OSPF & DHCP

Jirasak Sittigorn
Internetworking Standards & Technologies
Department of Computer Engineering, Faculty of Engineering
King Mongkut's Institute of Technology Ladkrabang

Cisco | Networking Academy®
Mind Wide Open™

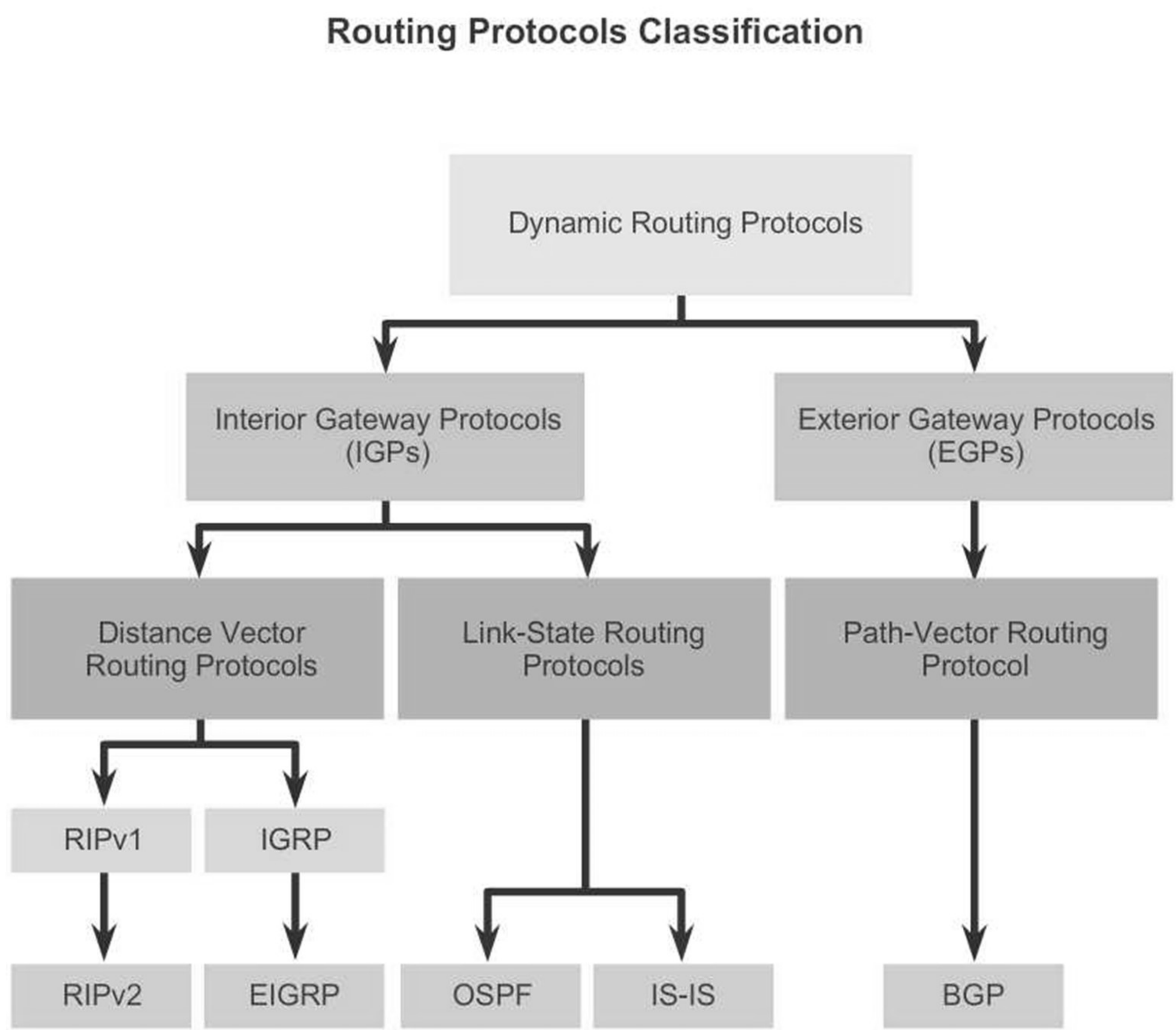
OSPF

- 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.

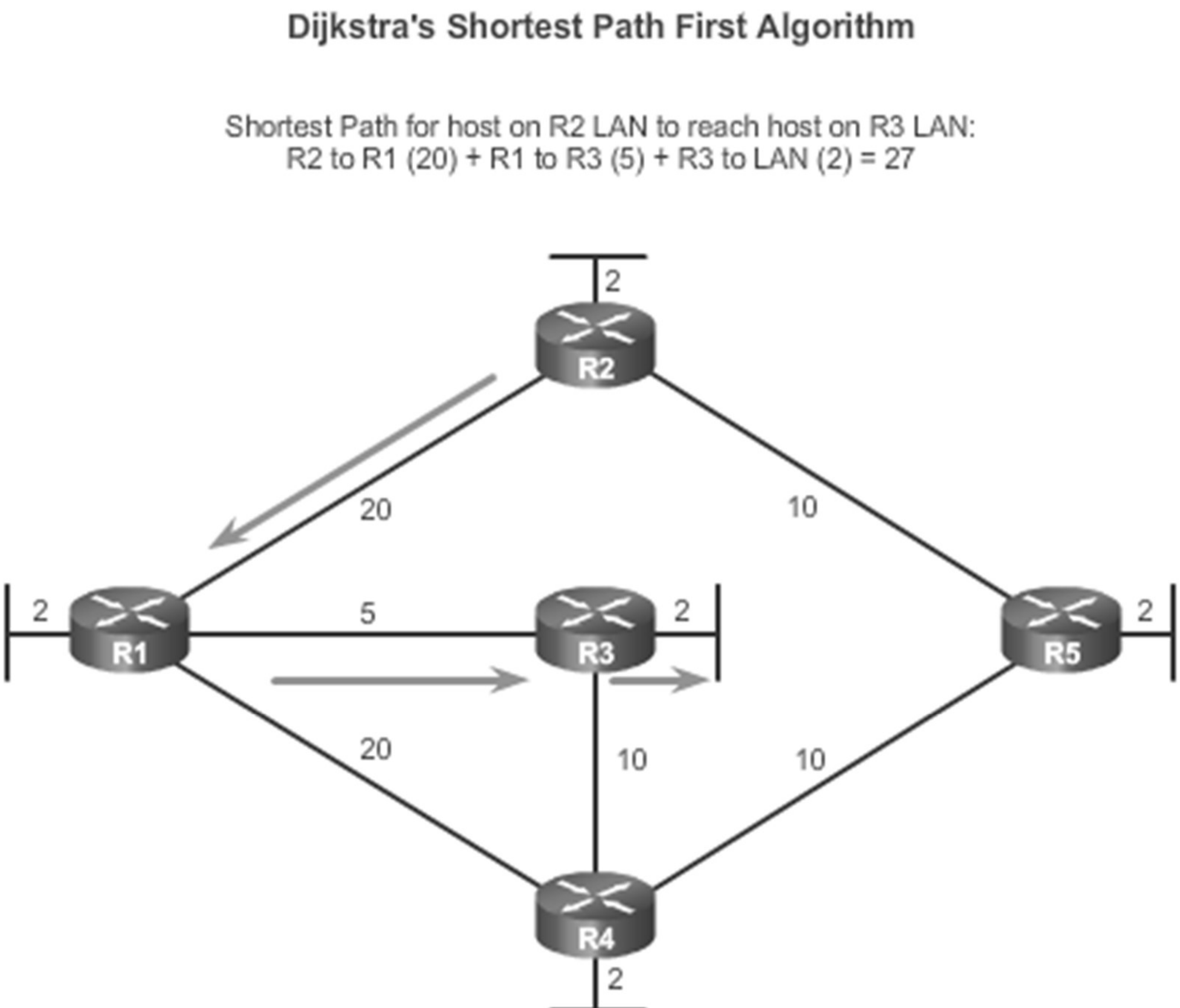
Link-State Routing Protocol

- 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

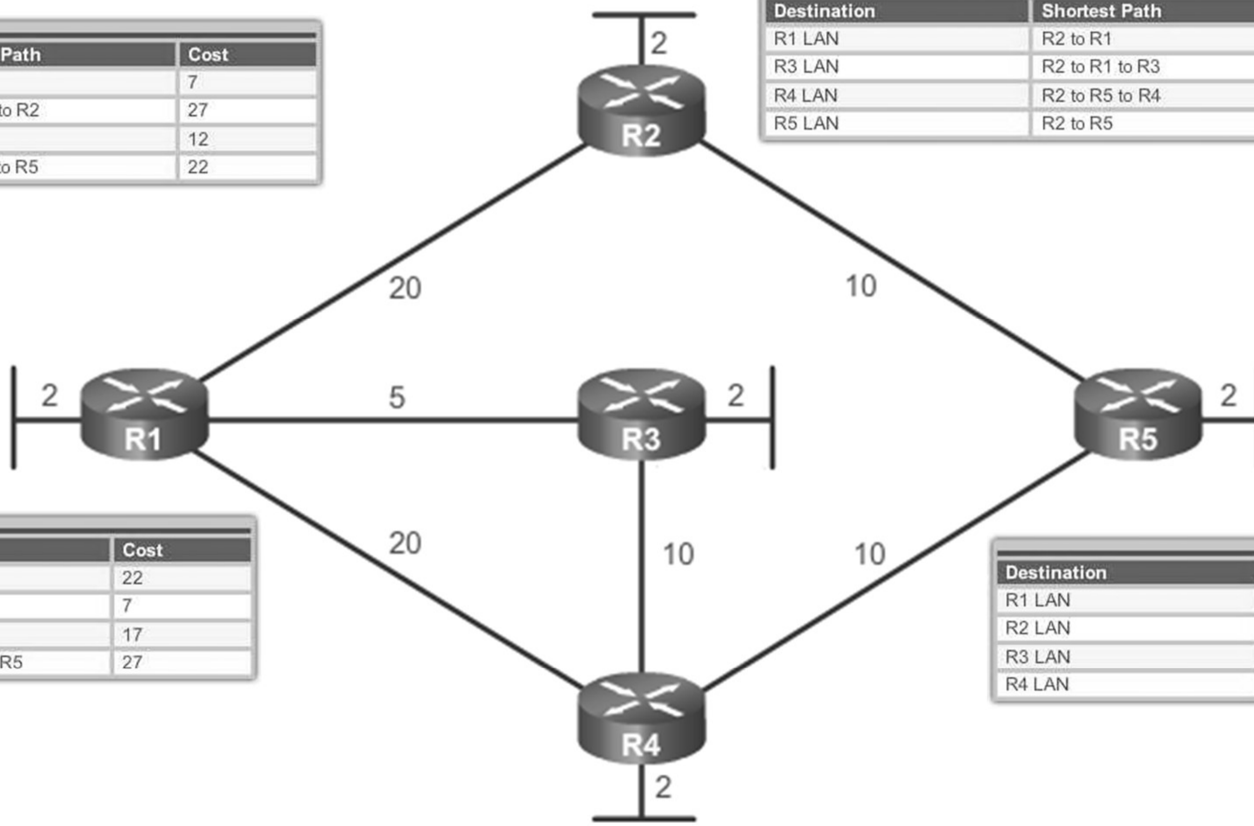


http://upload.wikimedia.org/wikipedia/commons/5/57/Dijkstra_Animation.gif

Link-State Routing Protocol

Destination	Shortest Path	Cost
R1 LAN	R3 to R1	7
R2 LAN	R3 to R1 to R2	27
R4 LAN	R3 to R4	12
R5 LAN	R3 to R4 to R5	22

Destination	Shortest Path	Cost
R1 LAN	R2 to R1	22
R3 LAN	R2 to R1 to R3	27
R4 LAN	R2 to R5 to R4	22
R5 LAN	R2 to R5	12



Destination	Shortest Path	Cost
R2 LAN	R1 to R2	22
R3 LAN	R1 to R3	7
R4 LAN	R1 to R3 to R4	17
R5 LAN	R1 to R3 to R4 to R5	27

Destination	Shortest Path	Cost
R1 LAN	R5 to R4 to R3 to R1	27
R2 LAN	R5 to R2	12
R3 LAN	R5 to R4 to R3	22
R4 LAN	R5 to R4	12

Destination	Shortest Path	Cost
R1 LAN	R4 to R3 to R1	17
R2 LAN	R4 to R5 to R2	22
R3 LAN	R4 to R3	12
R5 LAN	R4 to R5	12

Link-State Routing Protocol

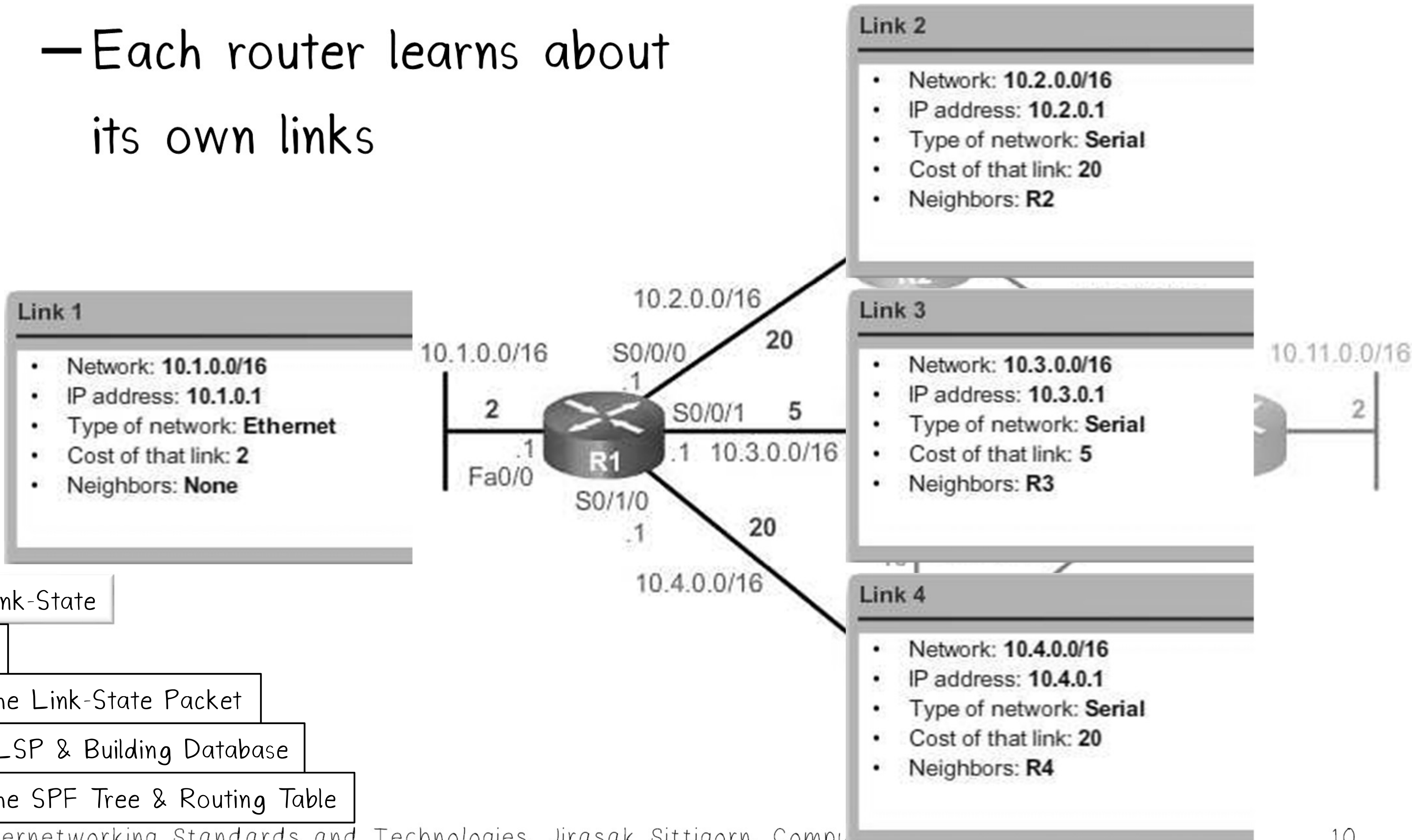
- Link-State Updates

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 & Link-State

Say Hello

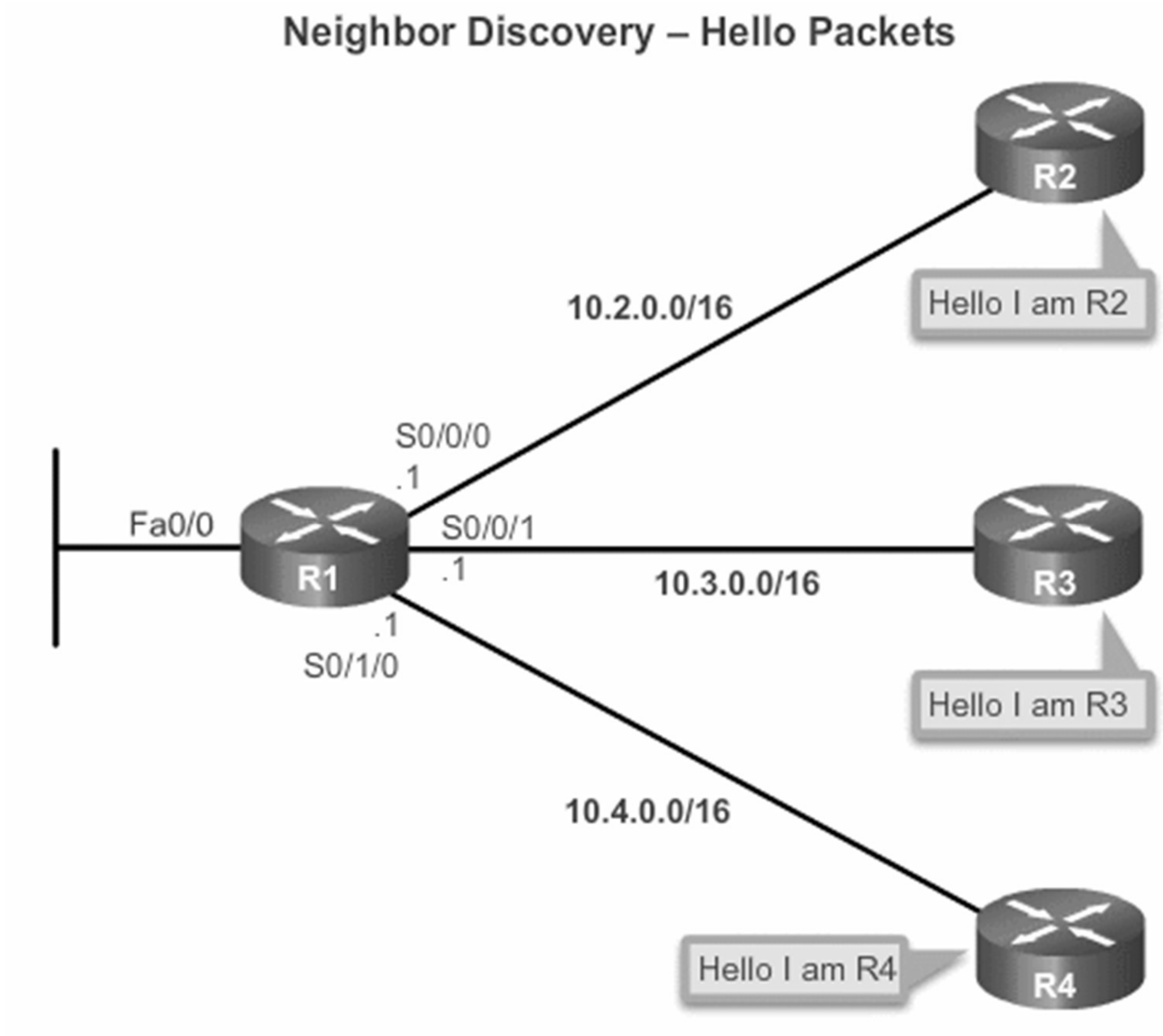
Building the Link-State Packet

Flooding LSP & Building Database

Building the SPF Tree & Routing Table

Link-State Routing Protocol

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

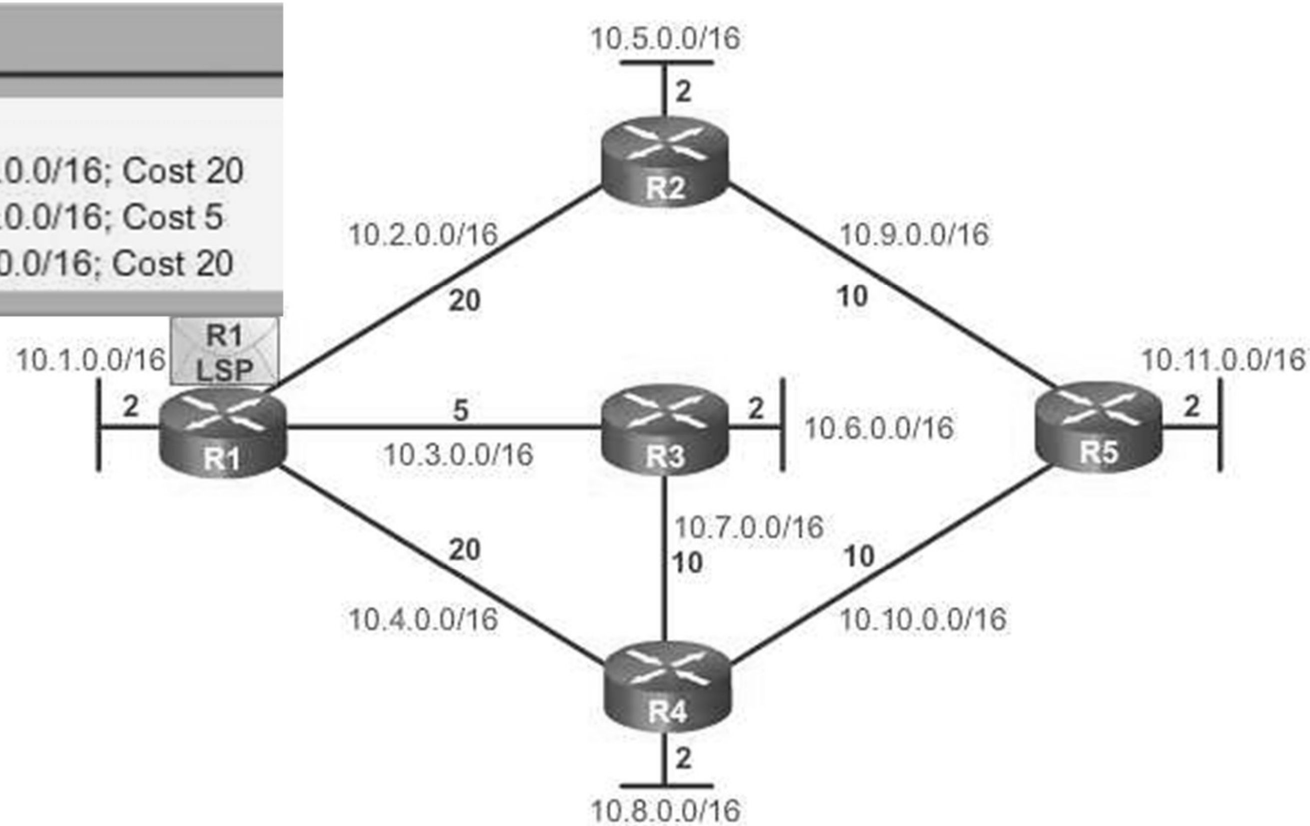


Link-State Routing Protocol

- 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

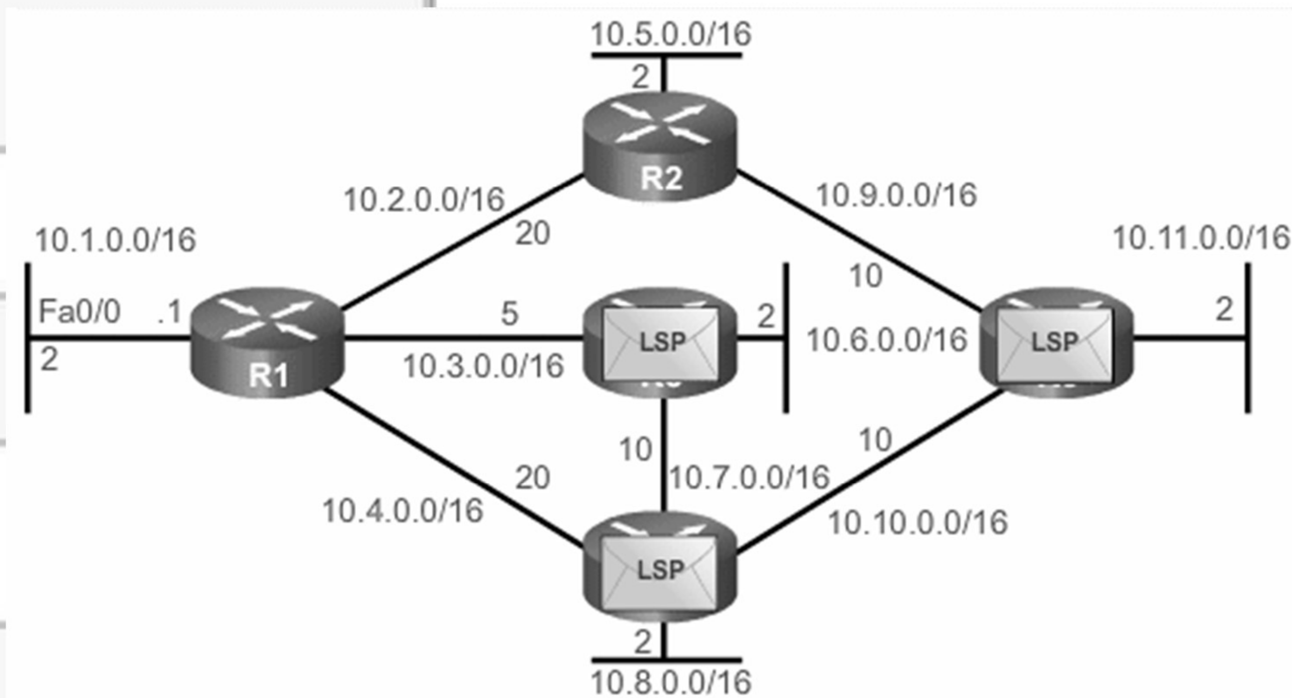
R1 Link-states:
- Connected to network 10.1.0.0/16, cost = 2
- Connected to R2 on network 10.2.0.0/16, cost = 20
- Connected to R3 on network 10.3.0.0/16, cost = 5
- Connected to R4 on network 10.4.0.0/16, cost = 20

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

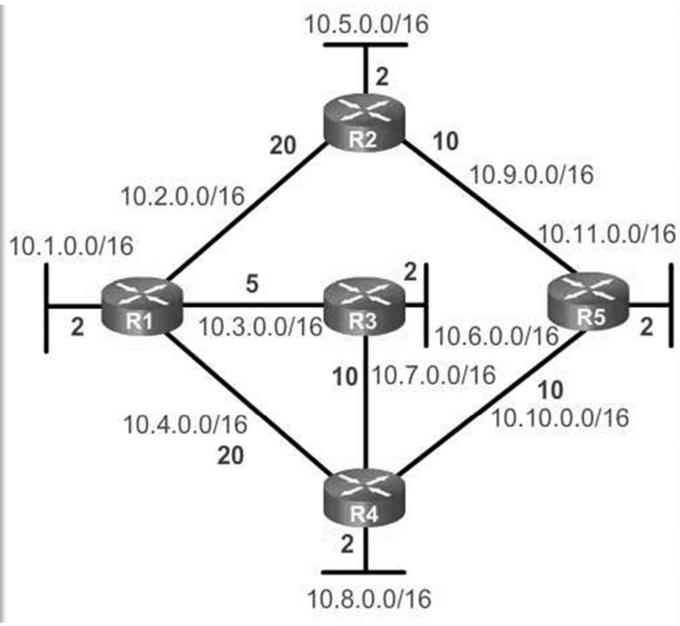
R4 Link-states:
- Connected to network 10.8.0.0/16, cost = 2
- Connected to R1 on network 10.4.0.0/16, cost = 20
- Connected to R3 on network 10.7.0.0/16, cost = 10
- Connected to R5 on network 10.10.0.0/16, cost = 10

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



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 & Link-State
Say Hello
Building the Link-State Packet
Flooding LSP & Building Database
Building the SPF Tree & Routing Table

Link-State Routing Protocol

Advantages of Link-State Routing Protocols

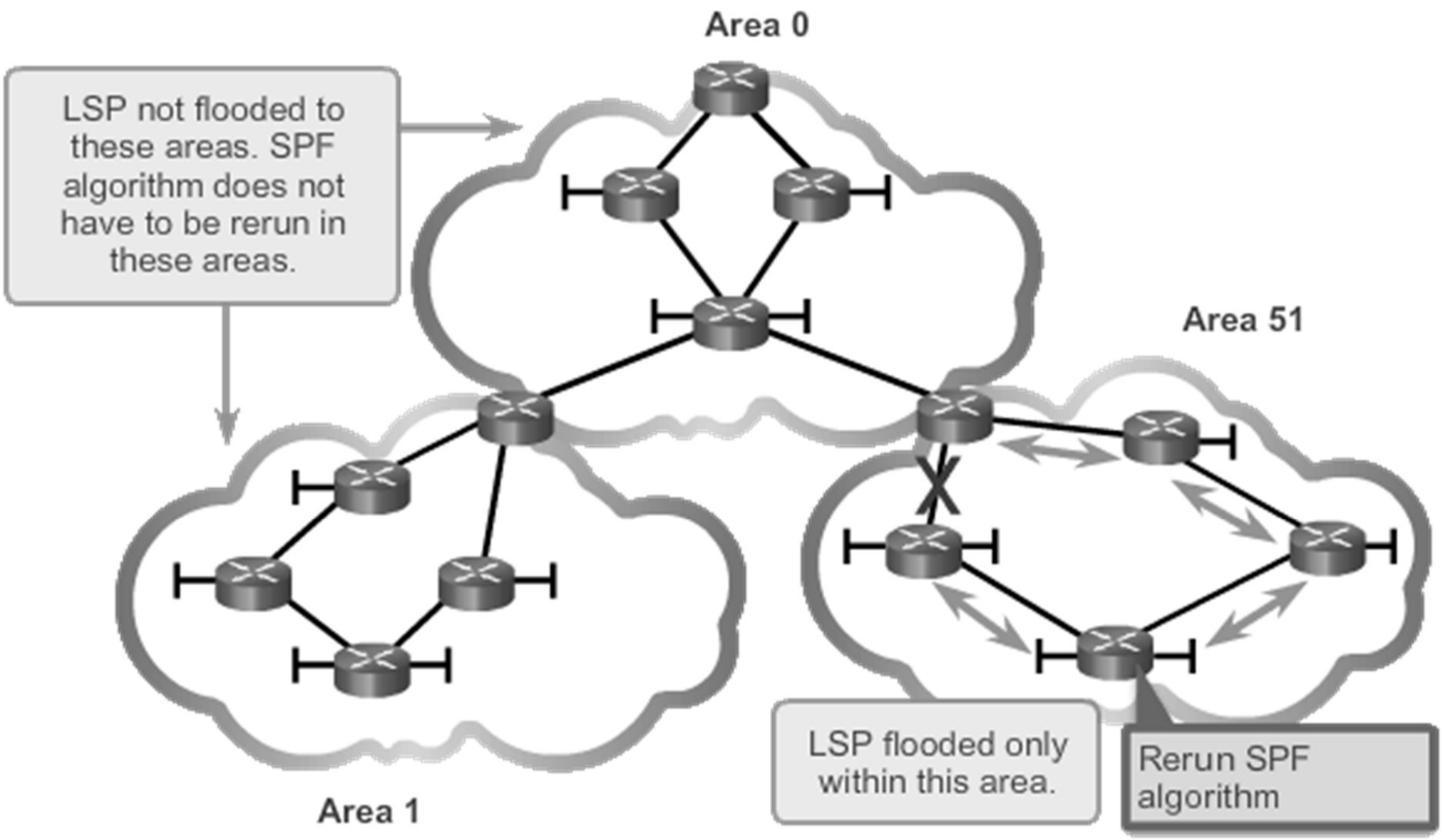
- Each router builds its own topological map of the network to determine the shortest path.
- Immediate flooding of LSPs achieves faster convergence.
- LSPs are sent only when there is a change in the topology and contain only the information regarding that change.
- Hierarchical design used when implementing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

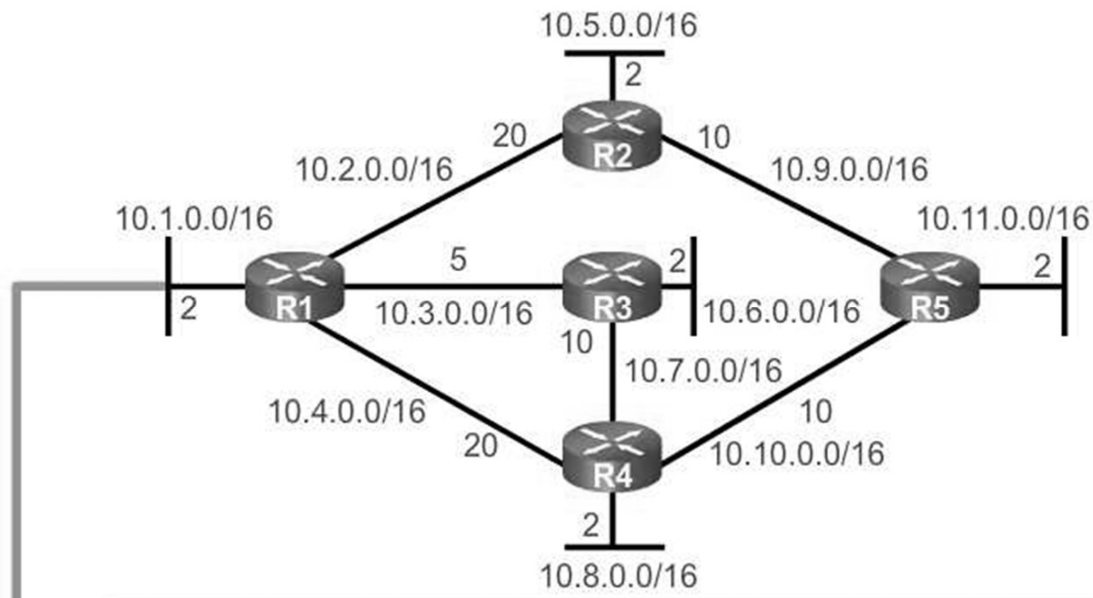
OSPF


Hello packets
Database Description packets
Link-state Request packets
Link-state Update packets
Link-state Acknowledgment packets

OSPF

- Link & Link-State
- Say Hello
- Building the Link-State Packet
- Flooding LSP & Building Database
- Building the SPF Tree & Routing Table

Content of the R1 SPF Tree

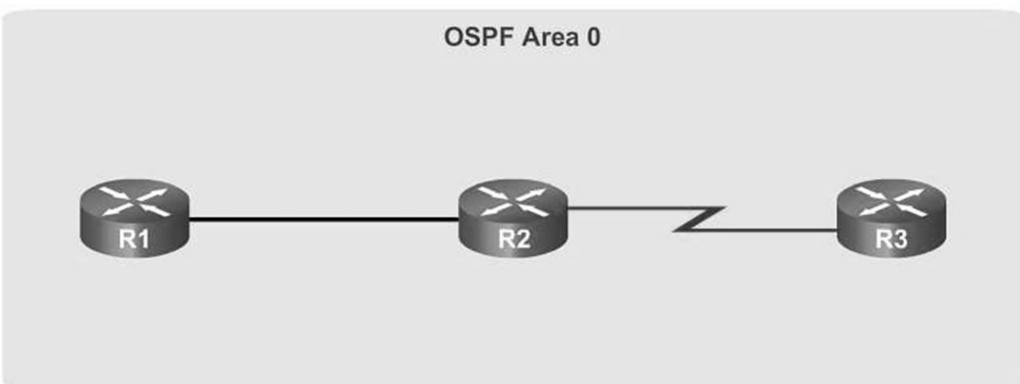


Destination	Shortest Path	Cost
10.5.0.0/16	R1 → R2	22
10.6.0.0/16	R1 → R3	7
10.7.0.0/16	R1 → R3	15
10.8.0.0/16	R1 → R3 → R4	17
10.9.0.0/16	R1 → R2	30
10.10.0.0/16	R1 → R3 → R4	25
10.11.0.0/16	R1 → R3 → R4 → R5	27

OSPF

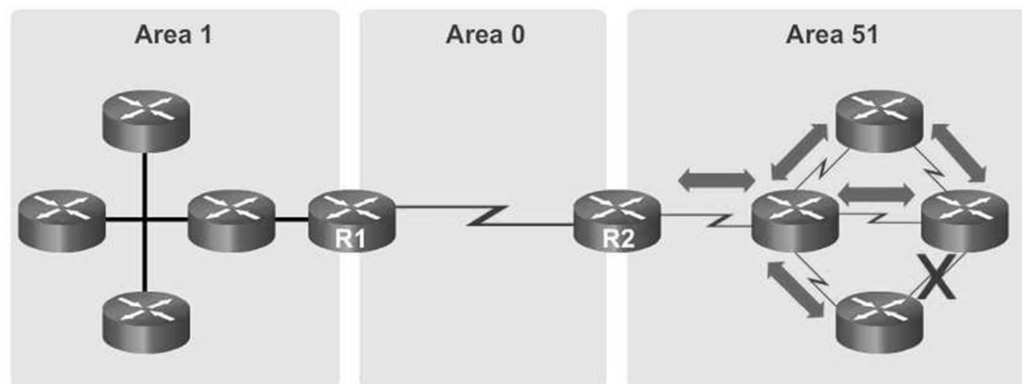
- Single-area and Multiarea OSPF

Single-Area OSPF



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

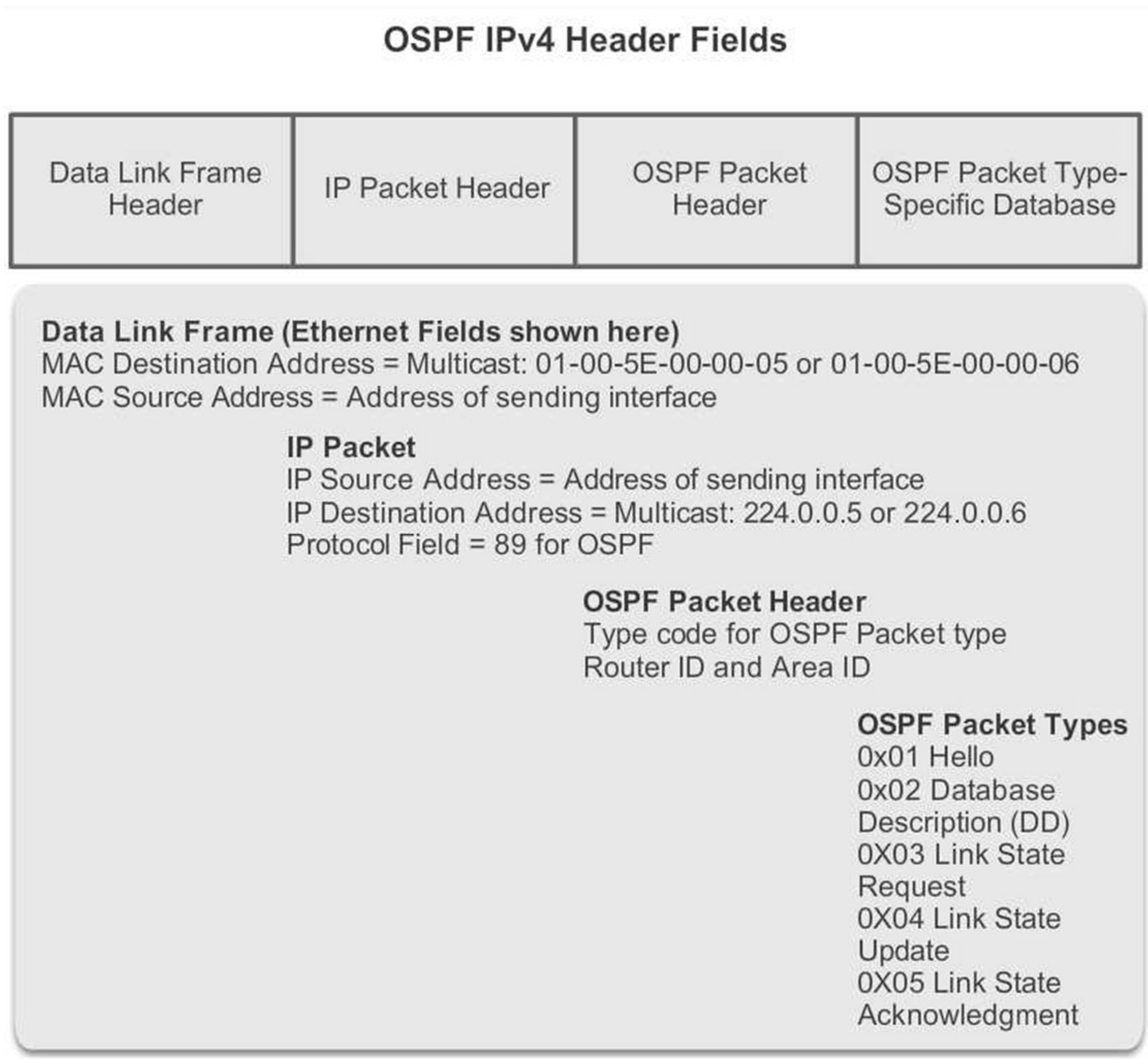
Link Change Impacts Local Area Only



- 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 Messages

- Types of OSPF Packets

OSPF Packet Descriptions

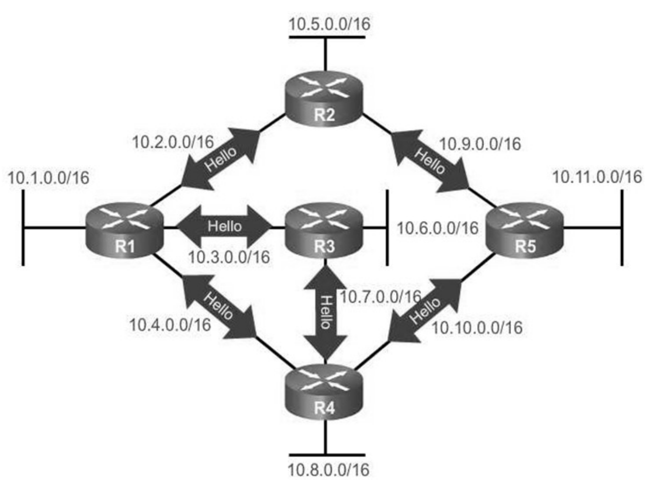
Type	Packet Name	Description
1	Hello	Discovers neighbors and builds adjacencies between them
2	Database Description (DBD)	Checks for database synchronization between routers
3	Link-State Request (LSR)	Requests specific link-state records from router to router
4	Link-State Update (LSU)	Sends specifically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

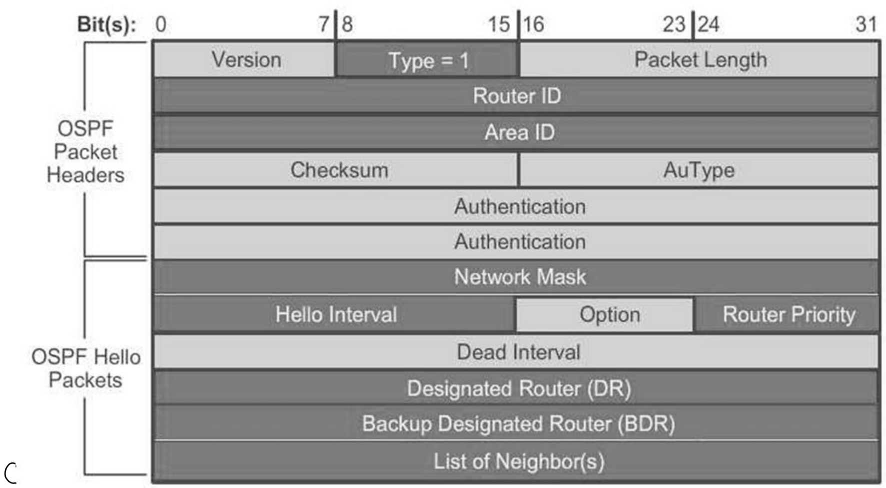
OSPF Messages

- 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 Hello Packet Content

Hello Packets Sent Periodically





OSPF Messages

- Link-State Updates

LSUs Contain LSAs

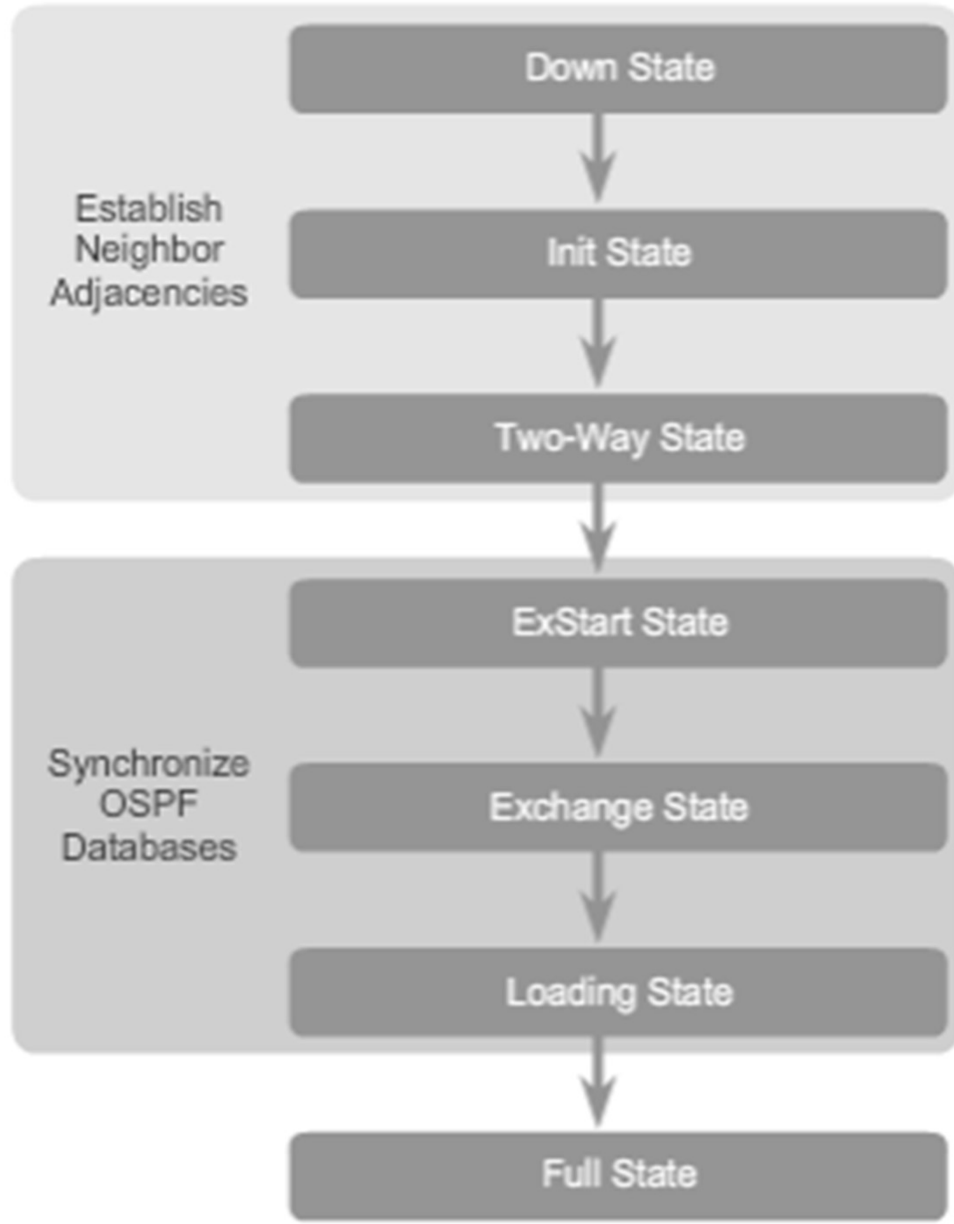
Type	Packet Name	Description
1	Hello	Discovers neighbors and builds adjacencies between them
2	DBD	Checks for database synchronization between router
3	LSR	Requests specific link-state records from router to router
4	LSU	Sends specifically requested link-state records
5	LSAck	Acknowledges the other packet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

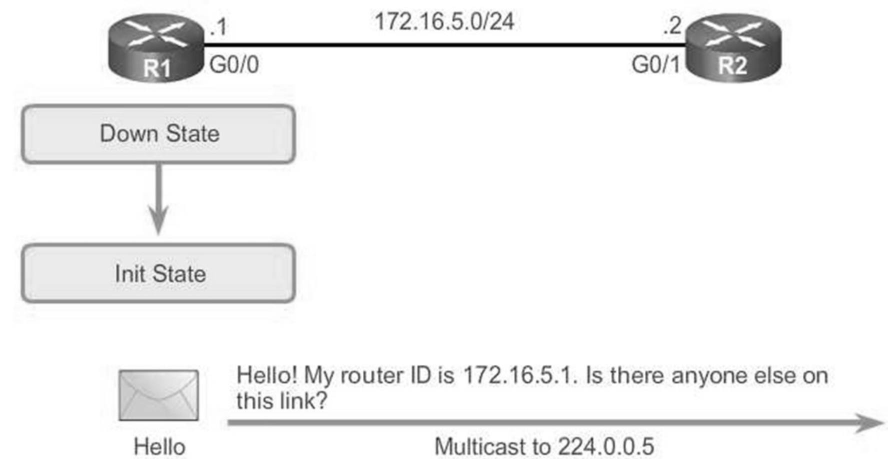
OSPF Operation

- 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.

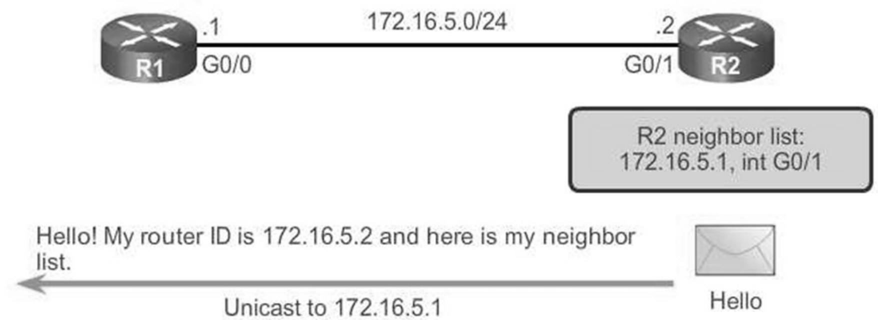


OSPF Operation

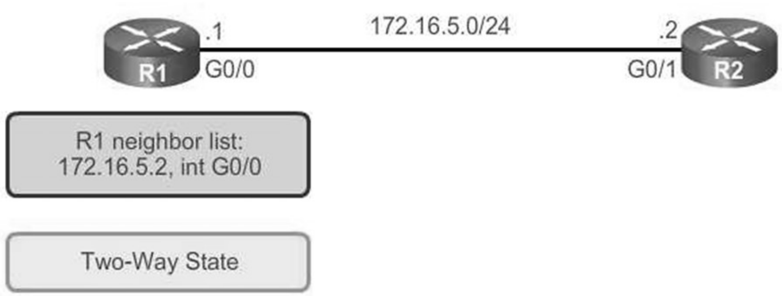
Down State to Init State



The Init State



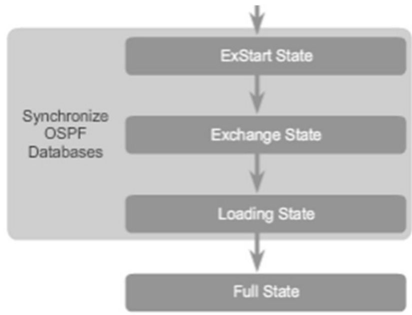
Two-Way State

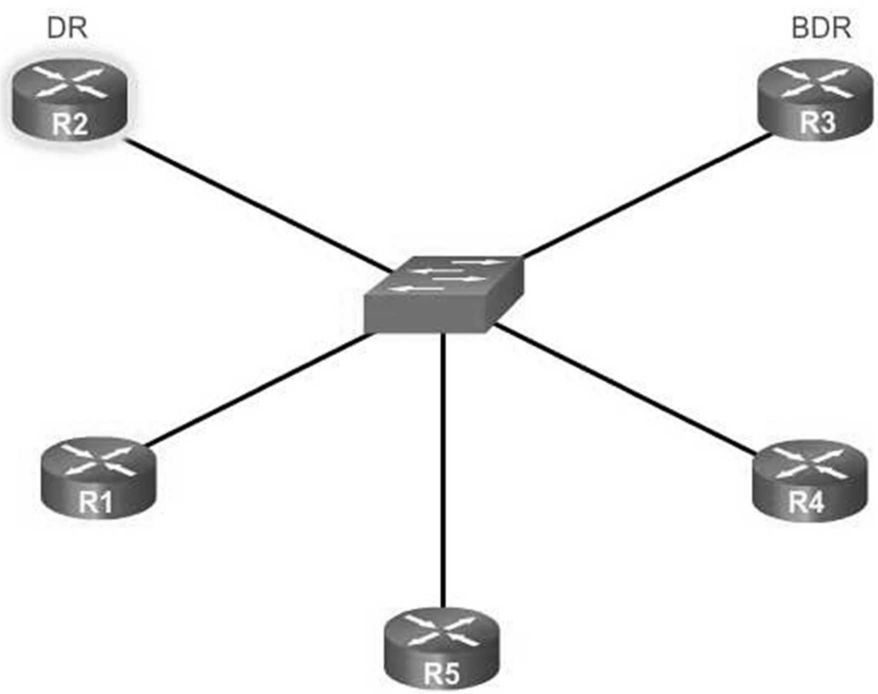


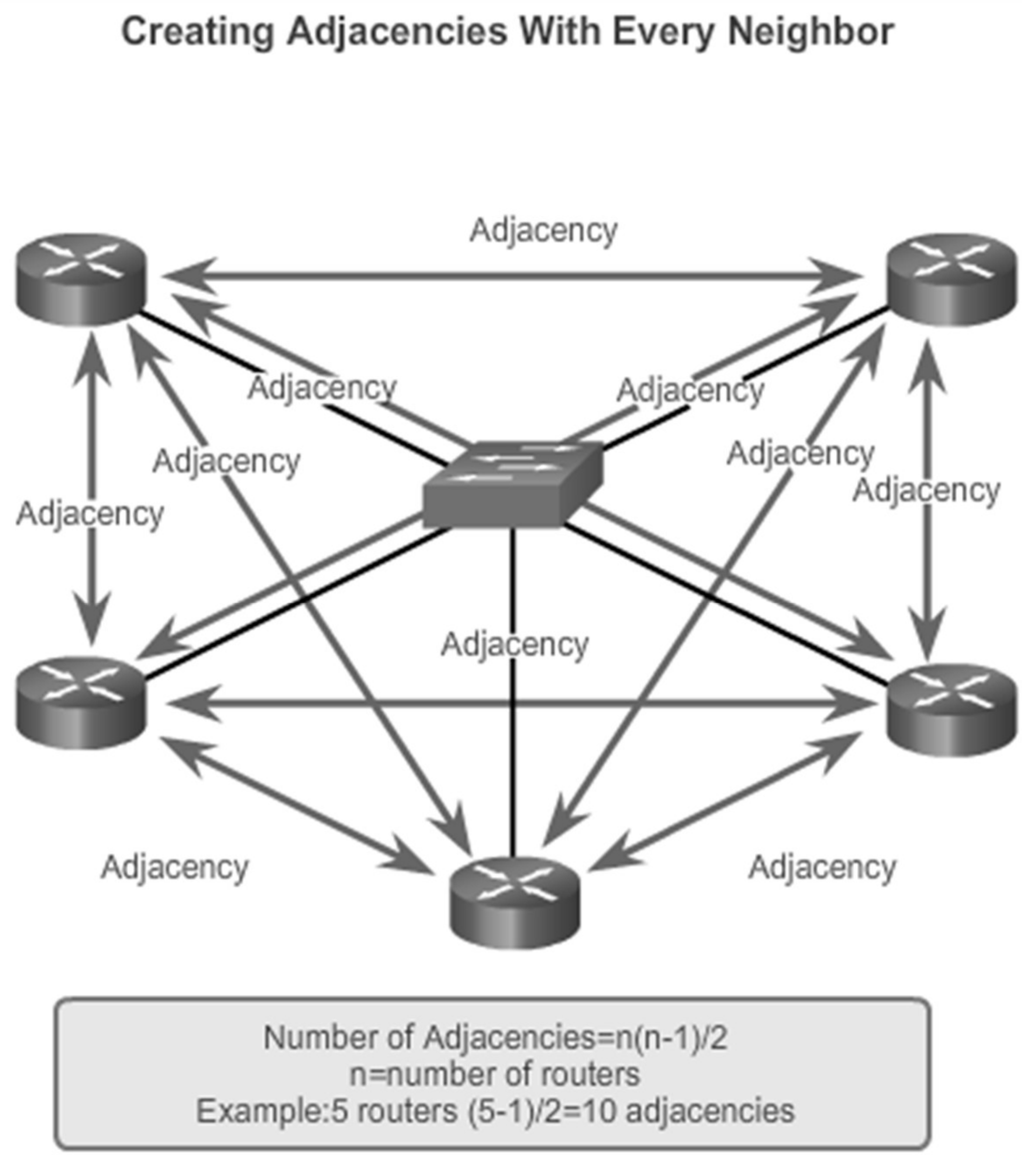
Elect the DR and BDR

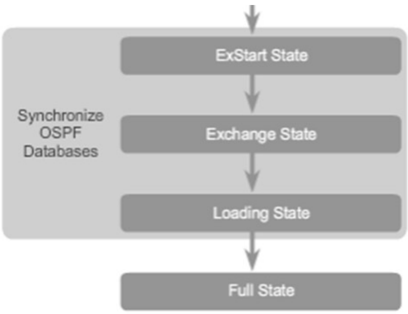
OSPF Operation

- DR and BDR

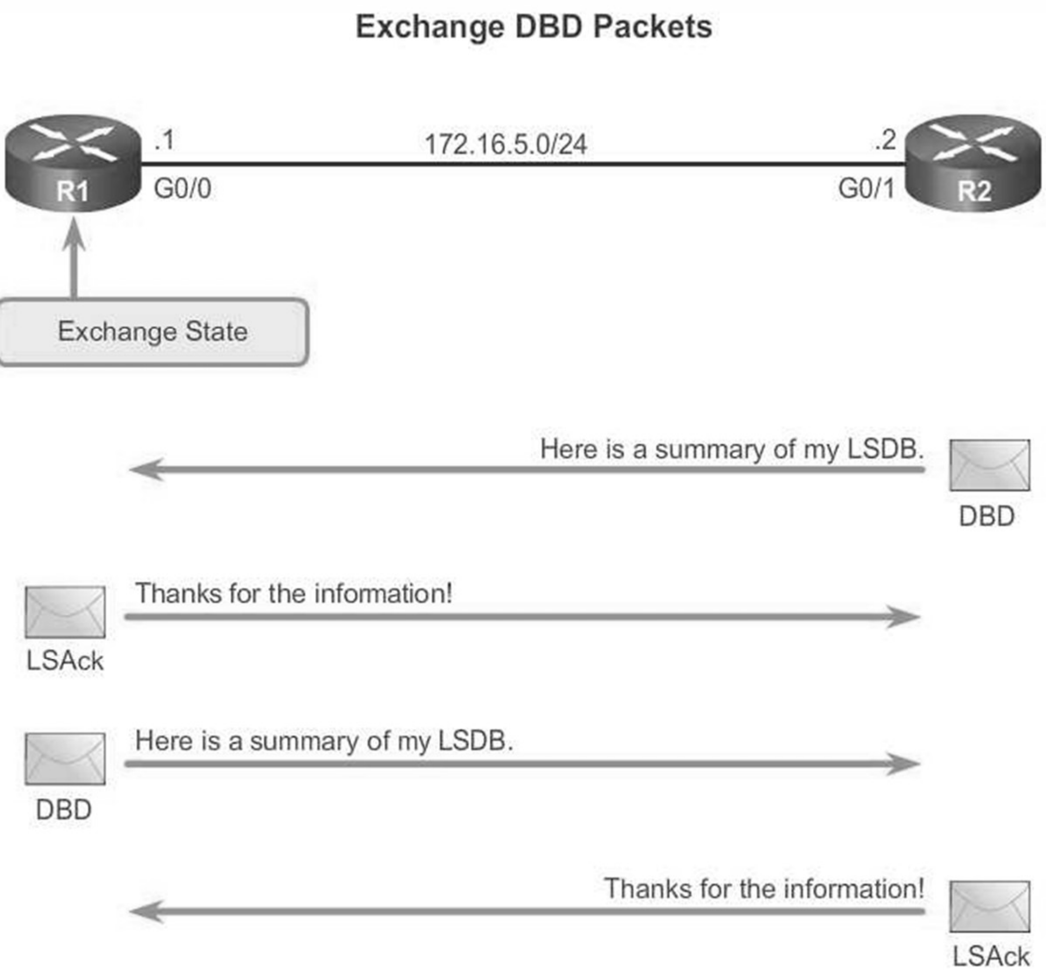


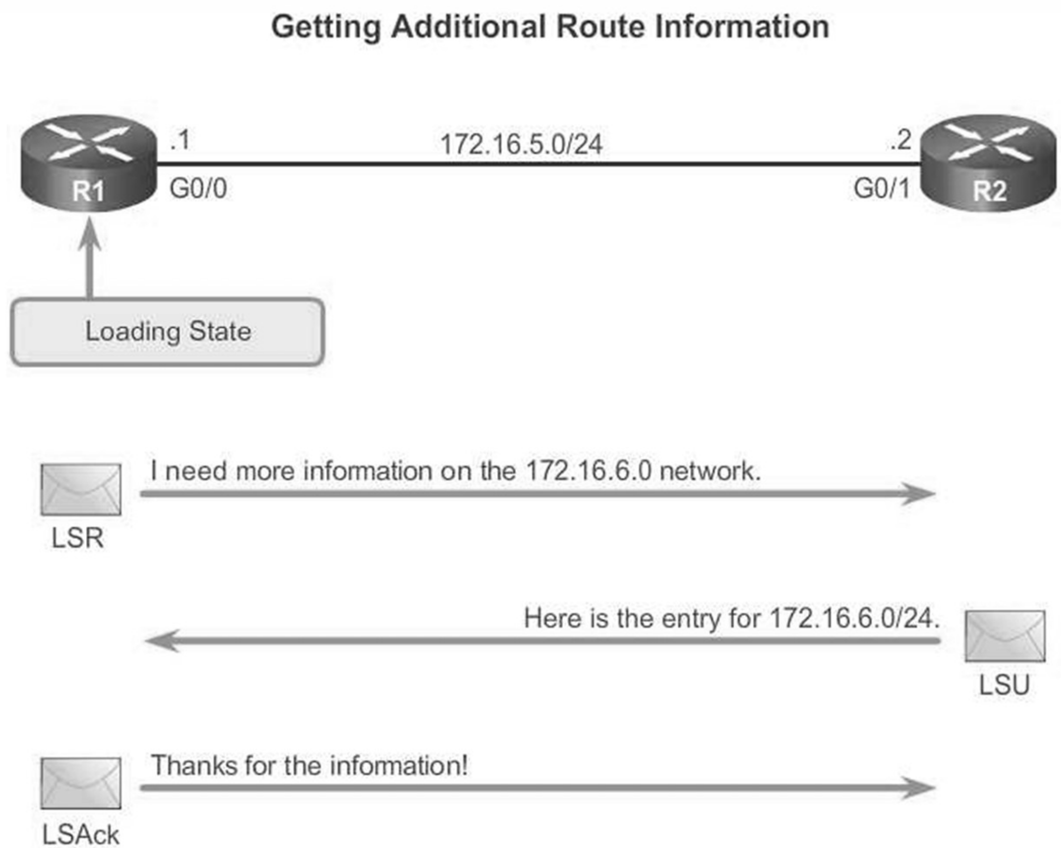






OSPF Operation





Configuring Single-Area OSPFv2

`router ospf` ***`process-id`***

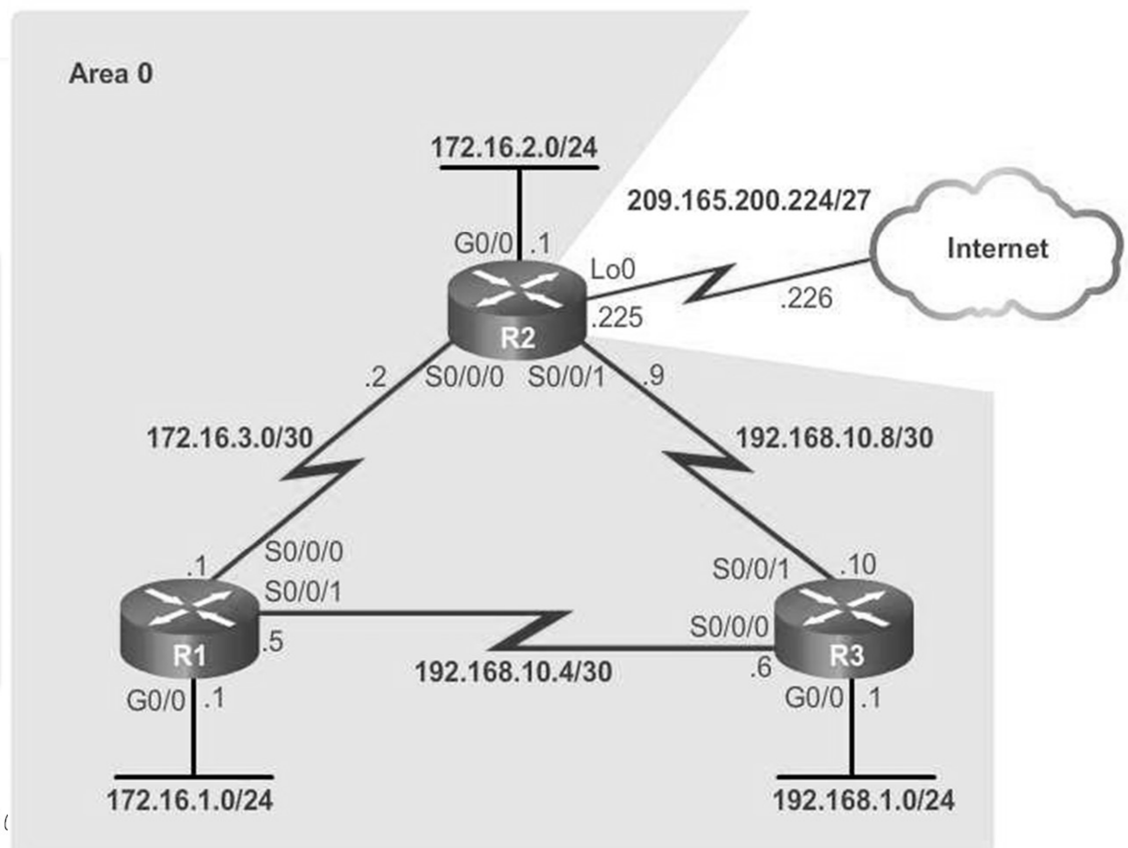
- process-id value
  - a number between 1 and 65,535
  - locally significant

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.

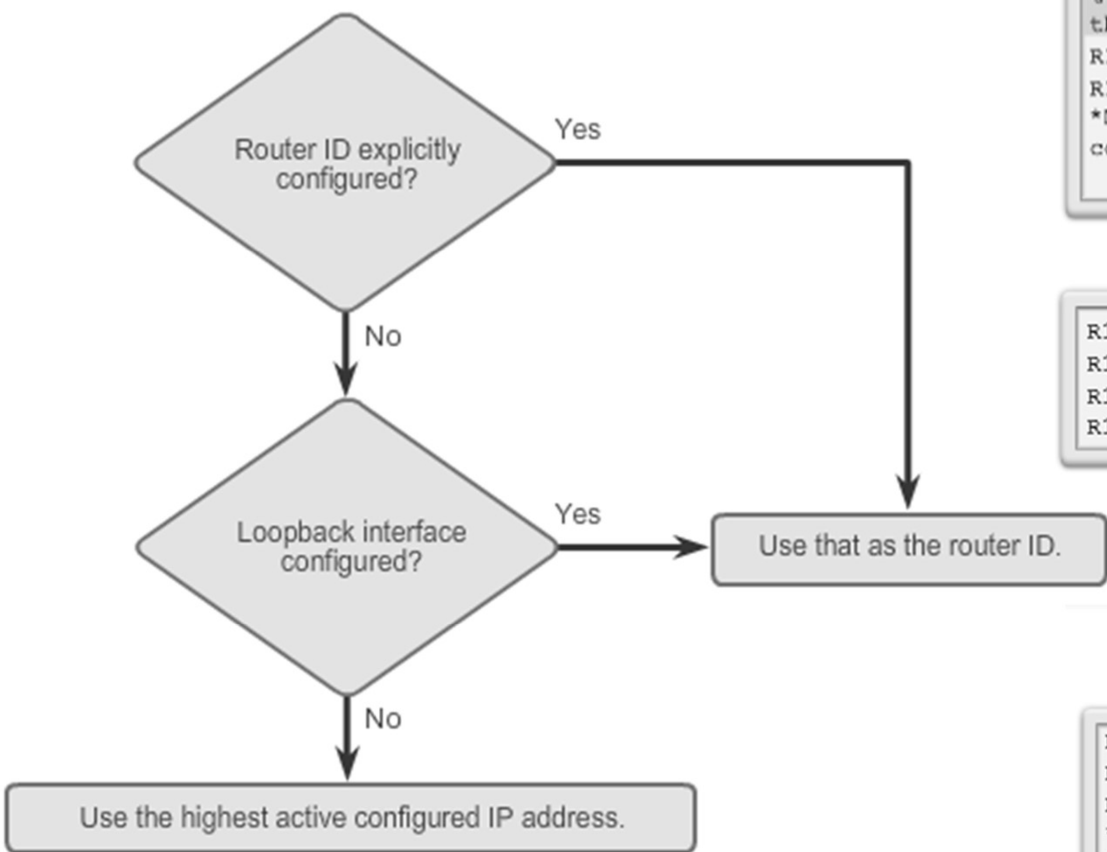
OSPF Reference Topology



Configuring Single-Area OSPFv2

- OSPF Router IDs

Router ID Order of Precedence




```
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
```

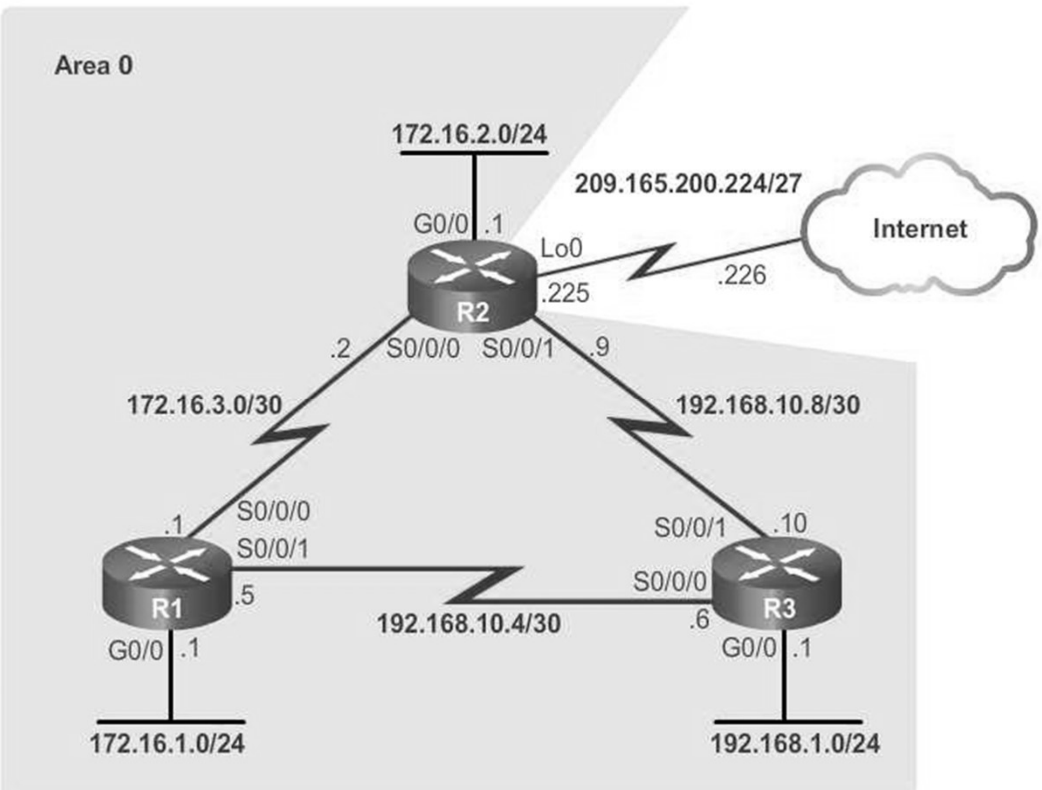
```
R1(config)# interface loopback 0
R1(config-if)# ip address 1.1.1.1 255.255.255.255
R1(config-if)# end
R1#
```

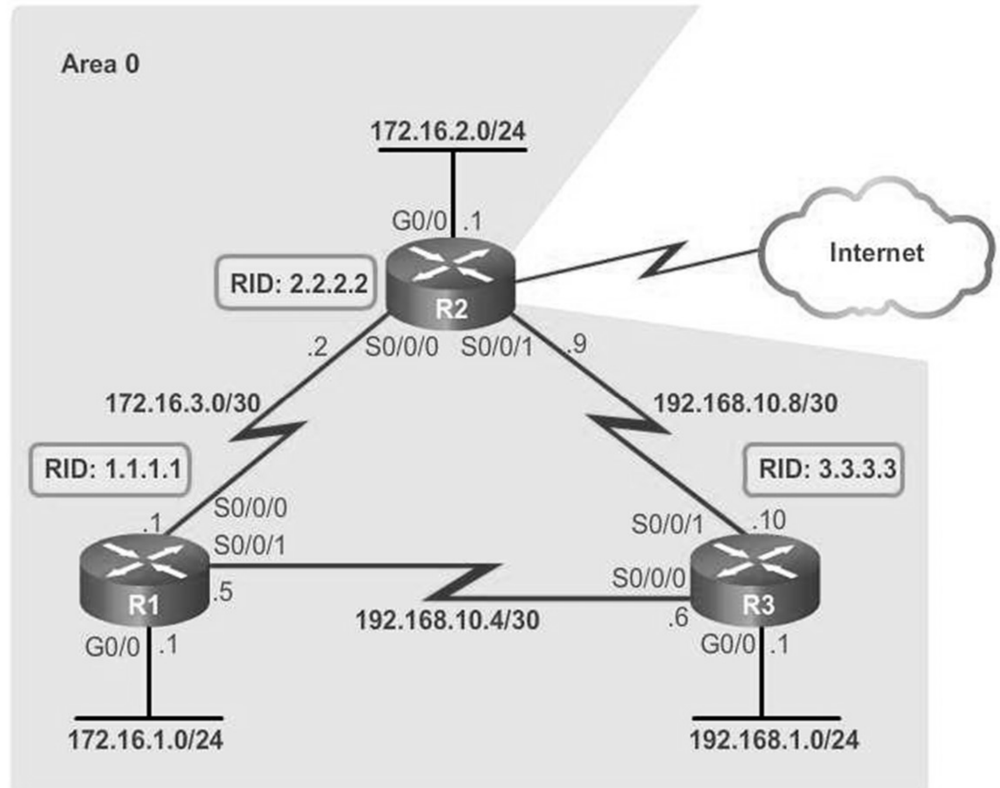
Clearing the OSPF Process

```
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

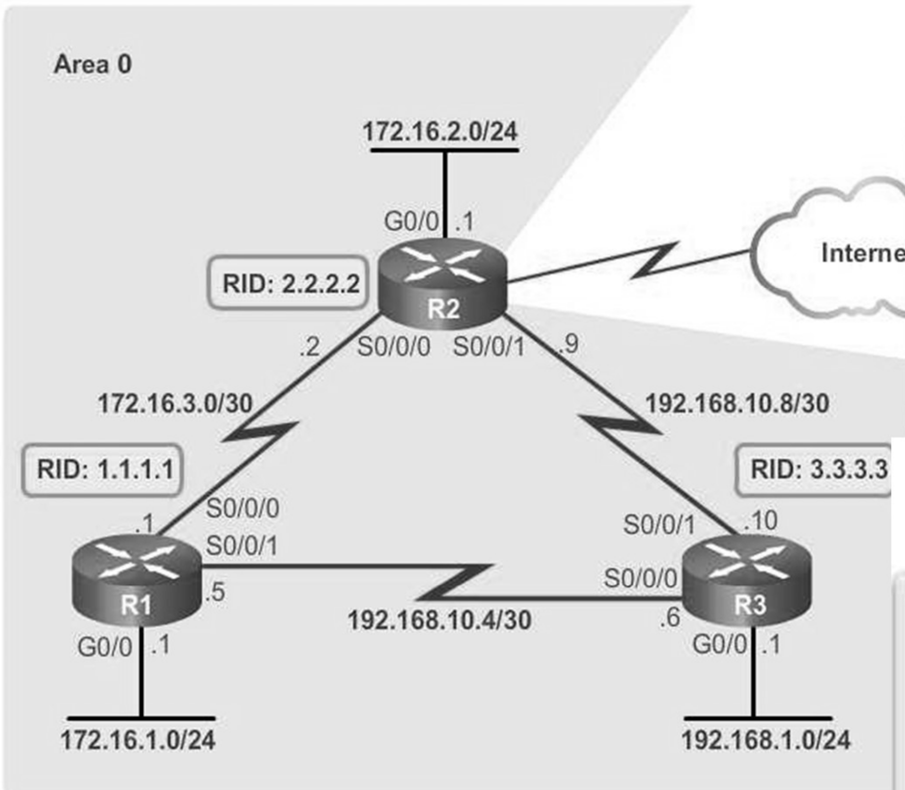
- OSPF Router IDs





Configuring Single-Area OSPFv2

router ospf ***process-id***
network ***network-address wildcard-mask*** **area** ***area-id***



Assigning Interfaces to an OSPF Area

```
R1(config)# router ospf 10
R1(config-router)# network 172.16.1.0 0.0.0.255 area 0
R1(config-router)# network 172.16.3.0 0.0.0.3 area 0
R1(config-router)# network 192.168.10.4 0.0.0.3 area 0
R1(config-router)#
R1#
```

Assigning Interfaces to an OSPF Area with a Quad Zero

```
R1(config)# router ospf 10
R1(config-router)# network 172.16.1.1 0.0.0.0 area 0
R1(config-router)# network 172.16.3.1 0.0.0.0 area 0
R1(config-router)# network 192.168.10.5 0.0.0.0 area 0
R1(config-router)#
R1#
```

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

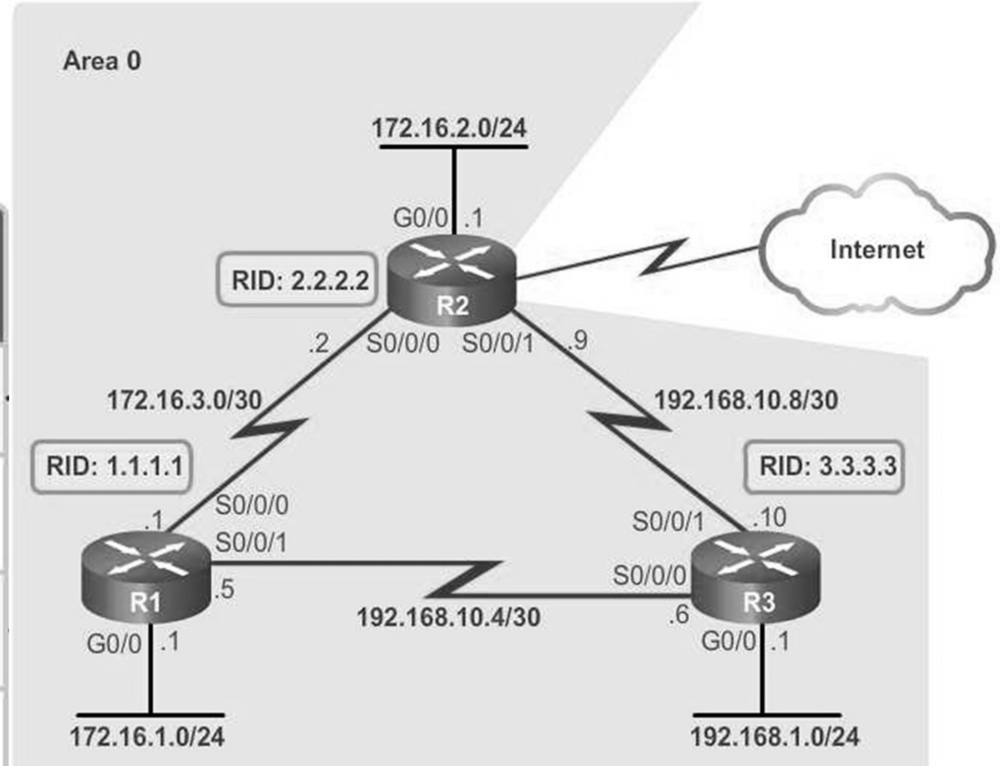
- The default reference bandwidth is 10^8 (100,000,000); therefore, the formula is:

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	÷	10,000,000,000	1
Gigabit Ethernet 1 Gbps	100,000,000	÷	1,000,000,000	1
Fast Ethernet 100 Mbps	100,000,000	÷	100,000,000	1
Ethernet 10 Mbps	100,000,000	÷	10,000,000	10
Serial 1.544 Mbps	100,000,000	÷	1,544,000	64
Serial 128 kbps	100,000,000	÷	128,000	781
Serial 64 kbps	100,000,000	÷	64,000	1562




```
R1# show ip route | include 172.16.2.0
O        172.16.2.0/24 [110/65] via 172.16.3.2, 03:39:07,
         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 110, metric 65, type intra
  area
  Last update from 172.16.3.2 on Serial0/0/0, 03:39:15 ago
  Routing Descriptor Blocks:
  * 172.16.3.2, from 2.2.2.2, 03:39:15 ago, via Serial0/0/0
      Route metric is 65, traffic share count is 1
R1#
```

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

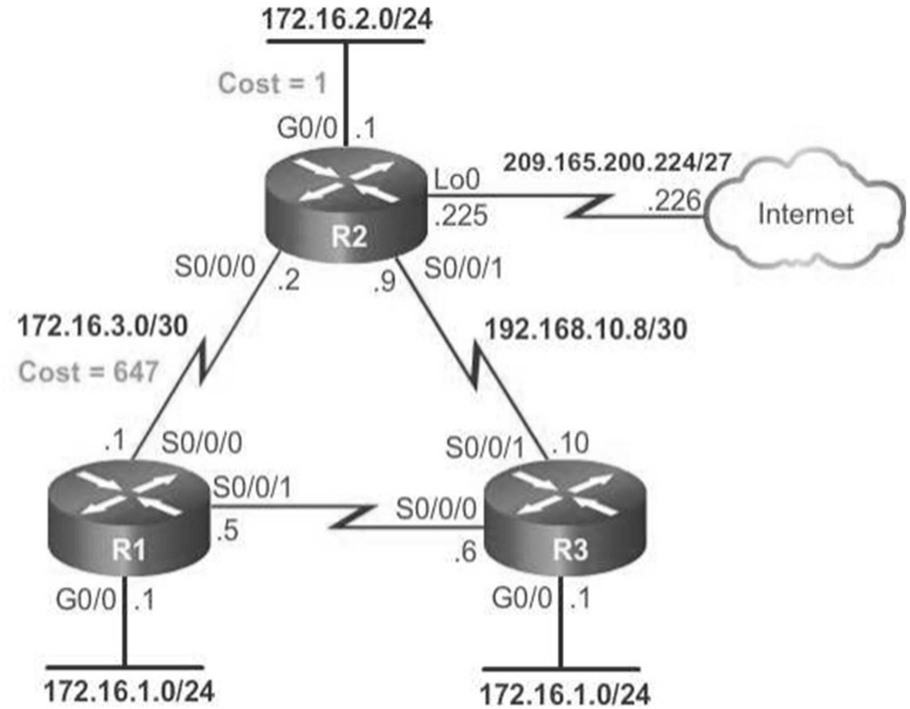
OSPF Cost

```
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 110, metric 648, type intra area
  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, 00:06:17 ago, via Serial0/0/0
      Route metric is 648, traffic share count is 1
```

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

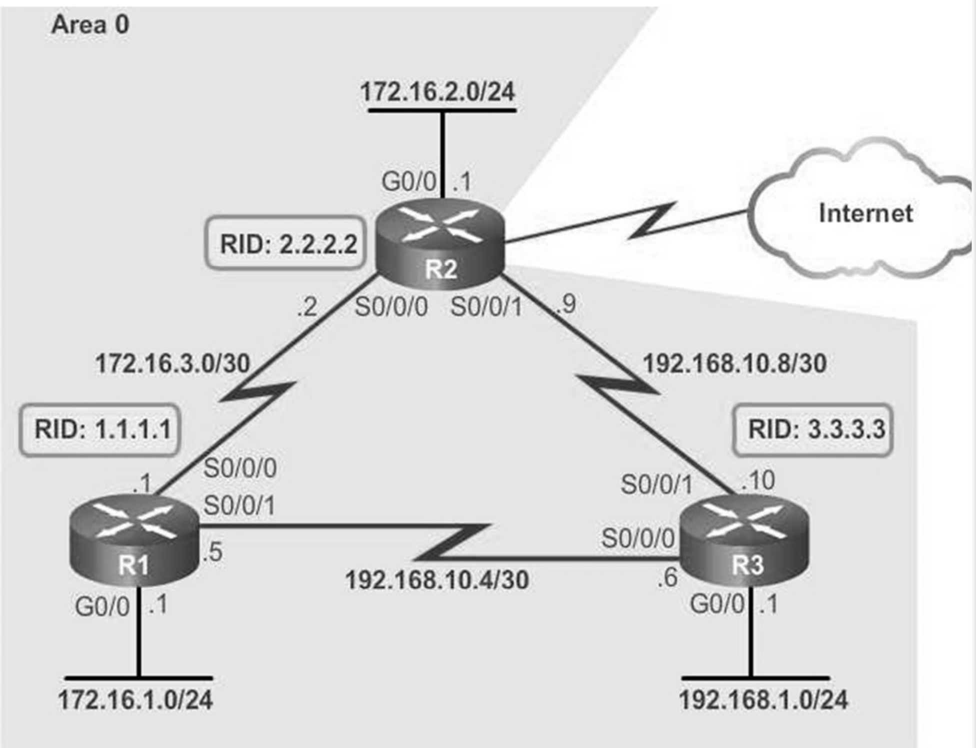
- Manually Setting the OSPF Cost
  - Both the bandwidth interface command and the ip ospf cost interface command achieve the same result, which is to provide an accurate value for use by OSPF in determining the best route.

```
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#
```




```
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
```

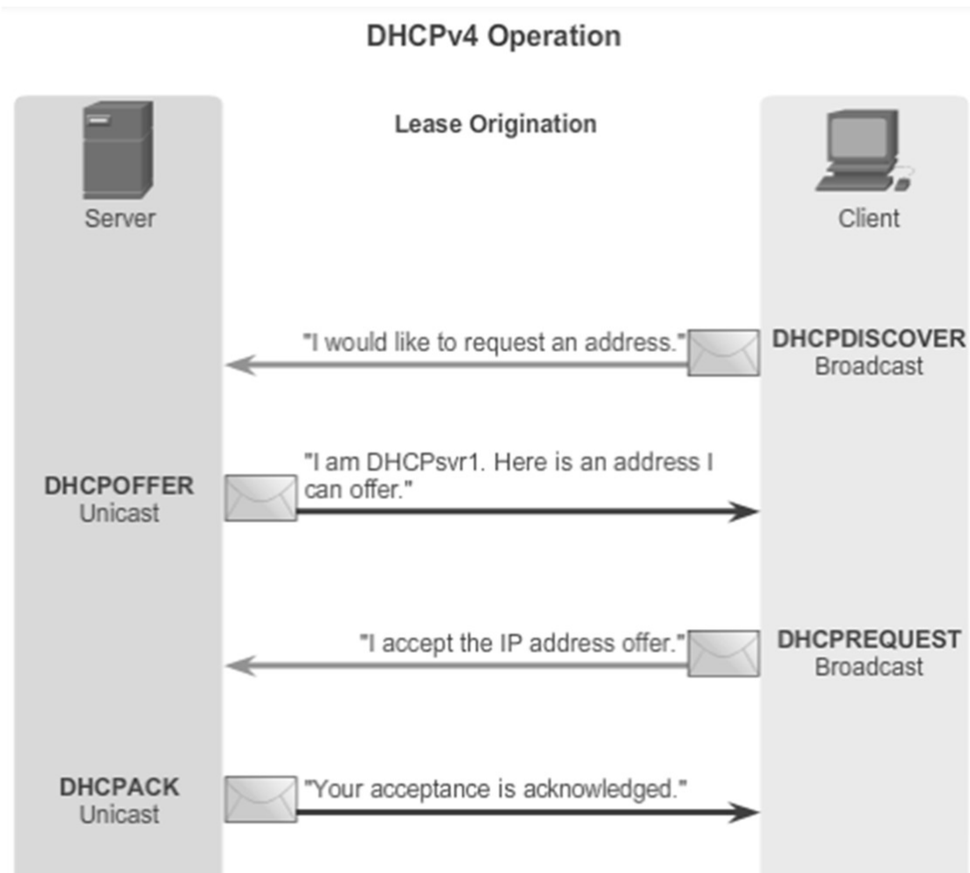
DHCP

- 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

DHCPv4 Discover Message

Ethernet Frame	IP	UDP	DHCPDISCOVER
SRC MAC: MAC A DST MAC:FF:FF:FF:FF:FF:FF	IP SRC: 0.0.0.0 IP DST:255.255.255.255	UDP 67	CIADDR: 0.0.0.0 GIADDR: 0.0.0.0 Mask: 0.0.0.0 CHADDR: MAC A

MAC: Media Access Control Address
CIADDR: Client IP Address
GIADDR: Gateway IP Address
CHADDR: Client Hardware Address

The DHCP client sends a directed IP broadcast with a DHCPDISCOVER packet. In this example, the DHCP server is on the same segment and will pick up this request. The server notes the GIADDR field is blank; therefore, the client is on the same segment. The server also notes the hardware address of the client in

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:\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:\Documents and settings\SpanPC>
```

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


```
SOHO(config)# interface g0/1
SOHO(config-if)# ip address dhcp
SOHO(config-if)# no shutdown
SOHO(config-if)#
*Jan 31 17:31:11.507: %DHCP-6-ADDRESS_ASSIGN: Interface
GigabitEthernet0/1 assigned DHCP address 209.165.201.12, mask
255.255.255.224, hostname SOHO
SOHO(config-if)# end
SOHO# show ip interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  Internet address is 209.165.201.12/27
  Broadcast address is 255.255.255.255
  Address determined by DHCP
  <Output omitted>
```

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