.0/16	R1 → R2	30
10.10.0.0/16	R1 → R3 → R4	25
10.11.0.0/16	R1 → R3 → R4 → R5	27

R1 Routing Table

Directly Connected Networks

- 10.1.0.0/16 Directly Connected Network
- 10.2.0.0/16 Directly Connected Network
- 10.3.0.0/16 Directly Connected Network
- 10.4.0.0/16 Directly Connected Network

Remote Networks

- 10.5.0.0/16 via R2 serial 0/0/0, cost = 22
- 10.6.0.0/16 via R3 serial 0/0/1, cost = 7
- 10.7.0.0/16 via R3 serial 0/0/1, cost = 15
- 10.8.0.0/16 via R3 serial 0/0/1, cost = 17
- 10.9.0.0/16 via R2 serial 0/0/0, cost = 30
- 10.10.0.0/16 via R3 serial 0/0/1, cost = 25
- 10.11.0.0/16 via R3 serial 0/0/1, cost = 27

Link-State Routing Protocol

Advantages of Link-State Routing Protocols

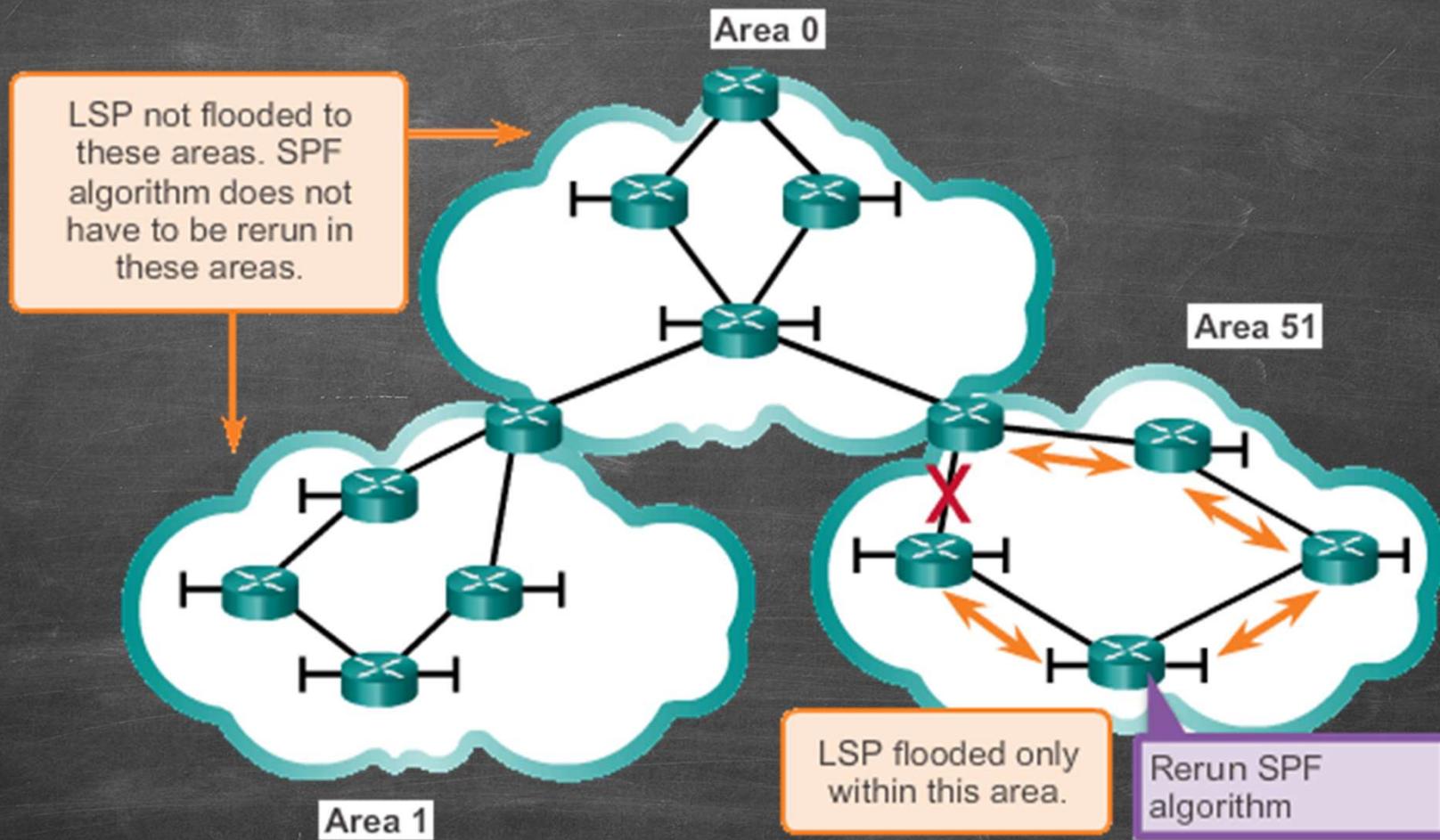
- Each router builds its own topological map of the network to determine the shortest path.
- Immediate flooding of LSPs achieves faster convergence.
- LSPs are sent only when there is a change in the topology and contain only the information regarding that change.
- Hierarchical design used when implementing multiple areas.

Disadvantages of Link-State Routing Protocols

- Maintaining a link-state database and SPF tree requires additional memory.
- Calculating the SPF algorithm also requires additional CPU processing.
- Bandwidth can be adversely affected by link-state packet flooding.

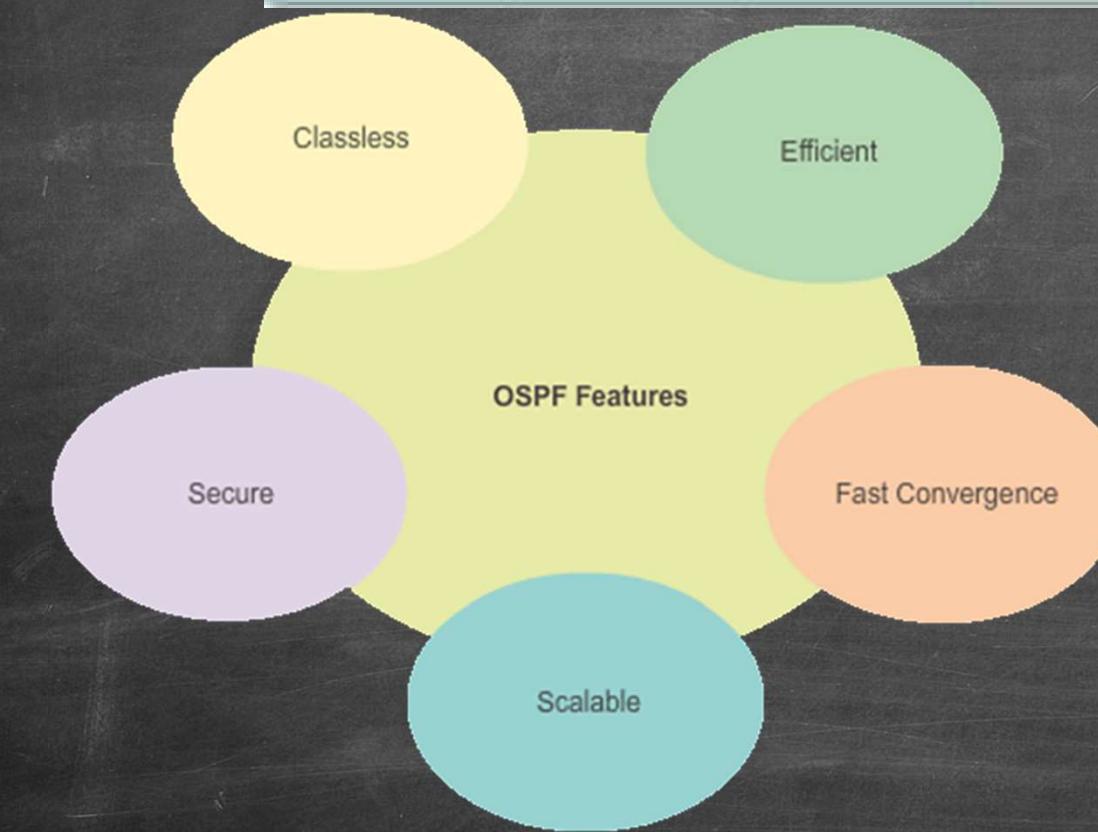
Link-State Routing Protocol

Create Areas to Minimize Router Resource Usage



OSPF

	Interior Gateway Protocols			Exterior Gateway Protocols	
	Distance Vector	Link-State		Path Vector	
IPv4	RIPv2	EIGRP	OSPFv2	IS-IS	BGP-4
IPv6	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	BGP-MP



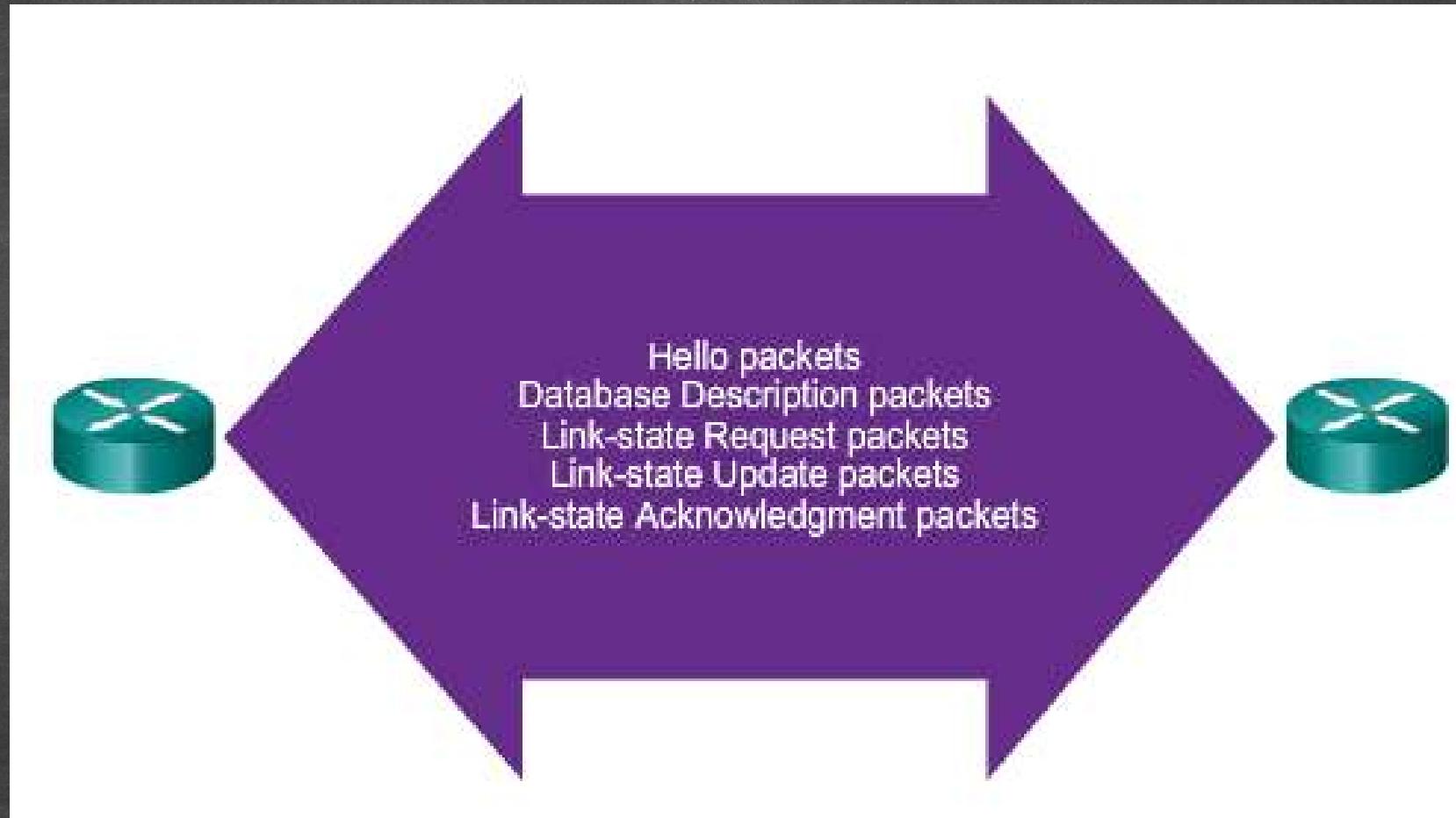
OSPF Administrative Distance	
Route Source	Administrative Distance
Connected	0
Static	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

OSPF

OSPF Data Structures

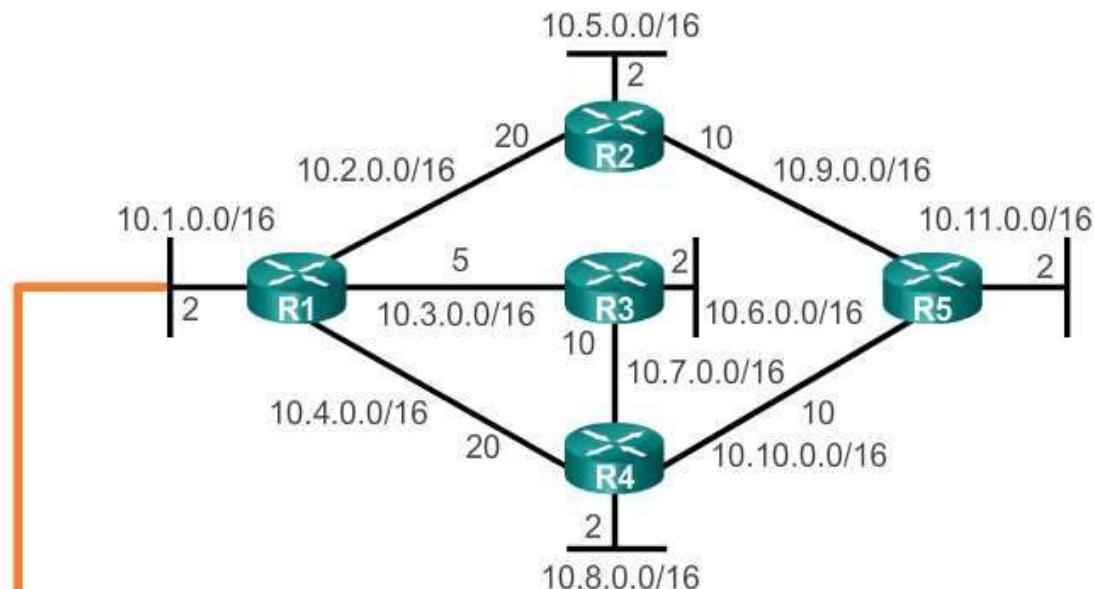
Database	Table	Description
Adjacency Database	Neighbor Table	<ul style="list-style-type: none">• List of all neighbor routers to which a router has established bidirectional communication.• This table is unique for each router.• Can be viewed using the show ip ospf neighbor command.
Link-state Database (LSDB)	Topology Table	<ul style="list-style-type: none">• Lists information about all other routers in the network.• The database shows the network topology.• All routers within an area have identical LSDB.• Can be viewed using the show ip ospf database command.
Forwarding Database	Routing Table	<ul style="list-style-type: none">• List of routes generated when an algorithm is run on the link-state database.• Each router's routing table is unique and contains information on how and where to send packets to other routers.• Can be viewed using the show ip route command.

OSPF



OSPF

Content of the R1 SPF Tree



Destination	Shortest Path	Cost
10.5.0.0/16	R1 → R2	22
10.6.0.0/16	R1 → R3	7
10.7.0.0/16	R1 → R3	15
10.8.0.0/16	R1 → R3 → R4	17
10.9.0.0/16	R1 → R2	30
10.10.0.0/16	R1 → R3 → R4	25
10.11.0.0/16	R1 → R3 → R4 → R5	27

Link & Link-State

Say Hello

Building the Link-State Packet

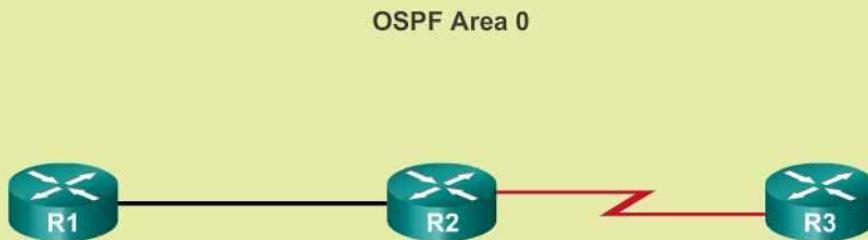
Flooding LSP & Building Database

Building the SPF Tree & Routing Table

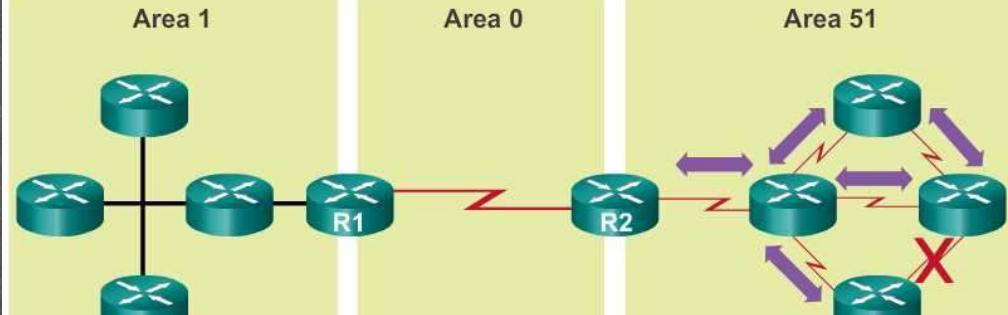
OSPF

- Single-area and Multiarea OSPF

Single-Area OSPF



Link Change Impacts Local Area Only



- Area 0 is also called the backbone area.
- Single-Area OSPF is useful in smaller networks with few routers.

- Link failure affects the local area only (area 51).
- The ABR (R2) isolates the fault to area 51 only.
- Routers in areas 0 and 1 do not need to run the SPF algorithm.

OSPF Messages

- Encapsulating OSPF Messages

OSPF IPv4 Header Fields			
Data Link Frame Header	IP Packet Header	OSPF Packet Header	OSPF Packet Type-Specific Database

Data Link Frame (Ethernet Fields shown here)
MAC Destination Address = Multicast: 01-00-5E-00-00-05 or 01-00-5E-00-00-06
MAC Source Address = Address of sending interface

IP Packet
IP Source Address = Address of sending interface
IP Destination Address = Multicast: 224.0.0.5 or 224.0.0.6
Protocol Field = 89 for OSPF

OSPF Packet Header
Type code for OSPF Packet type
Router ID and Area ID

OSPF Packet Types
0x01 Hello
0x02 Database Description (DD)
0X03 Link State Request
0X04 Link State Update
0X05 Link State Acknowledgment

OSPF Messages

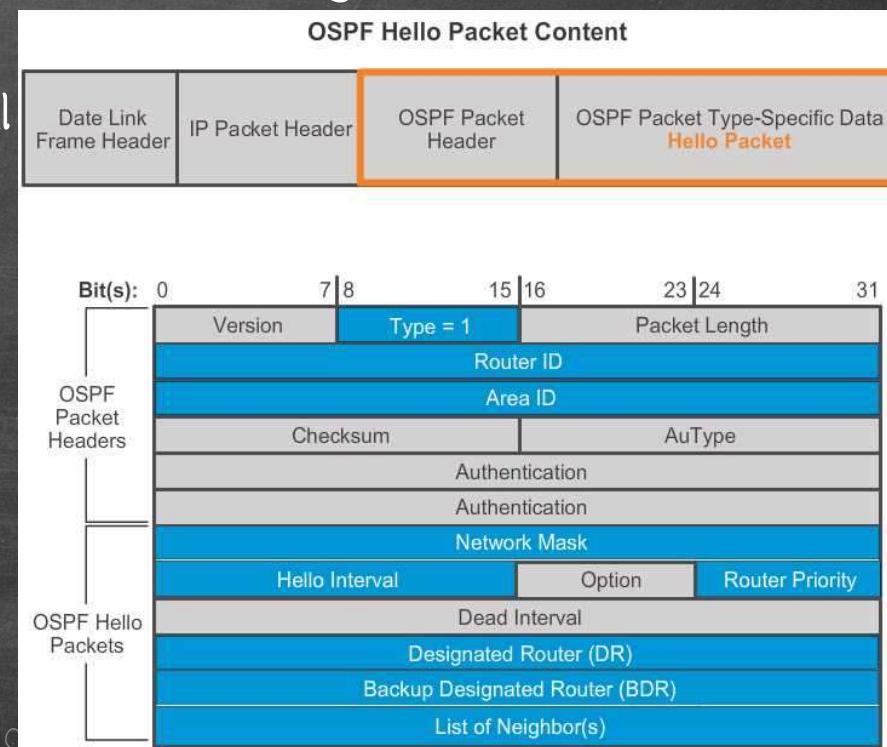
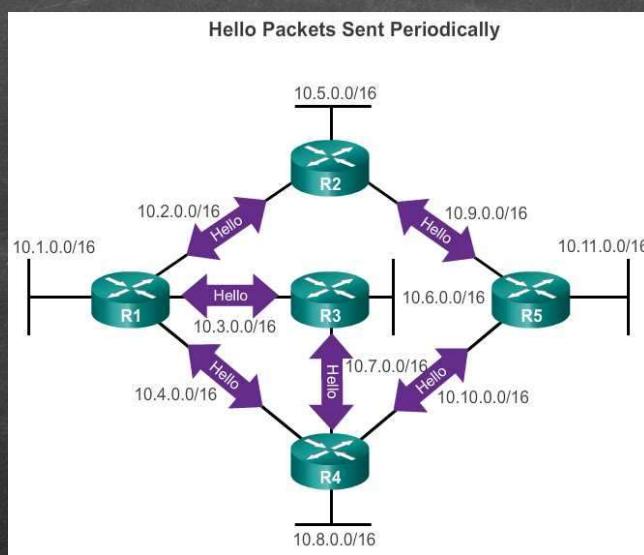
- Types of OSPF Packets

OSPF Packet Descriptions

Type	Packet Name	Description
1	Hello	Discovers neighbors and builds adjacencies between them
2	Database Description (DBD)	Checks for database synchronization between routers
3	Link-State Request (LSR)	Requests specific link-state records from router to router
4	Link-State Update (LSU)	Sends specifically requested link-state records
5	Link-State Acknowledgment (LSAck)	Acknowledges the other packet types

OSPF Messages

- OSPF Hello packets are transmitted
 - To 224.0.0.5 in IPv4 and FF02::5 in IPv6 (all OSPF routers)
 - Every 10 seconds (default on multiaccess and point-to-point networks)
 - Every 30 seconds (default on non-broadcast multiaccess [NBMA] networks)
 - Dead interval is the period that the router waits to receive a Hello packet before declaring the neighbor down
 - Router floods the LSDB with information about down neighbors out all OSPF enabled interfaces
 - Cisco's default is 4 times the Hello interval



OSPF Messages

- Link-State Updates

LSUs Contain LSAs

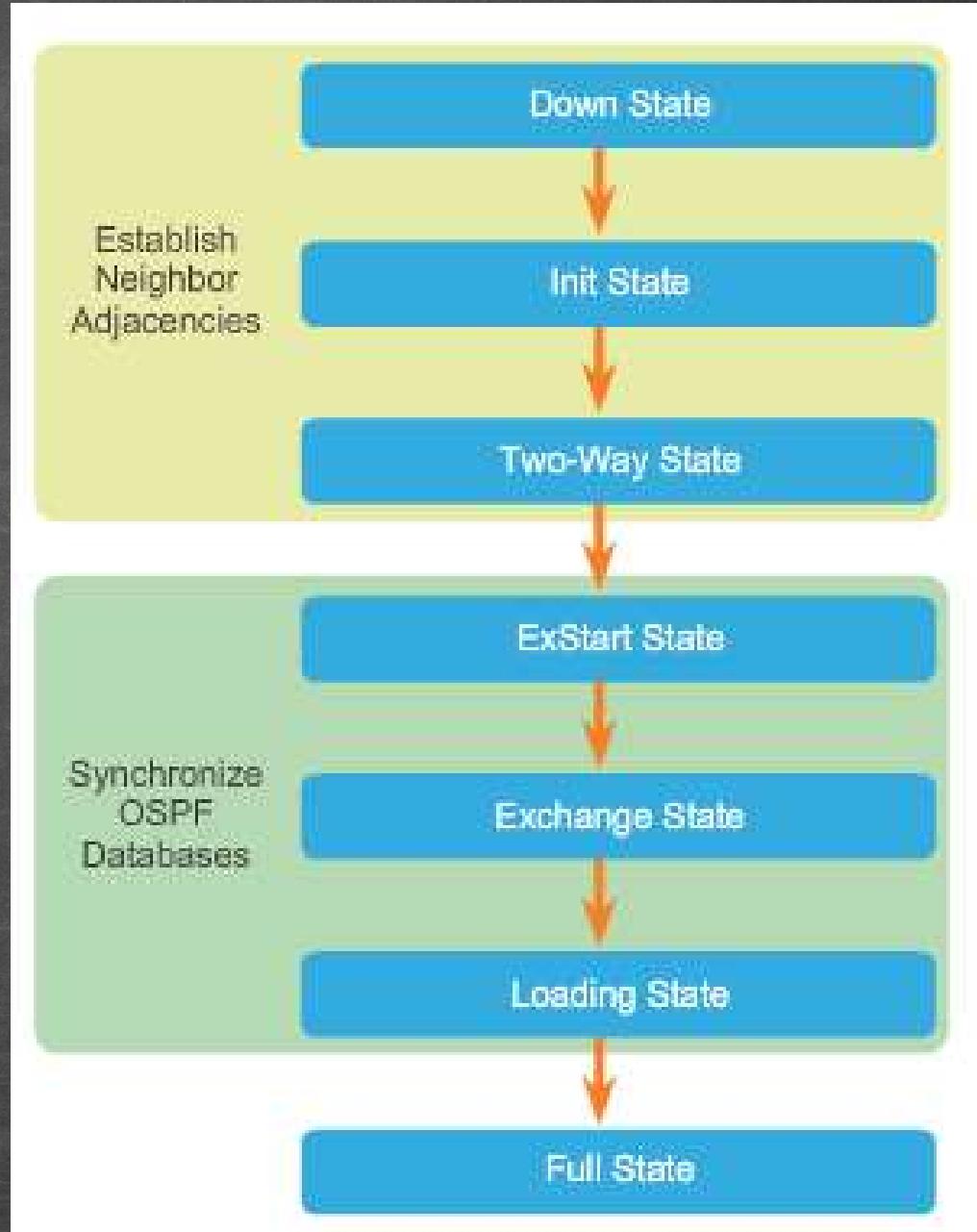
Type	Packet Name	Description
1	Hello	Discovers neighbors and builds adjacencies between them
2	DBD	Checks for database synchronization between router
3	LSR	Requests specific link-state records from router to router
4	LSU	Sends specifically requested link-state records
5	LSAck	Acknowledges the other packet types

- An LSU contains one or more LSAs.
- LSAs contain route information for destination networks.

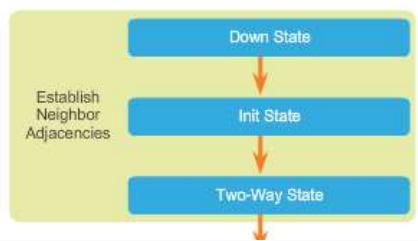
LSA Type	Description
1	Router LSAs
2	Network LSAs
3 or 4	Summary LSAs
5	Autonomous System External LSAs
6	Multicast OSPF LSAs
7	Defined for Not-So-Stubby Areas
8	External Attributes LSA for Border Gateway Protocol (BGP)
9,10,11	Opaque LSAs

OSPF Operation

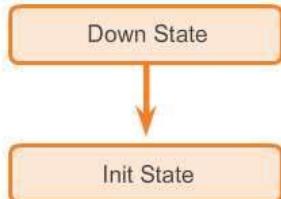
- When an OSPF router is initially connected to a network, it attempts to:
 - Create adjacencies with neighbors
 - Exchange routing information
 - Calculate the best routes
 - Reach convergence
 - OSPF progresses through several states while attempting to reach convergence.



OSPF Operation



Down State to Init State



Hello! My router ID is 172.16.5.1. Is there anyone else on this link?
Hello
Multicast to 224.0.0.5

The Init State



R2 neighbor list:
172.16.5.1, int G0/1

Hello! My router ID is 172.16.5.2 and here is my neighbor list.
Unicast to 172.16.5.1



Hello

Two-Way State



R1 neighbor list:
172.16.5.2, int G0/0

Elect the DR and BDR

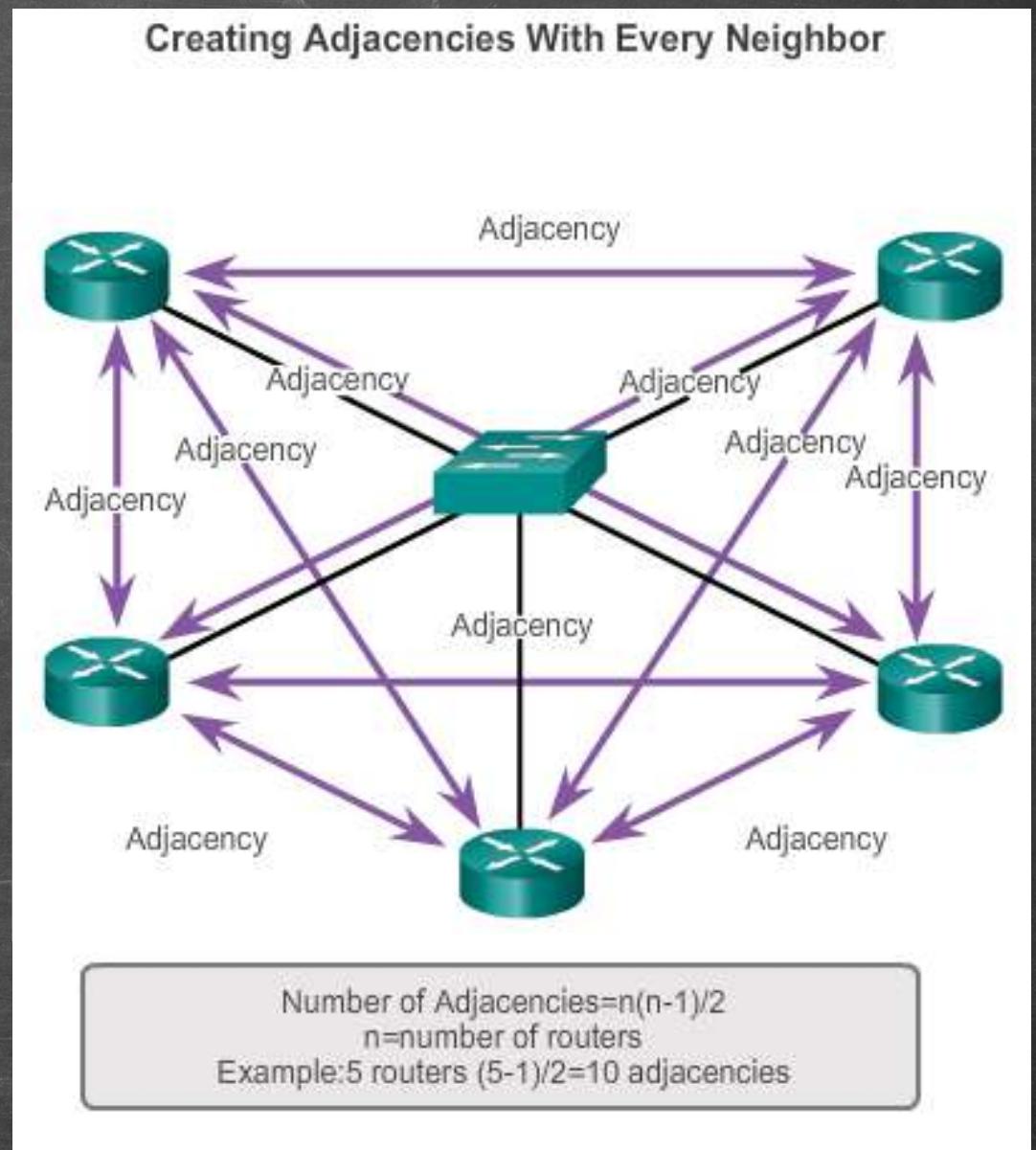
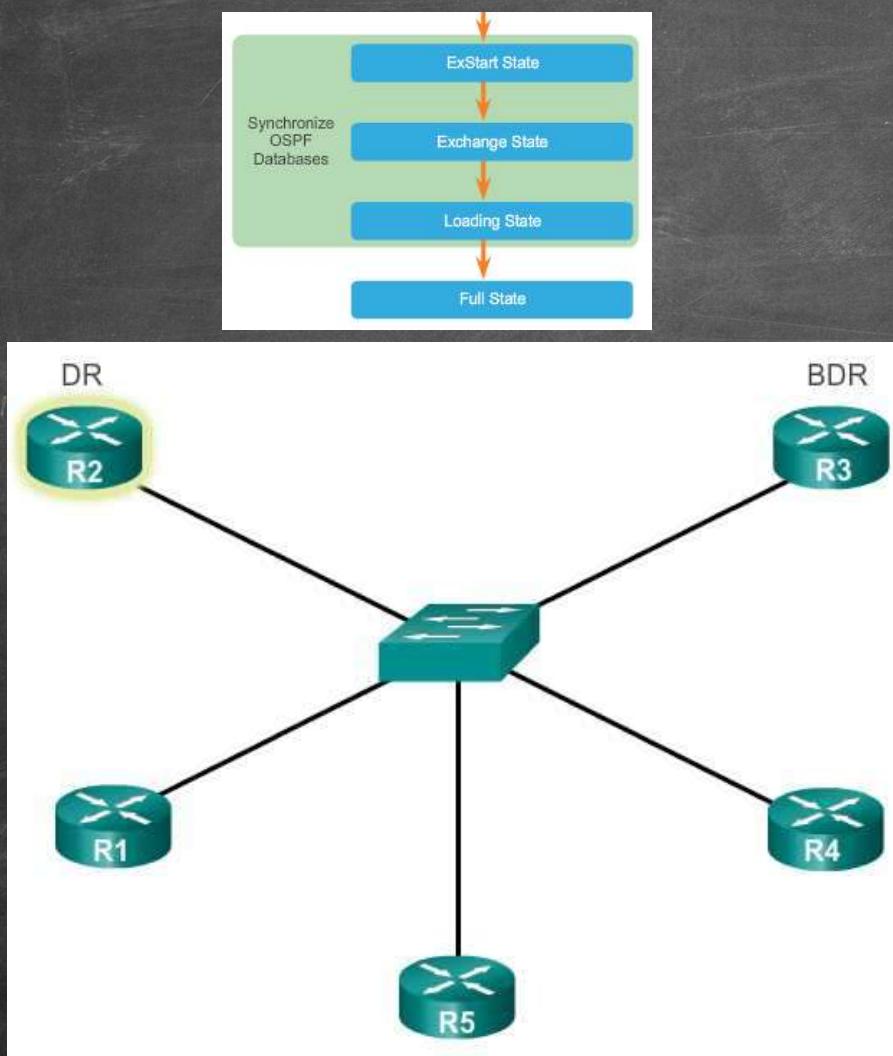


R2 has a default priority of 1 and the highest router ID. It will be the DR on this link.

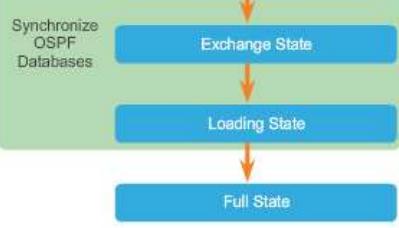
Two-Way State

OSPF Operation

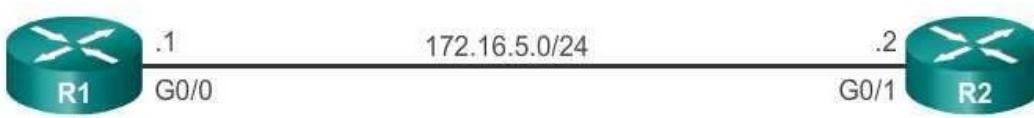
- DR and BDR



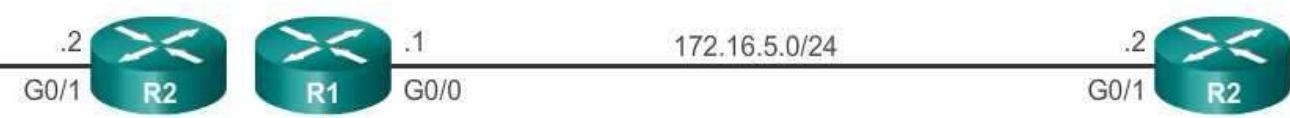
OSPF Operation



Exchange DBD Packets



Exchange State

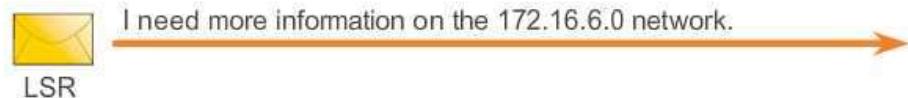


Loading State

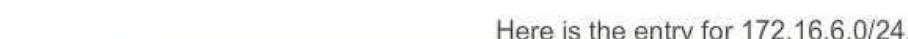
Here is a summary of my LSDB.



I need more information on the 172.16.6.0 network.



Thanks for the information!



Here is a summary of my LSDB.



Thanks for the information!

Thanks for the information!



Configuring Single-Area OSPFv2

router ospf process-id

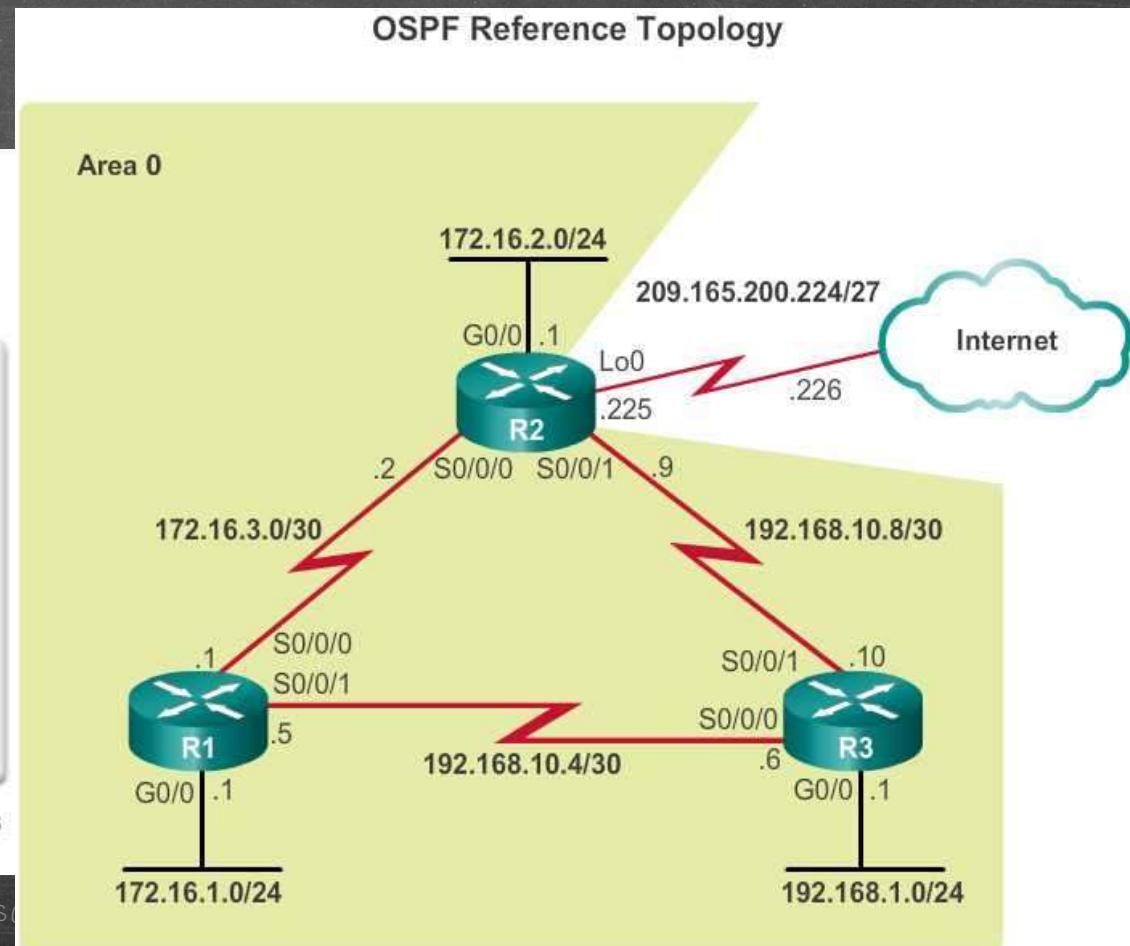
—process-id value

- a number between 1 and 65,535
- locally significant

Entering Router OSPF Configuration Mode on R1

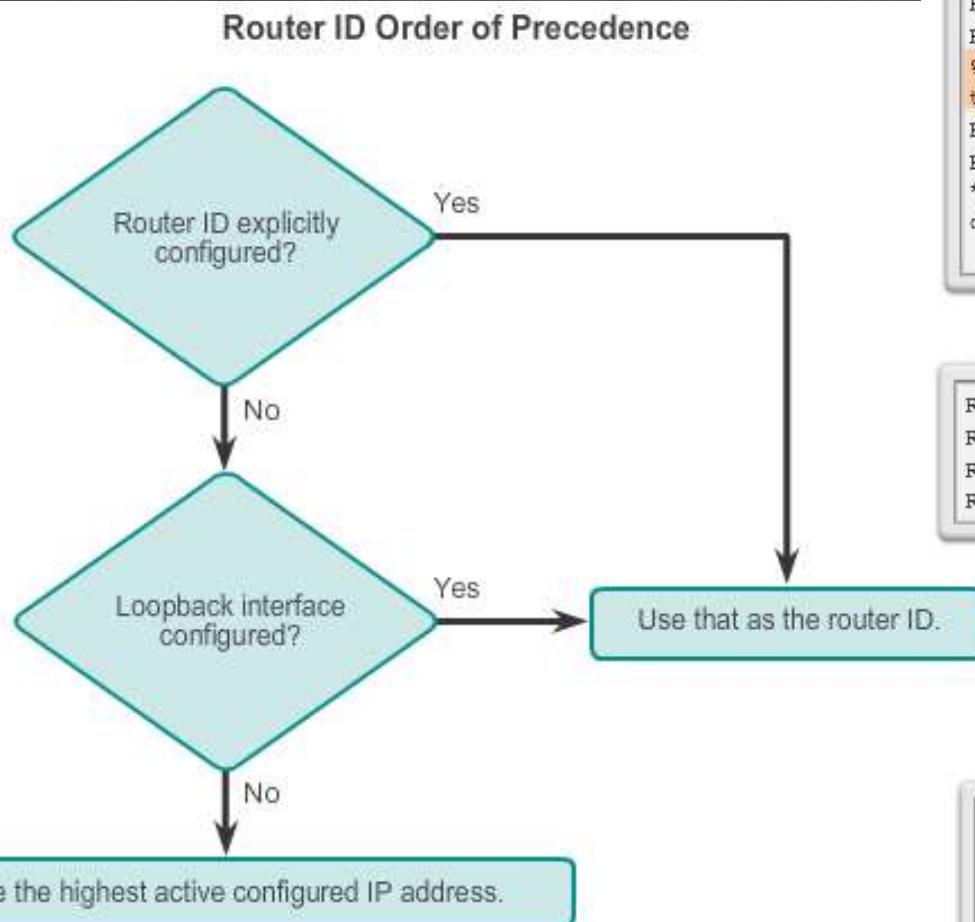
```
R1(config)# router ospf 10
R1(config-router)#
Router configuration commands:
 auto-cost           Calculate OSPF interface cost
                     according to bandwidth
 network             Enable routing on an IP network
 no                  Negate a command or set its defaults
 passive-interface  Suppress routing updates on an
                     interface
 priority            OSPF topology priority
 router-id           router-id for this OSPF process
```

Note: Output has been altered to display only the commands that will be used in this chapter.



Configuring Single-Area OSPFv2

- OSPF Router IDs



```

R1(config)# router ospf 10
R1(config-router)# router-id 1.1.1.1
% OSPF: Reload or use "clear ip ospf process" command, for
this to take effect
R1(config-router)# end
R1#
*Mar 25 19:46:09.711: %SYS-5-CONFIG_I: Configured from
console by console
  
```

```

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

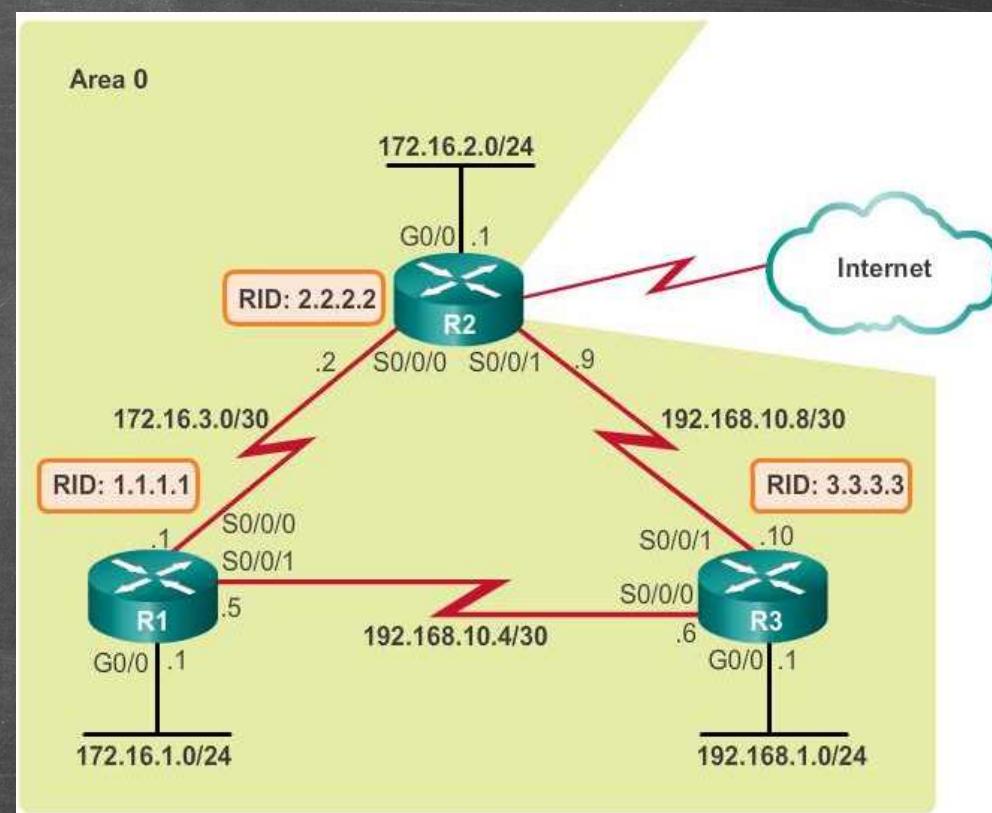
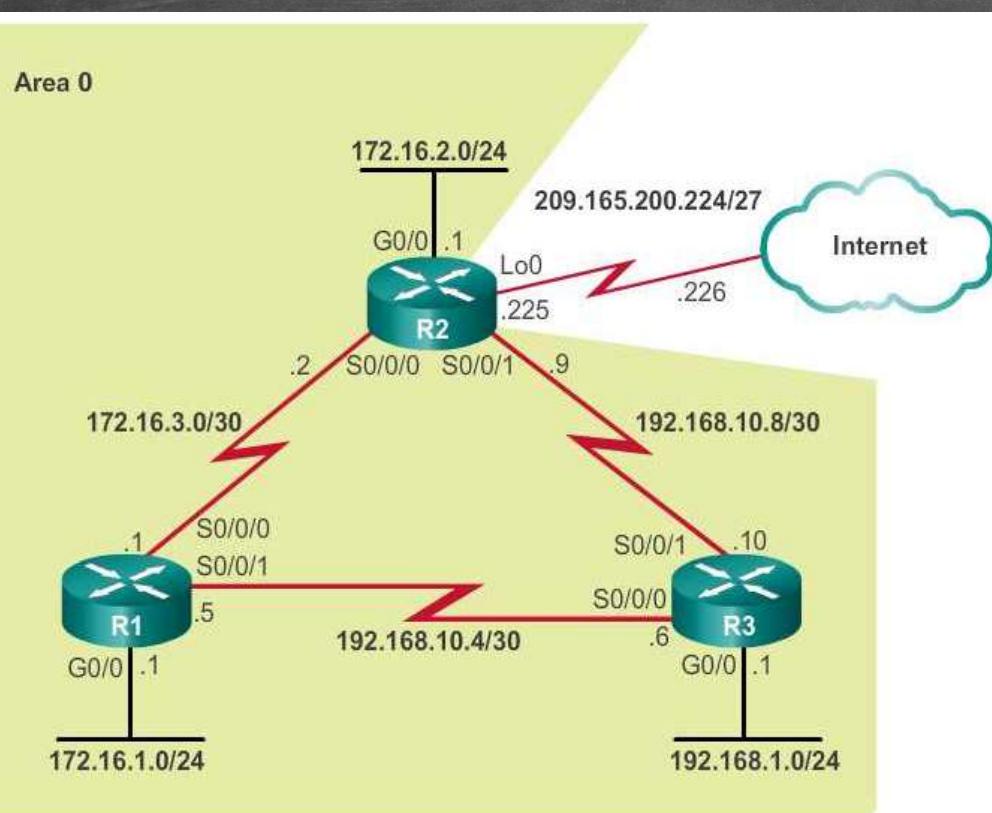
Clearing the OSPF Process

```

R1# clear ip ospf process
Reset ALL OSPF processes? [no]: y
R1#
*Mar 25 19:46:22.423: %OSPF-5-ADJCHG: Process 10, Nbr
3.3.3.3 on Serial0/0/1 from FULL to DOWN, Neighbor Down:
Interface down or detached
*Mar 25 19:46:22.423: %OSPF-5-ADJCHG: Process 10, Nbr
2.2.2.2 on Serial0/0/0 from FULL to DOWN, Neighbor Down:
Interface down or detached
  
```

Configuring Single-Area OSPFv2

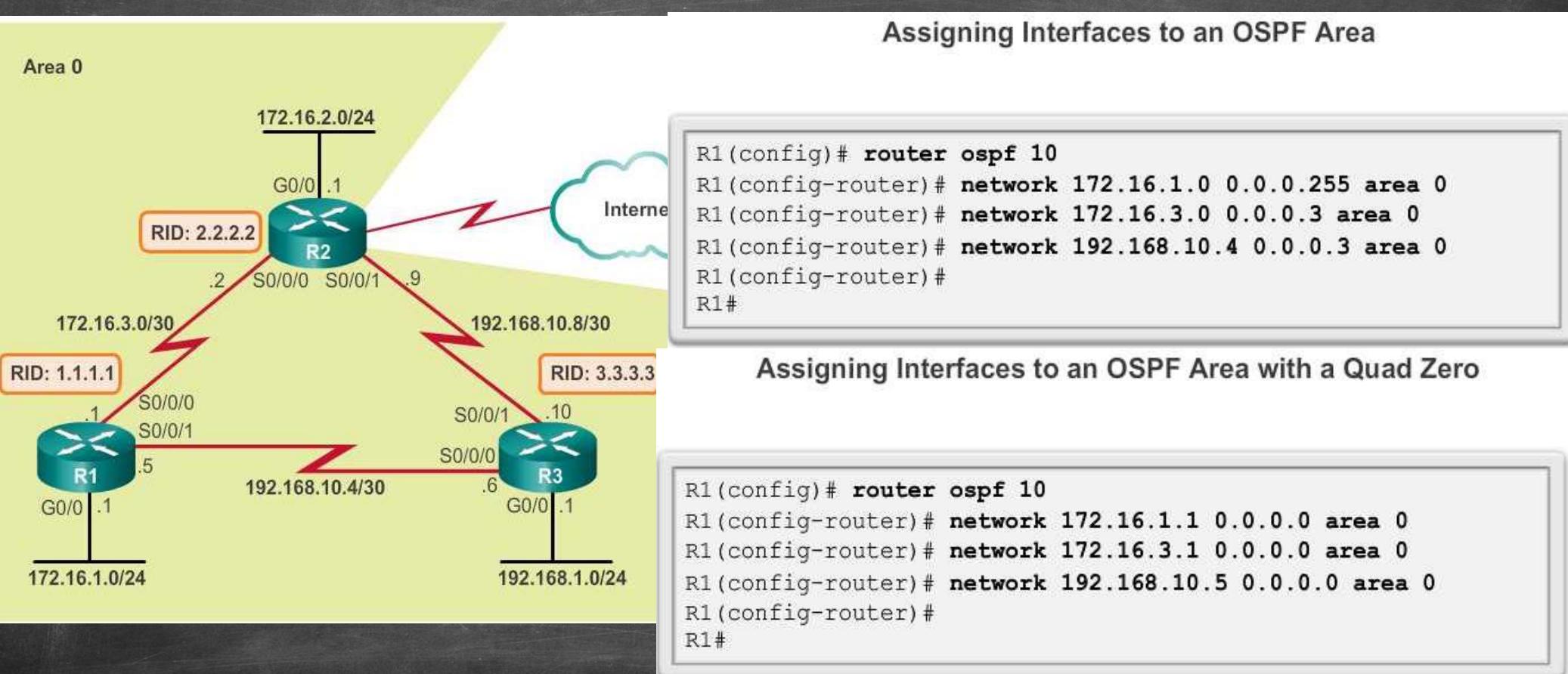
- OSPF Router IDs



Configuring Single-Area OSPFv2

router ospf process-id

network network-address wildcard-mask area area-id



Configuring Single-Area OSPFv2

Configuring a Passive Interface on R1

```
R1(config)# router ospf 10
R1(config-router)# passive-interface GigabitEthernet 0/0
R1(config-router)# end
R1#
```

Verifying a Default Route on R1

```
R1# show ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "ospf 10"
  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:
    172.16.1.1 0.0.0.0 area 0
    172.16.3.1 0.0.0.0 area 0
    192.168.10.5 0.0.0.0 area 0
  Passive Interface(s):
    GigabitEthernet0/0
  Routing Information Sources:
    Gateway          Distance      Last Update
    3.3.3.3           110          00:08:35
    2.2.2.2           110          00:08:35
  Distance: (default is 110)

R1#
```

OSPF Cost

- The formula used to calculate the OSPF cost is:

Cost = reference bandwidth/interface bandwidth

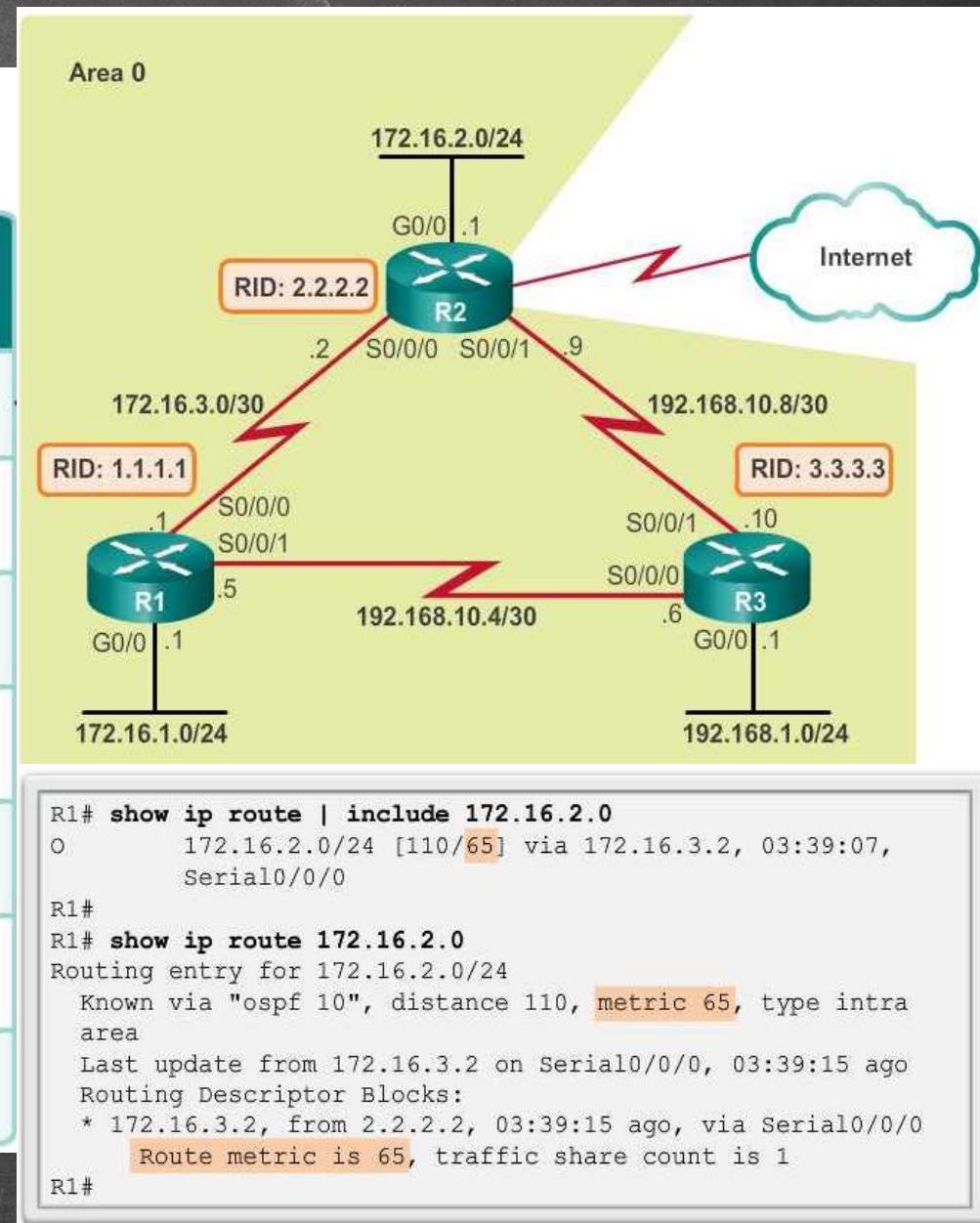
- The default reference bandwidth is 10^8 (100,000,000); therefore, the formula is:

Cost = 100,000,000 bps/interface bandwidth in bps

OSPF Cost

Default Cisco OSPF Cost Values

Interface Type	Reference Bandwidth in bps	Default Bandwidth in bps	Cost
10 Gigabit Ethernet 10 Gbps	100,000,000	\div 10,000,000,000	1
Gigabit Ethernet 1 Gbps	100,000,000	\div 1,000,000,000	1
Fast Ethernet 100 Mbps	100,000,000	\div 100,000,000	1
Ethernet 10 Mbps	100,000,000	\div 10,000,000	10
Serial 1.544 Mbps	100,000,000	\div 1,544,000	64
Serial 128 kbps	100,000,000	\div 128,000	781
Serial 64 kbps	100,000,000	\div 64,000	1562



OSPF Cost

auto-cost reference-bandwidth bandwidth_mbps

– Fast Ethernet

auto-cost reference-bandwidth 100

– Gigabit Ethernet

auto-cost reference-bandwidth 1000

– 10 Gigabit Ethernet

auto-cost reference-bandwidth 10000

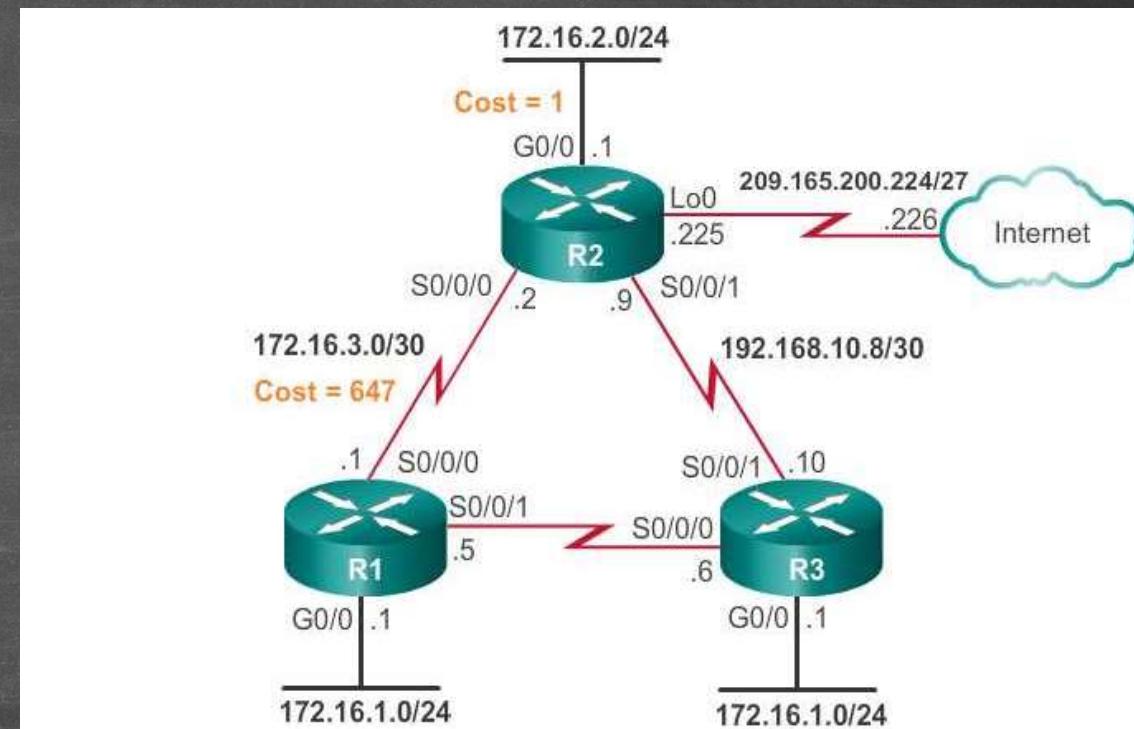
OSPF Cost

```
auto-cost reference-bandwidth 1000
```

Interface Type	Reference Bandwidth in bps	Default Bandwidth in bps	Cost
10 Gigabit Ethernet 10 Gbps	1,000,000,000	÷ 10,000,000,000	1
Gigabit Ethernet 1 Gbps	1,000,000,000	÷ 1,000,000,000	1
Fast Ethernet 100 Mbps	1,000,000,000	÷ 100,000,000	10
Ethernet 10 Mbps	1,000,000,000	÷ 10,000,000	100
Serial 1.544 Mbps	1,000,000,000	÷ 1,544,000	647

```
auto-cost reference-bandwidth 10000
```

Interface Type	Reference Bandwidth in bps	Default Bandwidth in bps	Cost
10 Gigabit Ethernet 10 Gbps	10,000,000,000	÷ 10,000,000,000	1
Gigabit Ethernet 1 Gbps	10,000,000,000	÷ 1,000,000,000	10
Fast Ethernet 100 Mbps	10,000,000,000	÷ 100,000,000	100
Ethernet 10 Mbps	10,000,000,000	÷ 10,000,000	1000
Serial 1.544 Mbps	10,000,000,000	÷ 1,544,000	6477



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

Serial0/0/0 is up, line protocol is up

Internet Address 172.16.3.1/30,Area 0,Attached via Network Statement
Process ID 10,Router ID 1.1.1.1,Network Type POINT TO POINT,Cost:647

```
R1# show ip route | include 172.16.2.0
```

O 172.16.2.0/24 [110/648] via 172.16.3.2, 00:06:03, Serial0/0/0

R1 #

```
R1# show ip route 172.16.2.0
```

Routing entry for 172.16.2.0/24

Known via "ospf 10", distance 1

Last update from 172.16.3.2 on Serial0/0/0, 00:06:17 ago

Routing Descriptor Blocks:

* 172.16.3.2, from 2.2.2.2, 00

OSPF Cost

- Default Interface Bandwidths
 - On Cisco routers, the default bandwidth on most serial interfaces is set to 1.544 Mb/s

```
R1# show interfaces serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Hardware is WIC MBRD Serial
  Description: Link to R2
  Internet address is 172.16.3.1/30
  MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:05, output 00:00:03, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total
```

OSPF Cost

- Adjusting the Interface Bandwidths
 - The command only modifies the bandwidth metric used by EIGRP and OSPF. The command does not modify the actual bandwidth on the link.

```
R1(config)# int s0/0/1
R1(config-if)# bandwidth 64
R1(config-if)# end
R1#
*Mar 27 10:10:07.735: %SYS-5-CONFIG_I: Configured from console by c
R1#
R1# show interfaces serial 0/0/1 | include BW
    MTU 1500 bytes, BW 64 Kbit/sec, DLY 20000 usec,
R1#
R1# show ip ospf interface serial 0/0/1 | include Cost:
    Process ID 10, Router ID 1.1.1.1, Network Type
    POINT_TO_POINT, Cost: 15625
R1#
```

OSPF Cost

- Manually Setting the OSPF Cost
 - Both the bandwidth interface command and the ip ospf cost interface command achieve the same result, which is to provide an accurate value for use by OSPF in determining the best route.

```
R1(config)# int s0/0/1
R1(config-if)# no bandwidth 64
R1(config-if)# ip ospf cost 15625
R1(config-if)# end
R1#
R1# show interface serial 0/0/1 | include BW
    MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
R1#
R1# show ip ospf interface serial 0/0/1 | include Cost:
    Process ID 10, Router ID 1.1.1.1, Network Type POINT_TO_POINT,
    Cost: 15625
R1#
```

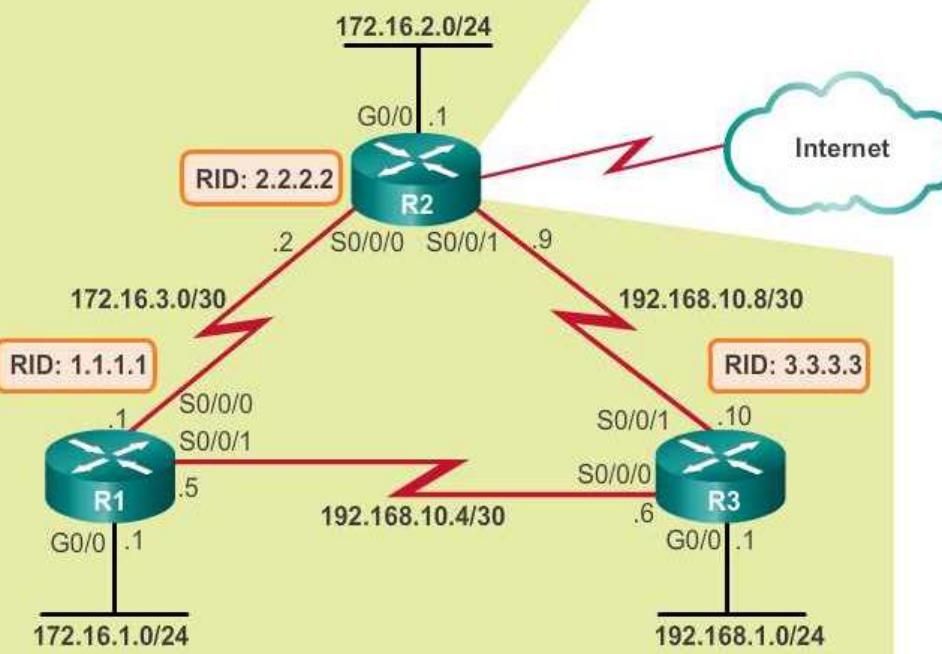
Verify OSPF

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
3.3.3.3	0	FULL/-	00:00:37	192.168.10.6	Serial0/0/1
2.2.2.2	0	FULL/-	00:00:30	172.16.3.2	Serial0/0/0

```
R1#
```

Area 0



```
R1# show ip protocols
```

```
*** IP Routing is NSF aware ***
```

Routing Protocol is "ospf 10"

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:

172.16.1.0 0.0.0.255 area 0

172.16.3.0 0.0.0.3 area 0

192.168.10.4 0.0.0.3 area 0

Routing Information Sources:

Gateway	Distance	Last Update
2.2.2.2	110	00:17:18
3.3.3.3	110	00:14:49

Distance: (default is 110)

```
R1#
```

Verify OSPF

```
R1# show ip ospf interface brief
```

Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs	F/C
Se0/0/1	10	0	192.168.10.5/30	15625	P2P	1/1	
Se0/0/0	10	0	172.16.3.1/30	647	P2P	1/1	
Gi0/0	10	0	172.16.1.1/24	1	DR	0/0	

```
R1#
```

```
R1# show ip ospf
```

Routing Process "ospf 10" with ID 1.1.1.1

Start time: 01:37:15.156, Time elapsed: 01:32:57.776

Supports only single TOS(TOS0) routes

Supports opaque LSA

Supports Link-local Signaling (LLS)

Supports area transit capability

Supports NSSA (compatible with RFC 3101)

Event-log enabled, Maximum number of events: 1000, Mode: cyclic

More OSPF Configuration

- Redistributing an OSPF Default Route

```
R(config)# ip route 0.0.0.0 0.0.0.0 loopback N
```

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

```
R(config-router)# default-information originate
```

- Redistributing an OSPF other

```
R(config-router)#redistribute ?
```

bgp	Border Gateway Protocol (BGP)
connected	Connected
eigrp	Enhanced Interior Gateway Routing Protocol (EIGRP)
metric	Metric for redistributed routes
ospf	Open Shortest Path First (OSPF)
rip	Routing Information Protocol (RIP)
static	Static routes

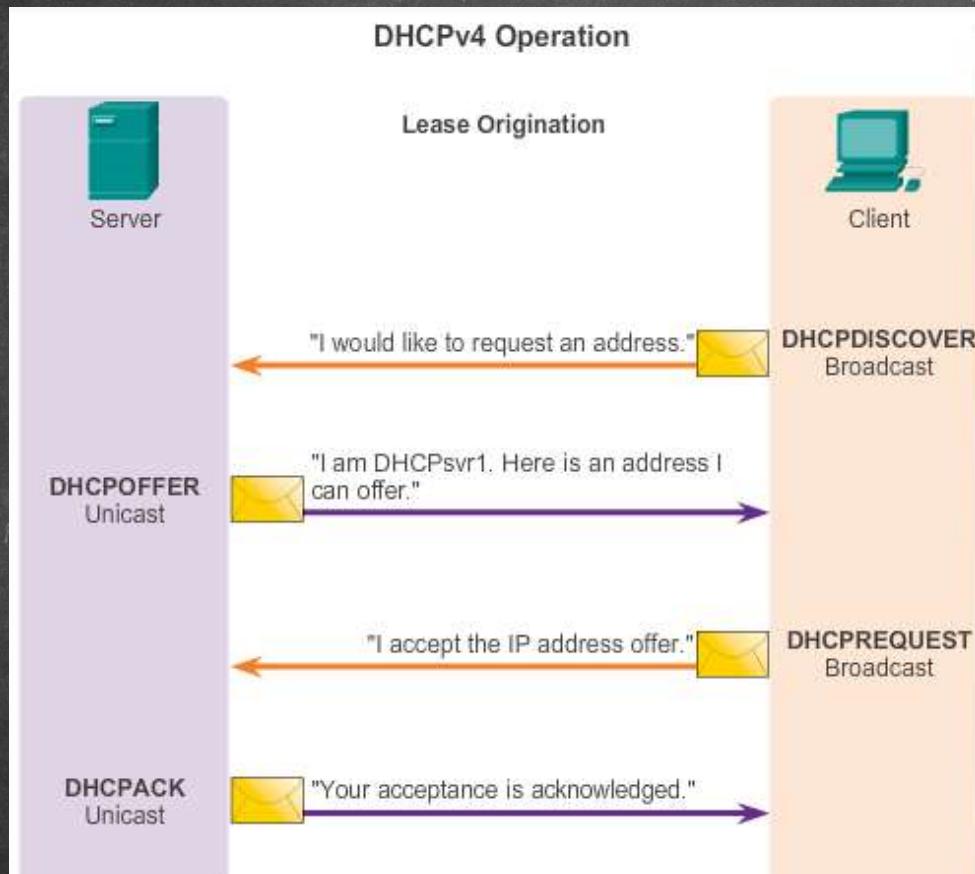
DHCP

- Introduction
- Dynamic Host Configuration Protocol (DHCP) is a network protocol that provides automatic IP addressing and other information to clients:
 - IP address
 - Subnet mask (IPv4) or prefix length (IPv6)
 - Default gateway address
 - DNS server address
- Available for both IPv4 and IPv6
- This chapter explores the functionality, configuration, and troubleshooting of DHCPv4

DHCP

- DHCPv4 uses three different address allocation methods
 - Manual Allocation - The administrator assigns a pre-allocated IPv4 address to the client, and DHCPv4 communicates only the IPv4 address to the device.
 - Automatic Allocation - DHCPv4 automatically assigns a static IPv4 address permanently to a device, selecting it from a pool of available addresses. No lease.
 - Dynamic Allocation - DHCPv4 dynamically assigns, or leases, an IPv4 address from a pool of addresses for a limited period of time chosen by the server, or until the client no longer needs the address. Most commonly used.

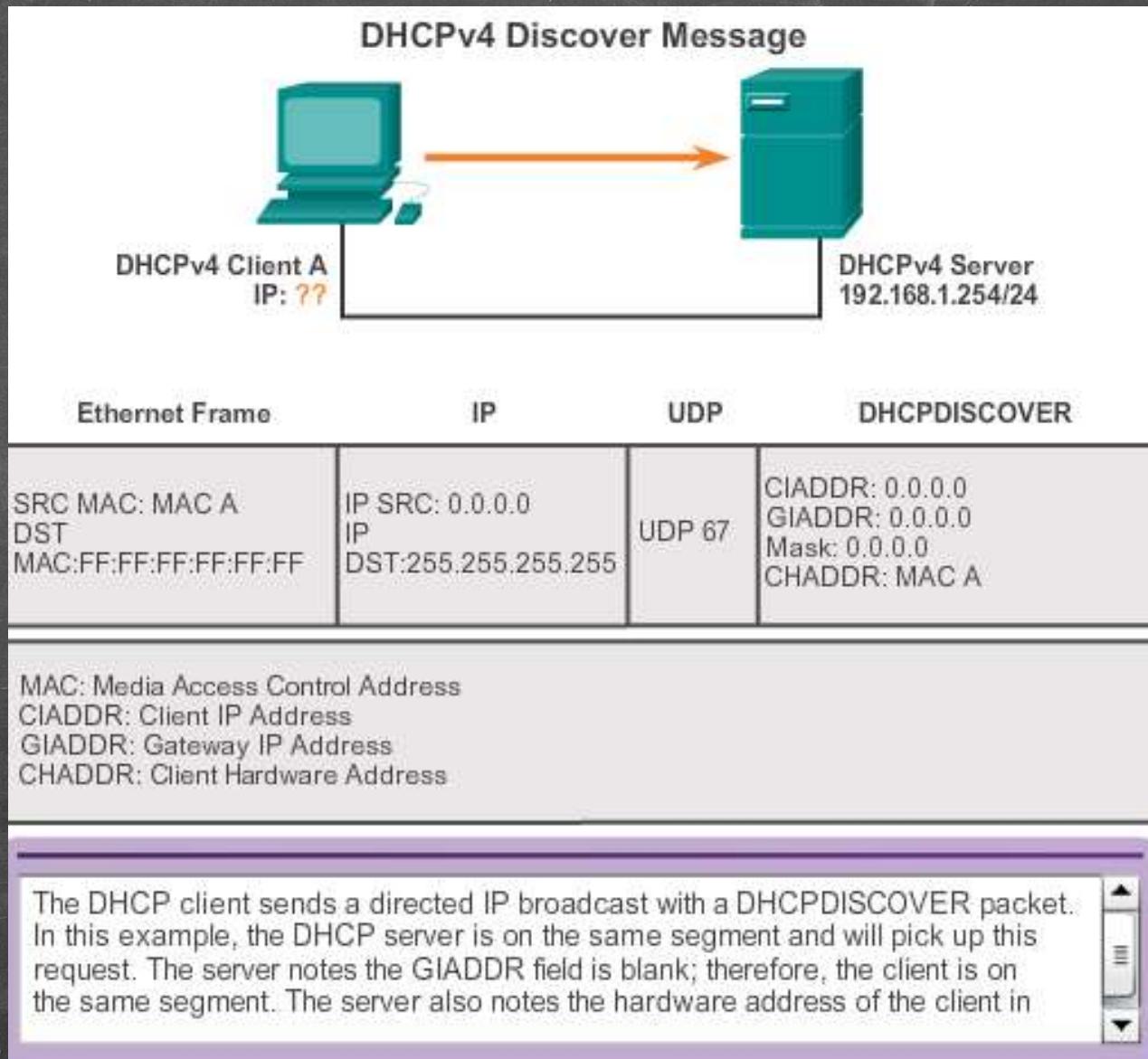
DHCPv4 Operation



DHCPv4 Message Format

8	16	24	32
OP Code (1)	Hardware type (1)	Hardware address length (1)	Hops (1)
Transaction Identifier			
Seconds - 2 bytes	Flags - 2 bytes		
Client IP Address (CIADDR) - 4 bytes			
Your IP Address (YIADDR) - 4 bytes			
Server IP Address (SIADDR) - 4 bytes			
Gateway IP Address (GIADDR) - 4 bytes			
Client Hardware Address (CHADDR) - 16 bytes			
Server name (SNAME) - 64 bytes			
Boot Filename - 128 bytes			
DHCP Options - variable			

DHCPv4 Operation



Configuring a DHCPv4 Server

- A Cisco router running Cisco IOS software can be configured to act as a DHCPv4 server. To set up DHCP
 - Exclude addresses from the pool.
 - Set up DHCP pool name
 - Configuring Specific Tasks -define range of addresses and subnet mask. Use default-router command for default gateway. Optional items that can be included in pool - dns server, domain-name

```
R1(config)# ip dhcp excluded-address 192.168.10.1 192.168.10.9
R1(config)# ip dhcp excluded-address 192.168.10.254
R1(config)# ip dhcp pool LAN-POOL-1
R1(dhcp-config)# network 192.168.10.0 255.255.255.0
R1(dhcp-config)# default-router 192.168.10.1
R1(dhcp-config)# dns-server 192.168.11.5
R1(dhcp-config)# domain-name example.com
R1(dhcp-config)# end
R1#
```

- To disable dhcp - **no service dhcp**

Verifying a DHCPv4 Server

- Commands to verify DHCP

show running-config | section dhcp

show ip dhcp binding

show ip dhcp server statistics

- On the PC -issue the **ipconfig /all** command

```
C:\> C:\WINDOWS\system32\cmd.exe
WINS Proxy Enabled .....: No
Ethernet Adapter Local Area Connection
Connection-specific DNS Suffix.: example.com
Description .....: SiS 900 PCI Fast Ethernet Adapter
Physical Address.....: 00-E0-18-5B-DD-35
Dhcp Enabled .....: Yes
Autoconfiguration Enabled....: Yes
IP Address .....: 192.168.10.10
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.10.1
DHCP Server .....: 192.168.10.1
Lease Obtained.....: Monday, May 27, 2013 1:06:22PM
Lease Expires .....: Tuesday, May 28, 2013 1:06:22PM
DNS Servers . . . . . : 192.168.11.5
C:\>
```

DHCPv4 Relay

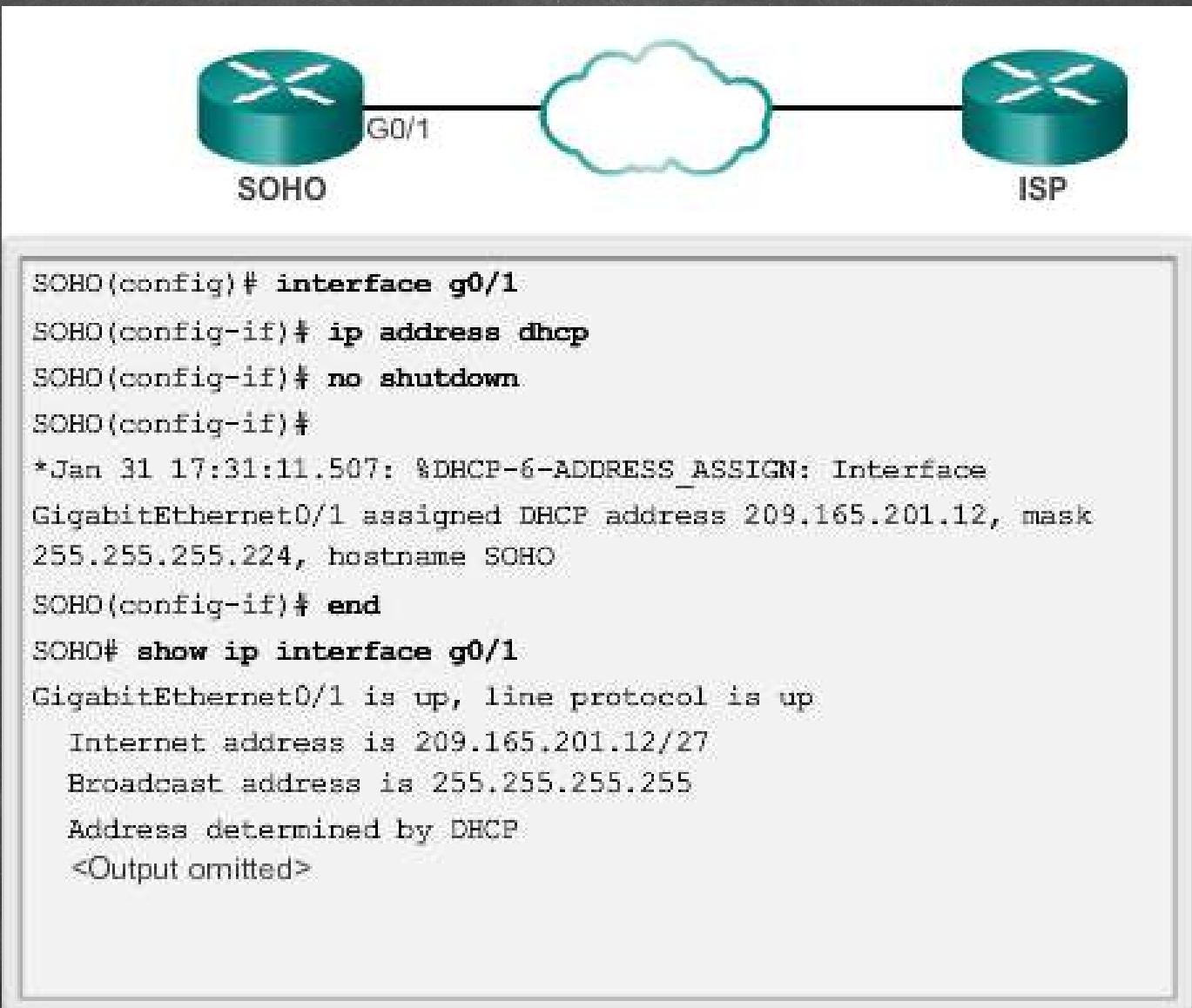
- Using an IP helper address enables a router to forward DHCPv4 broadcasts to the DHCPv4 server. Acting as a relay.

```
R1(config)# interface g0/0
R1(config-if)# ip helper-address 192.168.11.6
R1(config-if)# end
R1# show ip interface g0/0
GigabitEthernet0/0 is up, line protocol is up
  Internet address is 192.168.10.1/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is 192.168.11.6
<Output omitted>
```

By default, the **ip helper-address** command forwards the following eight UDP services:

- Port 37: Time
- Port 49: TACACS
- Port 53: DNS
- Port 67: DHCP/BOOTP client
- Port 68: DHCP/BOOTP server
- Port 69: TFTP
- Port 137: NetBIOS name service
- Port 138: NetBIOS datagram service

Configuring a DHCPv4 client



Troubleshoot DHCPv4

- Troubleshooting Tasks

Troubleshooting Task 1:	Resolve conflicts.
Troubleshooting Task 2:	Verify physical connectivity.
Troubleshooting Task 3:	Test with a static IPv4 address.
Troubleshooting Task 4:	Verify switch port configuration.
Troubleshooting Task 5:	Test from the same subnet or VLAN.

Troubleshoot DHCPv4

- Verify Router DHCPv4 Configuration

Verifying DHCPv4 Relay and DHCPv4 Services

```
R1# show running-config | section interface GigabitEthernet0/0  
interface GigabitEthernet0/0
```

```
  ip address 192.168.10.1 255.255.255.0  
  ip helper-address 192.168.11.6  
  duplex auto  
  speed auto
```

```
R1#
```

```
R1# show running-config | include no service dhcp  
R1#
```

Troubleshoot DHCPv4

- Debugging DHCPv4

Verifying DHCPv4 Using Router debug Commands

```
R1(config)# access-list 100 permit udp any any eq 67
R1(config)# access-list 100 permit udp any any eq 68
R1(config)# end
R1# debug ip packet 100
IP packet debugging is on for access list 100
*IP: s=0.0.0.0 (GigabitEthernet0/1), d=255.255.255.255, len 333,
rcvd 2
*IP: s=0.0.0.0 (GigabitEthernet0/1), d=255.255.255.255, len 333,
stop process pak for forus packet
*IP: s=192.168.11.1 (local), d=255.255.255.255
(GigabitEthernet0/1), len 328, sending broad/multicast

<Output omitted>

Router1# debug ip dhcp server events
DHCPD: returned 192.168.10.11 to address pool LAN-POOL-1
DHCPD: assigned IP address 192.168.10.12 to client
0100.0103.85e9.87.
DHCPD: checking for expired leases.
DHCPD: the lease for address 192.168.10.10 has expired.
DHCPD: returned 192.168.10.10 to address pool LAN-POOL-1
```

Questions and Answers

