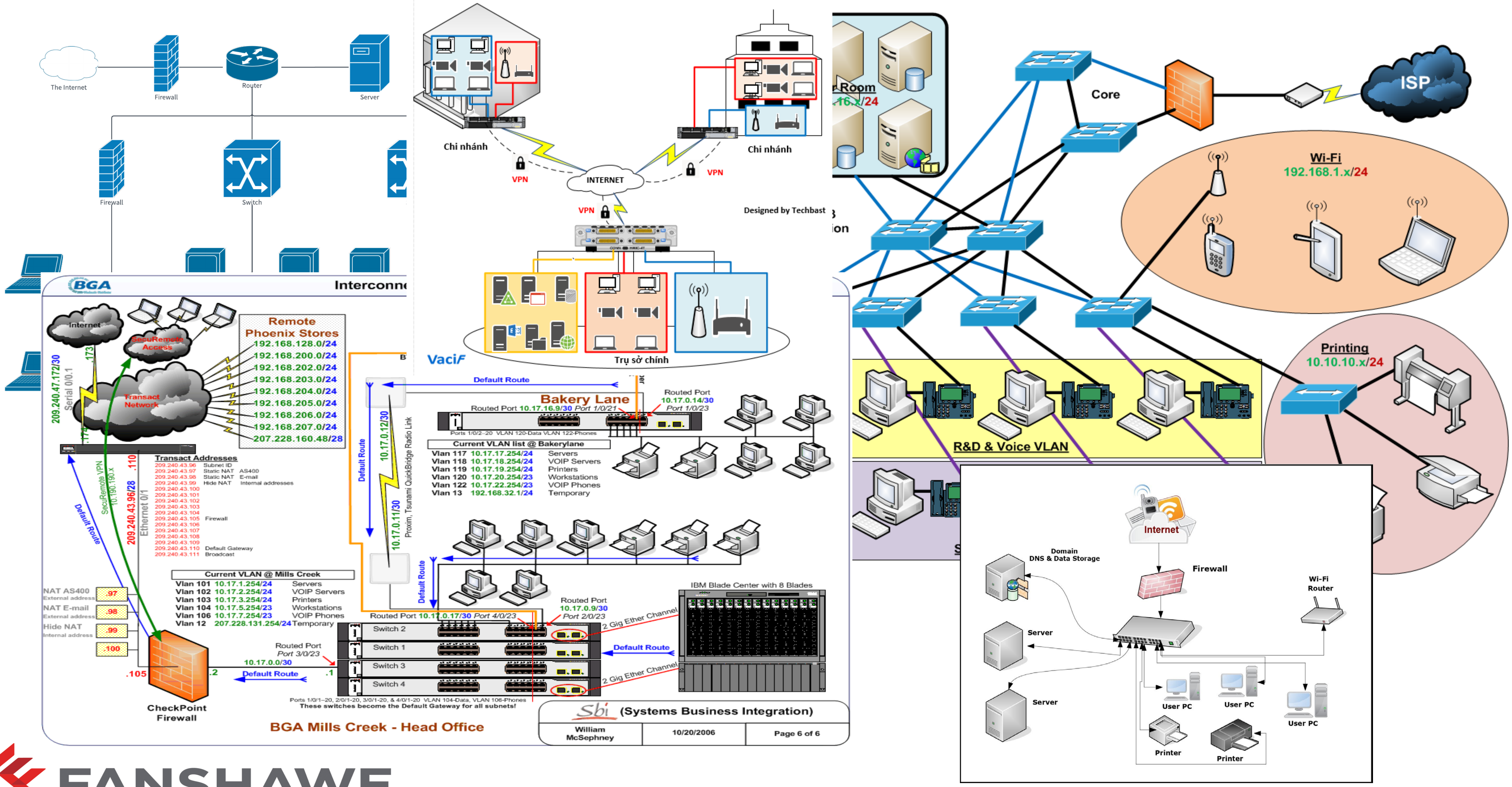
Dynamic Routing Protocols - OSPF



INFO-6047 Switching and Routing

ISM1 - Information Security Management (ISM1-ITY-20189) Detailed Weekly Content

Week	Date of Lecture or Tests, 7:00 – 9:00 PM EST	Lecture/Test	Reading	Lab Time INFO-6047-01 Wednesday 5:00 – 8:00 PM EST INFO-6047-02 Tuesday 5:00 – 8:00 PM EST	Grade
Week 01	Monday, January 02, 2023	College-Wide Orientation			
Week 02	Monday, January 09, 2023	Introduction	N/A	Lab 01 - Basics of PT	3.0%
Week 03	Monday, January 16, 2023	Basics of Routing	Chapter 01 & 02 *(Introduction to Networking, Network Media Copper)*	Lab 02 - Intro to Routing	3.0%
Week 04	Monday, January 23, 2023	Basics of Switching	Chapter 03 & 04 *(Network Media Fiber Network Media Wireless)*	Lab 03 - Intro to Switching	3.0%
Week 05	Monday, January 30, 2023	VLANs	Chapter 05 *(Data Encoding & Transmission)*	Lab 04 - VLANs	3.0%
Week 06	Monday, February 06, 2023	Routing	Chapter 06 *(Network OS & Communications)*	Lab 05 - Routing	3.0%
Week 07	Monday, February 13, 2023	Mid-Term Test		Mid-Term (Test 1)	32.0%
Study Break	Monday, February 20, 2023	Study Break - No Class This Week			
Week 08	Monday, February 27, 2023	Inter-VLAN Routing	Chapter 10 *(TCP/IP Fundamentals)*	Lab 06 - Inter VLAN Routing	3.0%
Week 09	Monday, March 06, 2023	Static Routing	Chapter 11 *(Subnetting)*	Lab 07 - Static & Default Routs	3.0%
Week 10	Monday, March 13, 2023	Dynamic Routing - RIP	Chapter 12 *(Additional Transmission Modalities)*	Lab 08 - RIP Protocol	3.0%
Week 11	Monday, March 20, 2023	Dynamic Routing - OSPF	Chapter 14 *(RA & LD Communications)*	Lab 09 - OSPF Protocol	3.0%
Week 12	Monday, March 27, 2023	Access Control Lists	Chapter 15 *(Network Security)*	Lab 10 - ACLs	3.0%
Week 13	Monday, April 03, 2023	DHCP	Chapter 16 *Maintaining the Network)*	Lab 11 - DHCP	3.0%
Week 14	Monday, April 10, 2023	NAT	Chapter 17 *(Troubleshooting Fundamentals of a Network)*	Lab 12 - NAT	3.0%
Week 15	Monday, April 17, 2023	Final Test		Final Test (Test 2)	32%

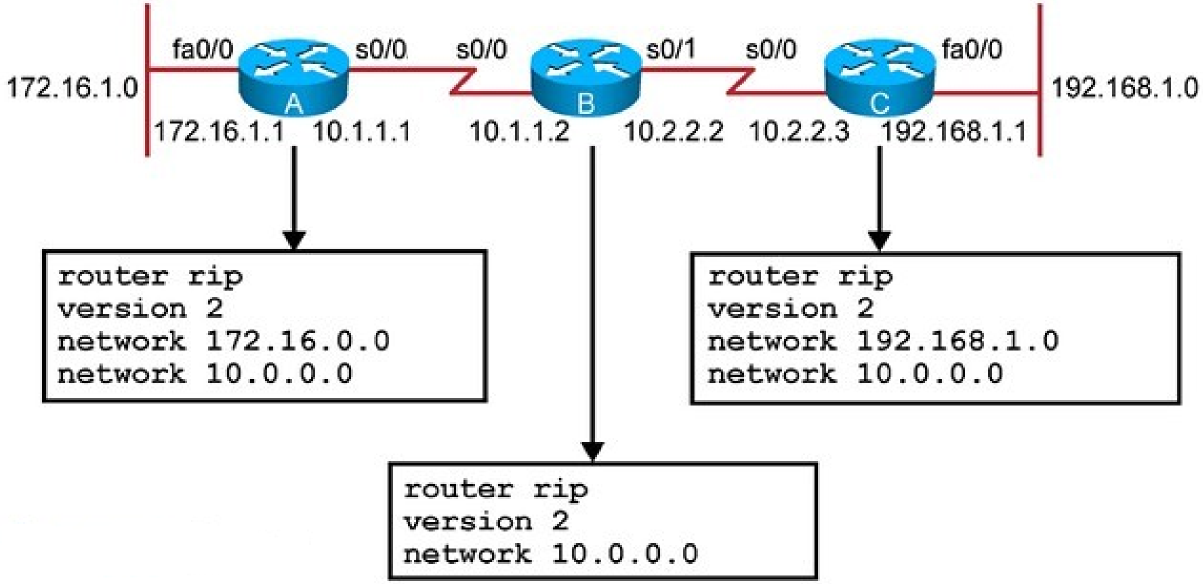
Final Exam

- Section 1 and 2
- When: Monday April 17th at 7:00 PM
- Where: B1071
- How: Open book (120 minutes for 120 points)
  - Allowed resources: Lecture slides, labs, and textbook
  - Not allowed: Phones, Google, and instant messaging.
- Note: Bring your laptop charger as you will be asked to keep your screen brightness up and to avoid having your laptop battery dying.

- Online and part-time
- When: Tuesday April 18th 12:00 AM to 11:59 PM (24 hours to begin exam)
- Where: Online (120 minutes for 120 points)
- How: Open book
  - Allowed resources: Lecture slides, labs, and textbook
  - Not allowed: Phones, Google, and instant messaging.

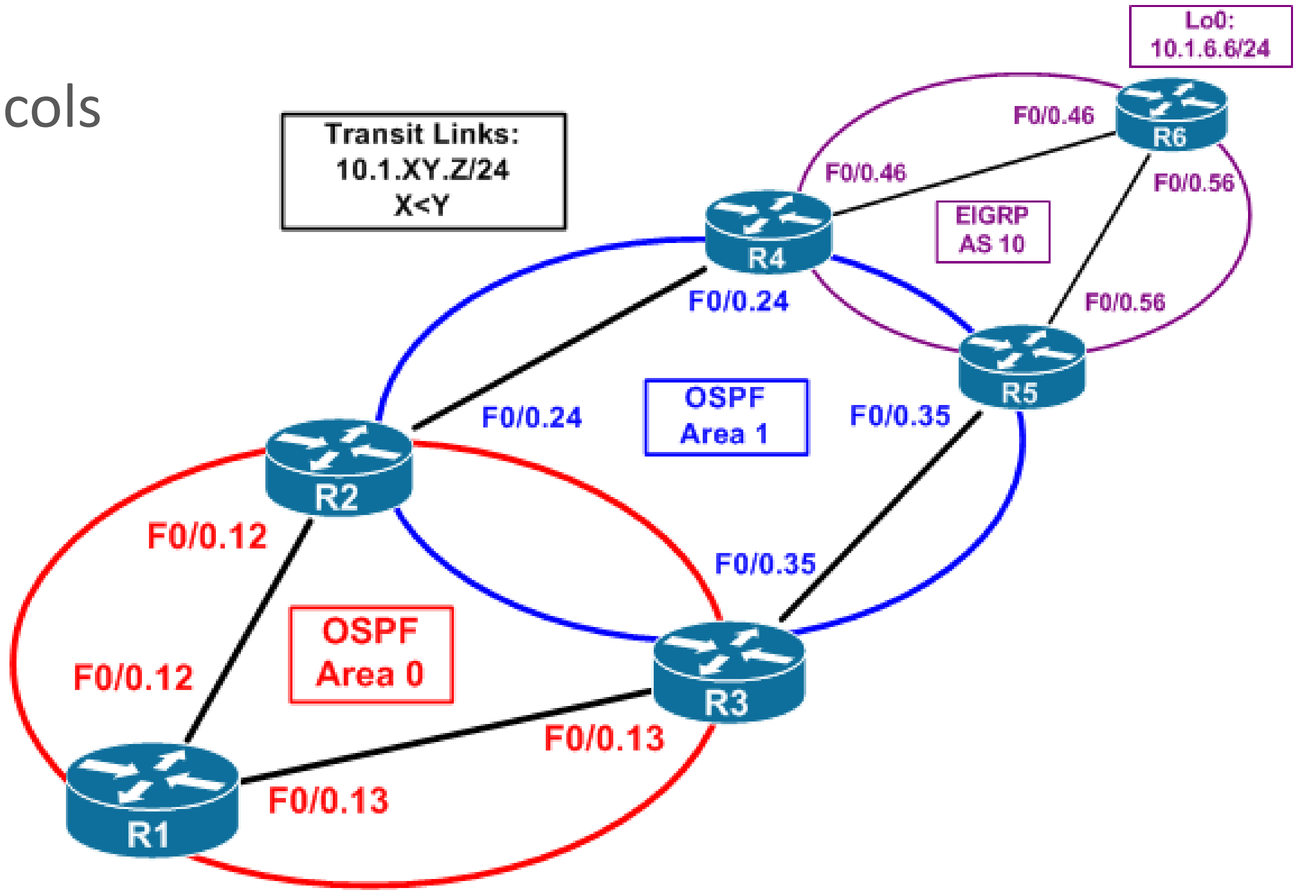
Review - Lecture 08 – Dynamic Routing - RIP

- Dynamic Routing Protocols
- Routing Protocol Operating Fundamentals
- Types of Routing Protocols
- Distance Vector Routing Protocol Operation
- RIP
- Configuring the RIP Protocol
- Configuring the RIPng Protocol
- Parts of an IPv4 Route Entry
- Parts of an IPv6 Route Entry



Summary - Dynamic Routing - OSPF

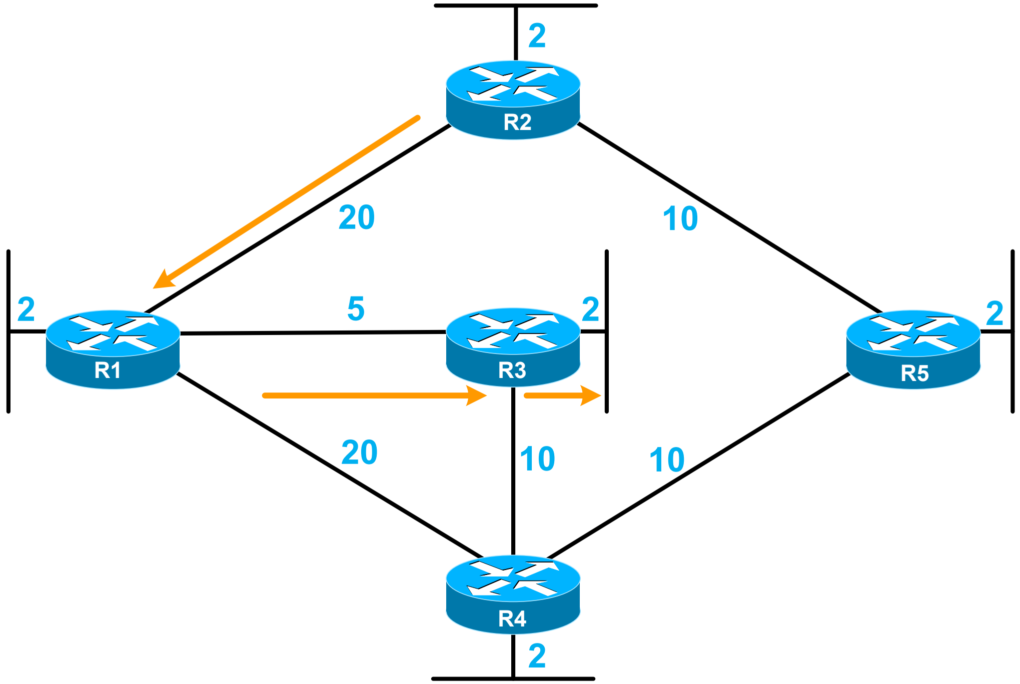
- Link-State Routing Protocol Operation
- Link-State Updates
- Why Use Link-State Routing Protocols
- Open Shortest Path First
- OSPF Messages
- OSPF Operation
- OSPF Router ID
- Configure Single-area OSPFv2
- OSPF Cost
- Verify OSPF
- OSPFv2 vs. OSPFv3
- Configuring OSFPv3
- Lab



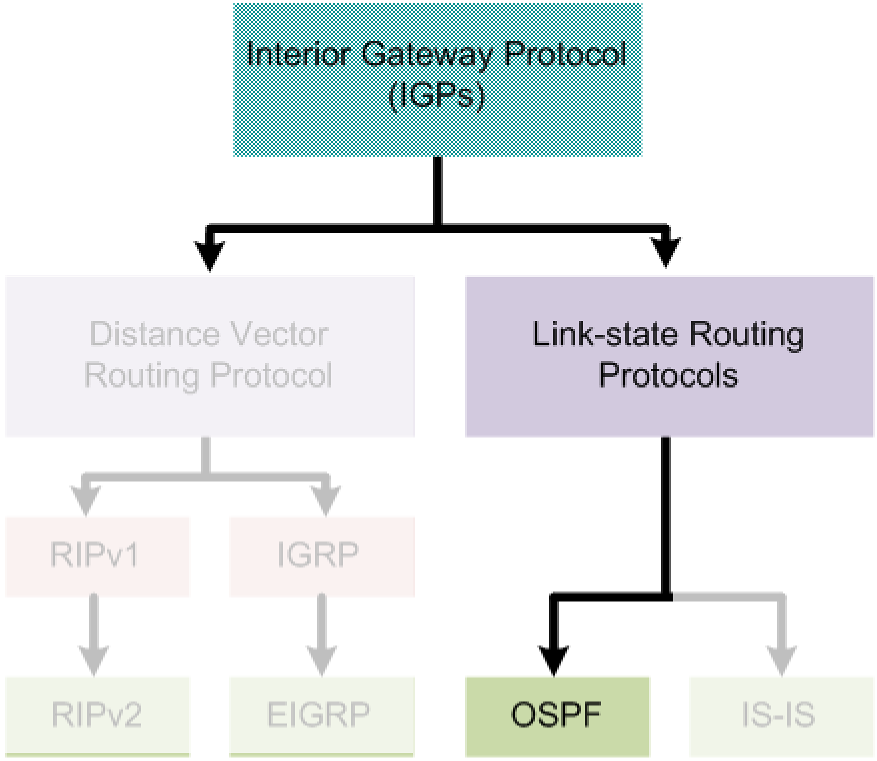
Link-State Routing Protocol Operation

- Open Shortest Path First Protocols
  - Dijkstra's Algorithm

Dijkstra's Shortest Path First Algorithm



R2 to R1 (20) + R1 to R3 (5) + R3 to LAN (2) = 27



Link-State Updates

- Link-State Routing Process

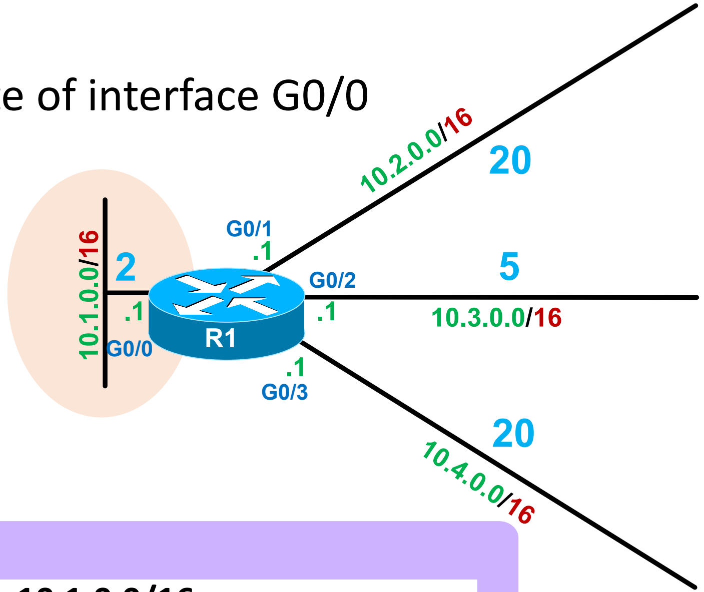
Link-State Routing Process

- Each router learns about each of its own directly connected networks
- Each router is responsible for “Saying Hello” to its neighbors on the 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 the 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 Updates (continued)

- Link and Link-state
  - The first step in the link-state routing process is that each router learns about its own links and its own directly connected networks.

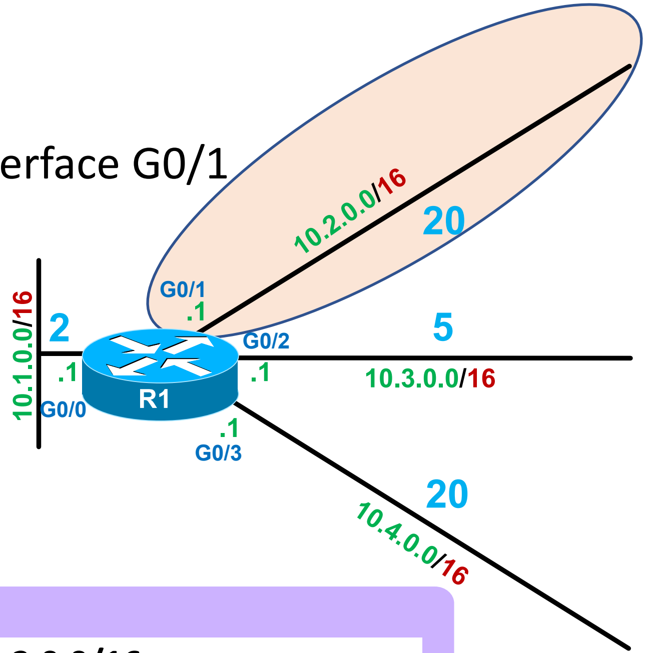
Link-state of interface G0/0



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-state of interface G0/1

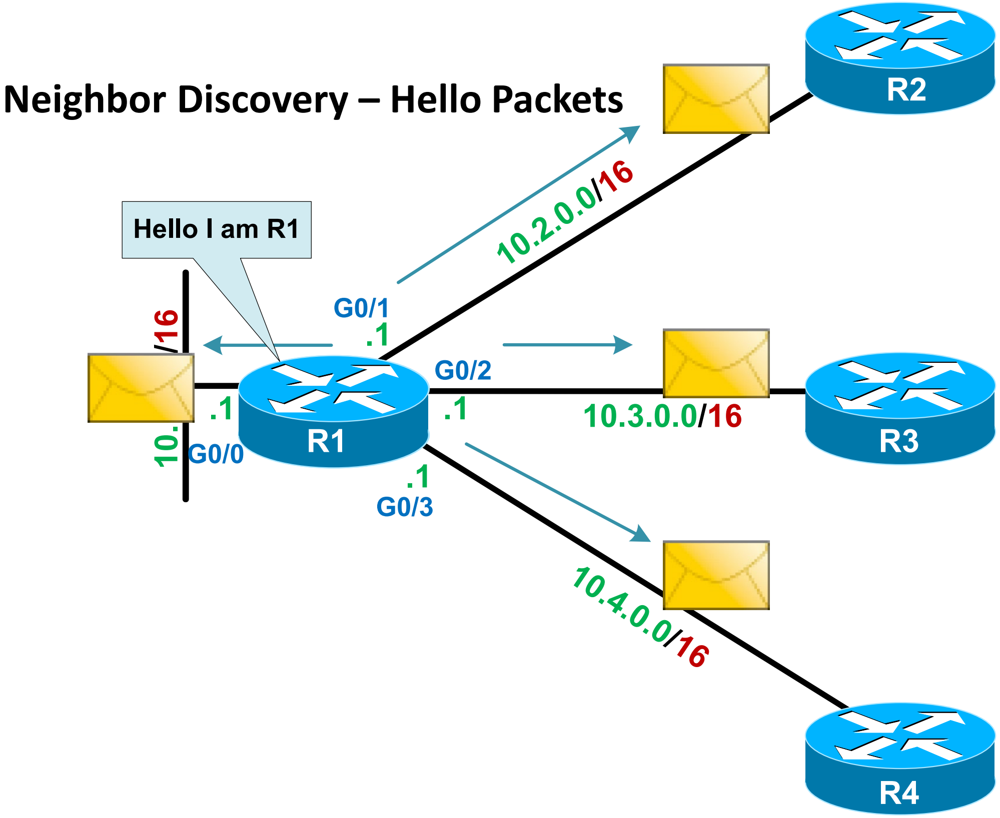


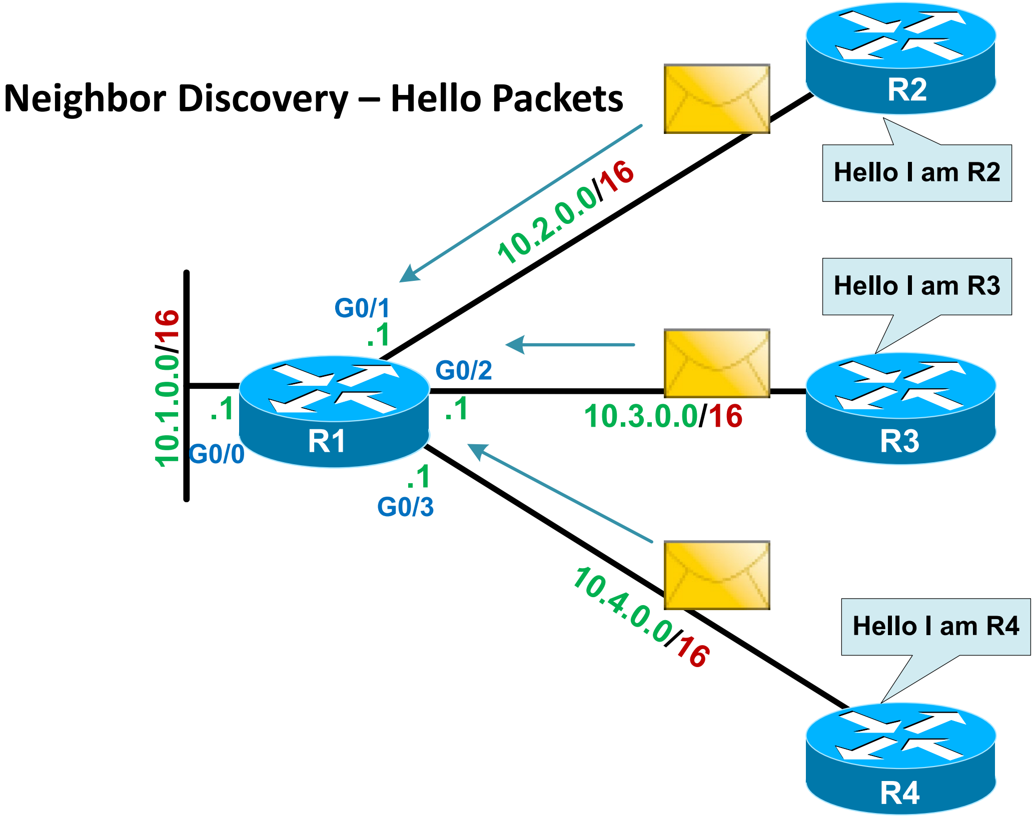
Link 2

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

Link-State Updates (continued)

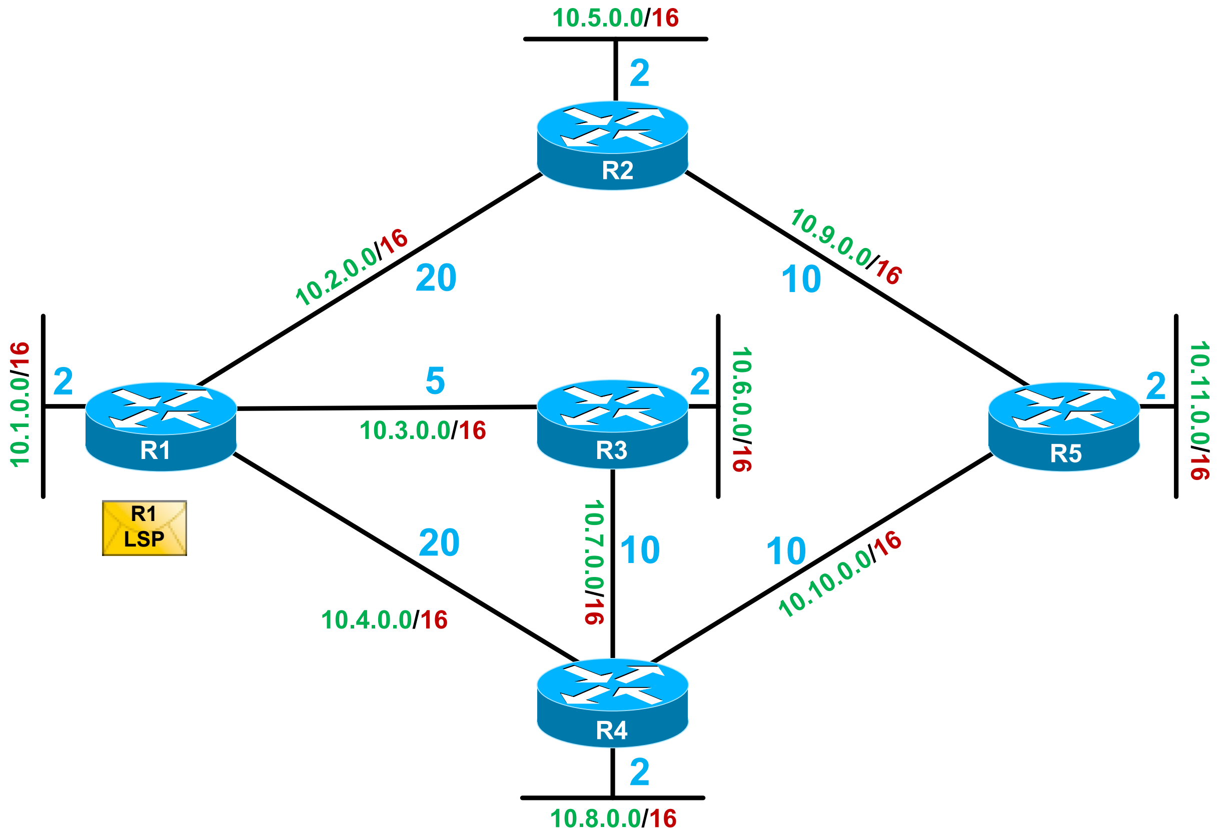
- Say Hello
  - The second step in the link-state routing process is that each router is responsible for meeting its neighbors on directly connected networks.





Link-State Updates (continued)

- Say Hello (continued)
  - The third step in the link-state routing process is that each router builds a link-state packet (LSP) containing the state of each directly connected link.



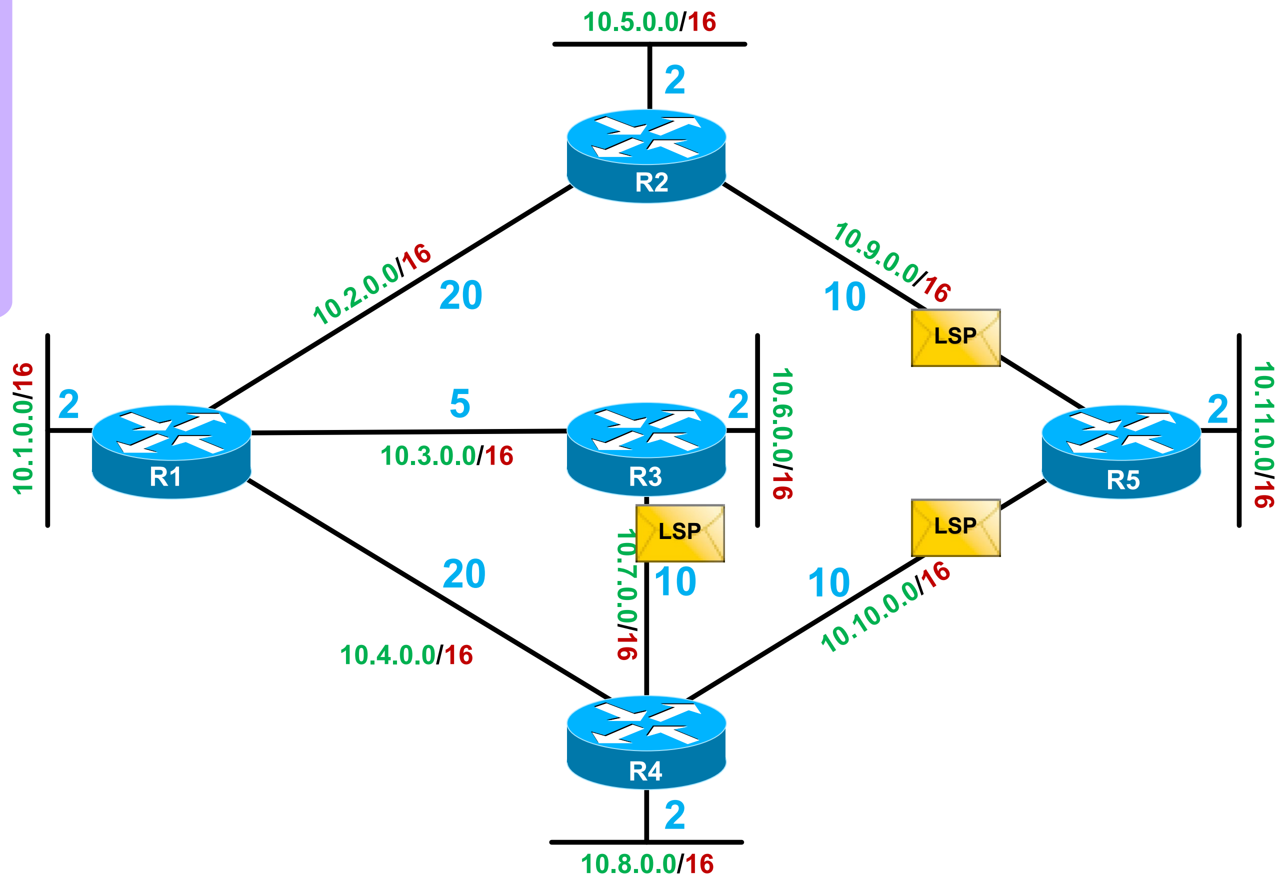
1. R1; Ethernet network 10.1.0.0/16; Cost 2
2. R1 -> R2; Ethernet network; 10.2.0.0/16; Cost 20
3. R1 -> R3; Ethernet network; 10.3.0.0/16; Cost 5
4. R1 -> R4; Ethernet network; 10.4.0.0/16; Cost 20

Link-State Updates (continued)

- Flooding the LSP
  - The fourth step in the link-state routing process is that each router floods the LSP to all neighbors, who then store all LSPs received in a database.

R1 Link-state Contents

- R1: Ethernet network, 10.1.0.0/16, Cost 2
- R1 -> R2: Ethernet network 10.2.0.0/16, Cost 20
- R1 -> R3: Ethernet network 10.3.0.0/16, Cost 5
- R1 -> R4: Ethernet network 10.4.0.0/16, Cost 20



Link-State Updates (continued)

- Building the Link-State Database
  - The final step in the link-state routing process is that each router uses the database to construct a complete map of the topology and computes the best path to each destination network.

R1 Link-state Database

R1 Link-state:
- Connected network, 10.1.0.0/16, Cost 2
- Connected to R2: network 10.2.0.0/16, Cost 20
- Connected to R3: network 10.3.0.0/16, Cost 5
- Connected to R4: network 10.4.0.0/16, Cost 20

R2 Link-state:
- Connected network, 10.5.0.0/16, Cost 2
- Connected to R1: network 10.2.0.0/16, Cost 20
- Connected to R5: network 10.9.0.0/16, Cost 10

R3 Link-state:
- Connected network, 10.6.0.0/16, Cost 2
- Connected to R1: network 10.3.0.0/16, Cost 5
- Connected to R4: network 10.7.0.0/16, Cost 10

R4 Link-state:
- Connected network, 10.8.0.0/16, Cost 2
- Connected to R1: network 10.4.0.0/16, Cost 20
- Connected to R3: network 10.7.0.0/16, Cost 10
- Connected to R5: network 10.10.0.0/16, Cost 10

R5 Link-state:
- Connected network, 10.11.0.0/16, Cost 2
- Connected to R2: network 10.9.0.0/16, Cost 10
- Connected to R4: network 10.10.0.0/16, Cost 10

Link-State Updates (continued)

- Building the SPF Tree

Identify the Directly Connected Networks

R1 Link-state Database

R1 Link-state:
- Connected network, 10.1.0.0/16, Cost 2
- Connected to R2: network 10.2.0.0/16, Cost 20
- Connected to R3: network 10.3.0.0/16, Cost 5
- Connected to R4: network 10.4.0.0/16, Cost 20

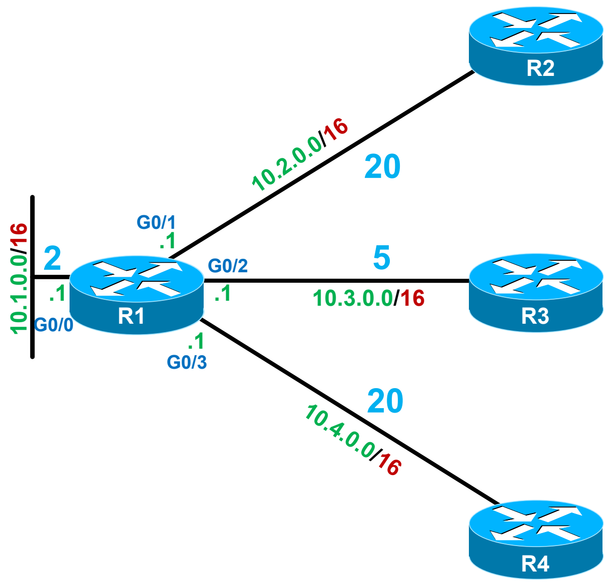
R2 Link-state:
- Connected network, 10.5.0.0/16, Cost 2
- Connected to R1: network 10.2.0.0/16, Cost 20
- Connected to R5: network 10.9.0.0/16, Cost 10

R3 Link-state:
- Connected network, 10.6.0.0/16, Cost 2
- Connected to R1: network 10.3.0.0/16, Cost 5
- Connected to R4: network 10.7.0.0/16, Cost 10

R4 Link-state:
- Connected network, 10.8.0.0/16, Cost 2
- Connected to R1: network 10.4.0.0/16, Cost 20
- Connected to R3: network 10.7.0.0/16, Cost 10
- Connected to R5: network 10.10.0.0/16, Cost 10

R5 Link-state:
- Connected network, 10.11.0.0/16, Cost 2
- Connected to R2: network 10.9.0.0/16, Cost 10
- Connected to R4: network 10.10.0.0/16, Cost 10

SPF Tree

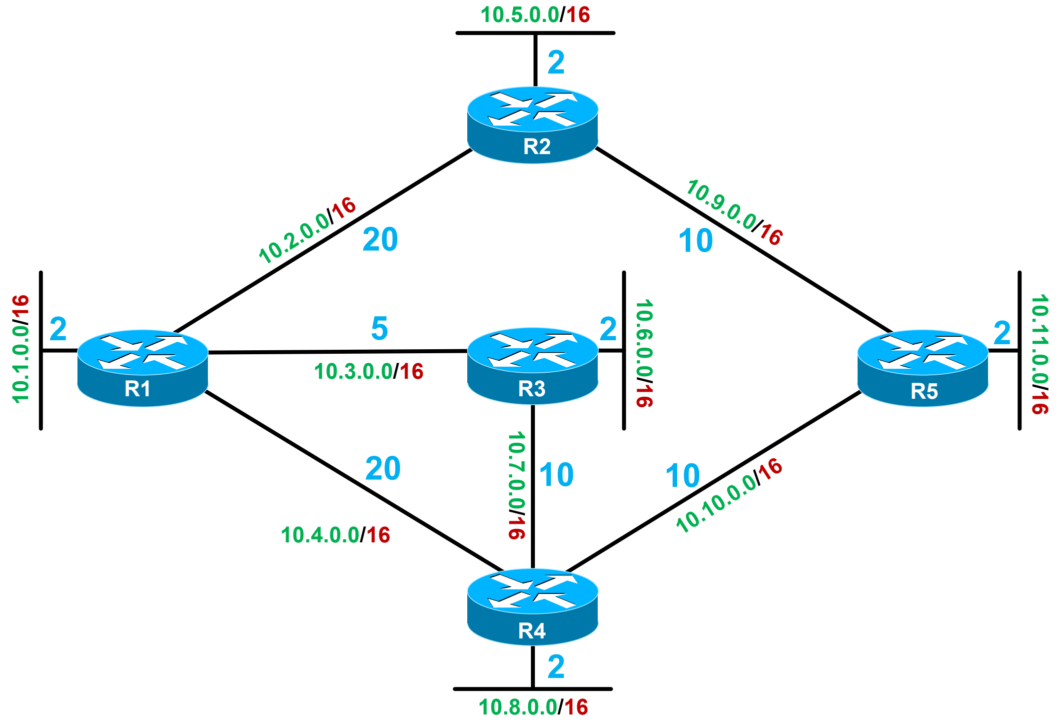


Link-State Updates (continued)

- Building the SPF Tree (continued)

Resulting SPF Tree or R1

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-State Updates (continued)

- Adding OSPF Routes to the Routing Table

Populating 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

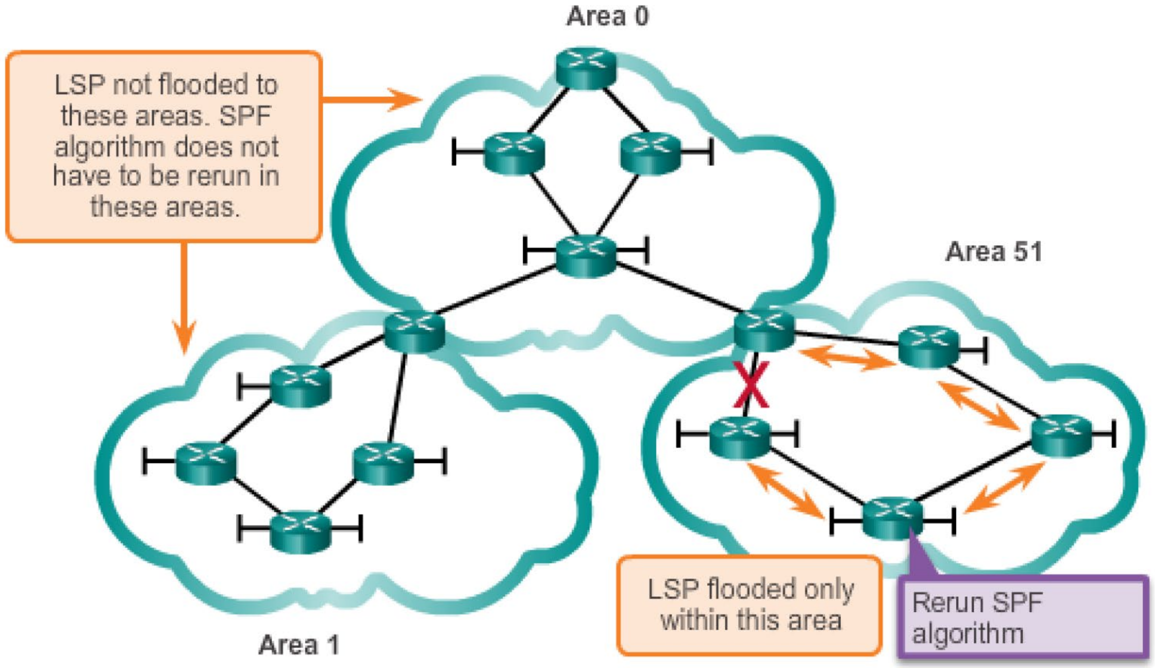
R1 Routing Table

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, ethernet G0/1, Cost=22
10.6.0.0/16, via R3, ethernet G0/1, Cost=22
10.7.0.0/16, via R3, ethernet G0/1, Cost=22
10.8.0.0/16, via R3, ethernet G0/1, Cost=22
10.9.0.0/16, via R2, ethernet G0/1, Cost=22
10.10.0.0/16, via R3, ethernet G0/1, Cost=22
10.11.0.0/16, via R3, ethernet G0/1, Cost=22

Why Use Link-State Routing Protocols

- Why Use Link-State Protocols?



- There are only two link-state routing protocols:
  - Open Shortest Path First (OSPF) most popular
    - began in 1987
    - two current versions
    - OSPFv2 -OSPF for IPv4 networks
    - OSPFv3 -OSPF for IPv6 networks
  - IS-IS was designed by International Organization for Standardization (ISO)

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

Open Shortest Path First

- Features of OSPF

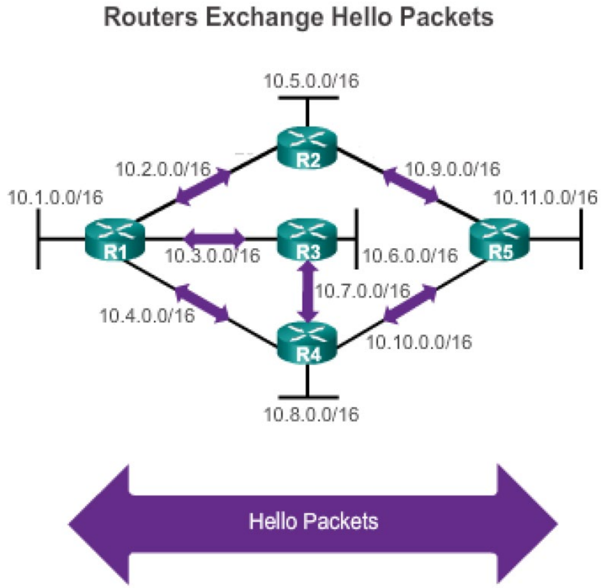
Open Shortest Path First (continued)

- Components of OSPF
  - OSPF Routers Exchange Packets -These packets are used to discover neighboring routers and also to exchange routing information to maintain accurate information about the network.

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.

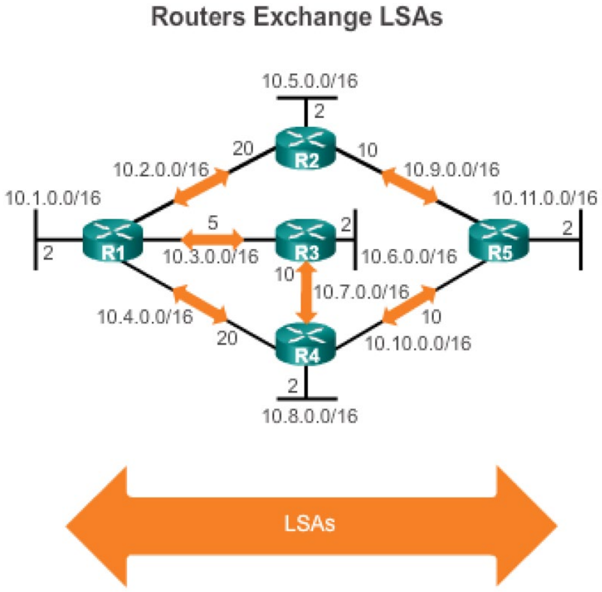
Open Shortest Path First (continued)

- Link-State Operation



- If a neighbor is present, the OSPF-enabled router attempts to establish a neighbor adjacency with that neighbor

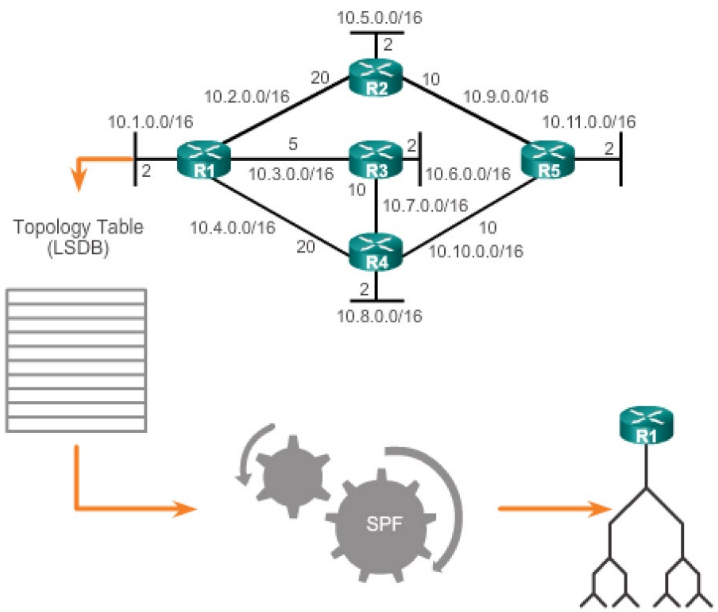
- Link-State Advertisements (LSAs) contain the state and cost of each directly connected link.
- Routers flood their LSAs to adjacent neighbors.
- Adjacent neighbors receiving the LSA immediately flood the LSA to other directly connected neighbors, until all routers in the area have all LSAs.



Open Shortest Path First (continued)

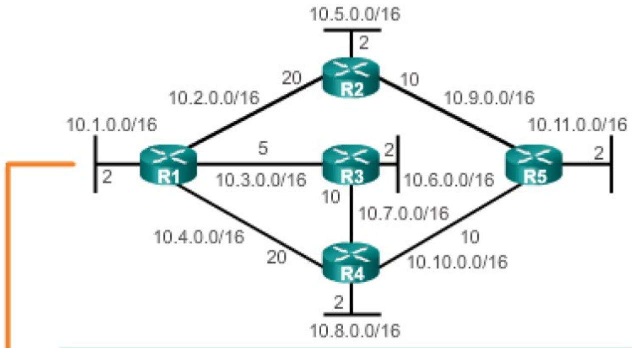
- ## Link-State Operation (continued)

R1 Creates the SPF Tree



- Build the topology table based on the received LSAs.
- This database eventually holds all the information about the topology of the network.
- Execute the SPF Algorithm.

Content of the R1 SPF Tree

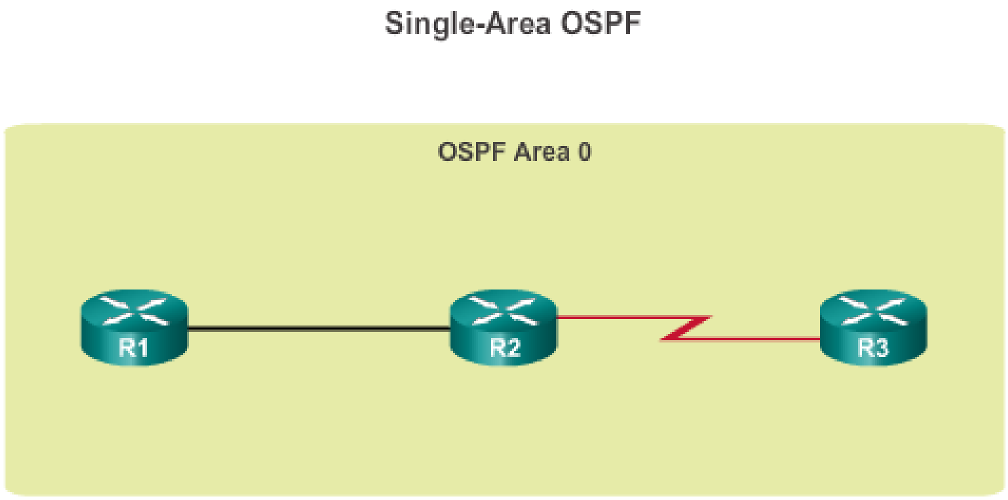


Destination	Shortest Path	Cost
10.5.0.0/16	R1 → R2	22
10.6.0.0/16	R1 → R3	7
10.7.0.0/16	R1 → R3	15
10.8.0.0/16	R1 → R3 → R4	17
10.9.0.0/16	R1 → R2	30
10.10.0.0/16	R1 → R3 → R4	25
10.11.0.0/16	R1 → R3 → R4 → R5	27

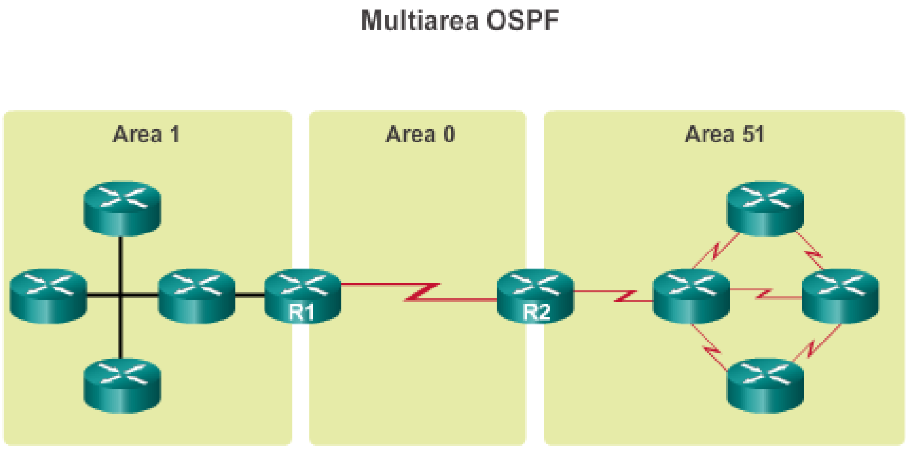
- From the SPF tree, the best paths are inserted into the routing table.

Open Shortest Path First (continued)

- Single-area and Multiarea OSPF



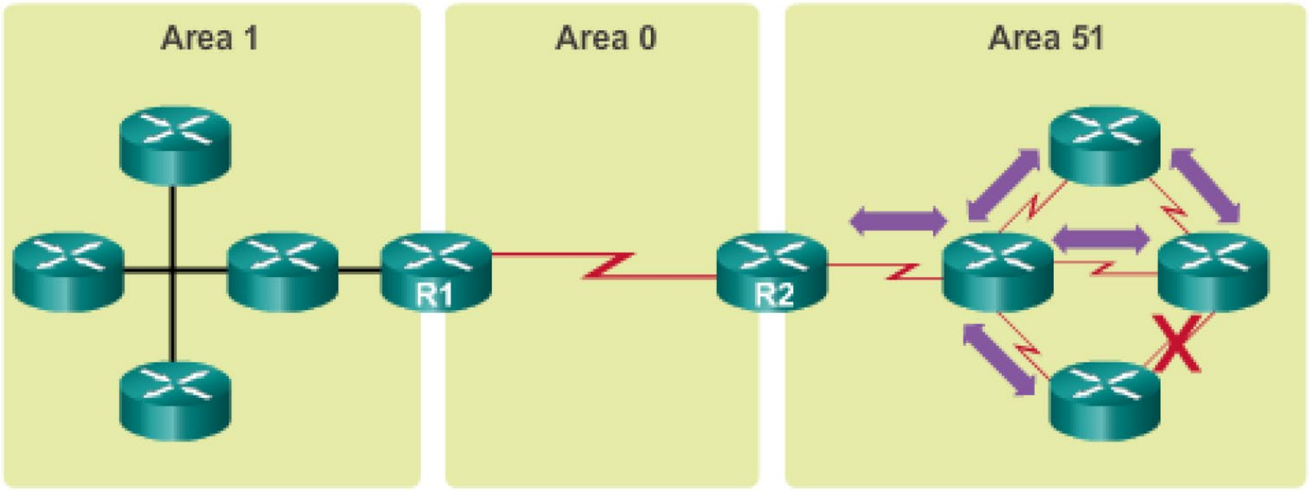
- Area 0 is also called the backbone area.
- Single-area OSPF is useful in smaller networks with few routers.



- Implemented using a two-layer area hierarchy as all areas must connect to the backbone area (area 0).
- Interconnecting routers are called Area Border Routers (ABR).
- Useful in larger network deployments to reduce processing and memory overhead.

Open Shortest Path First (continued)

- Single-area and Multiarea OSPF (continued)
  - Link failure affects the local area only (area 51).
  - The **A**rea **B**order **R**outer (**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

- Types of OSPF Packets & 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 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

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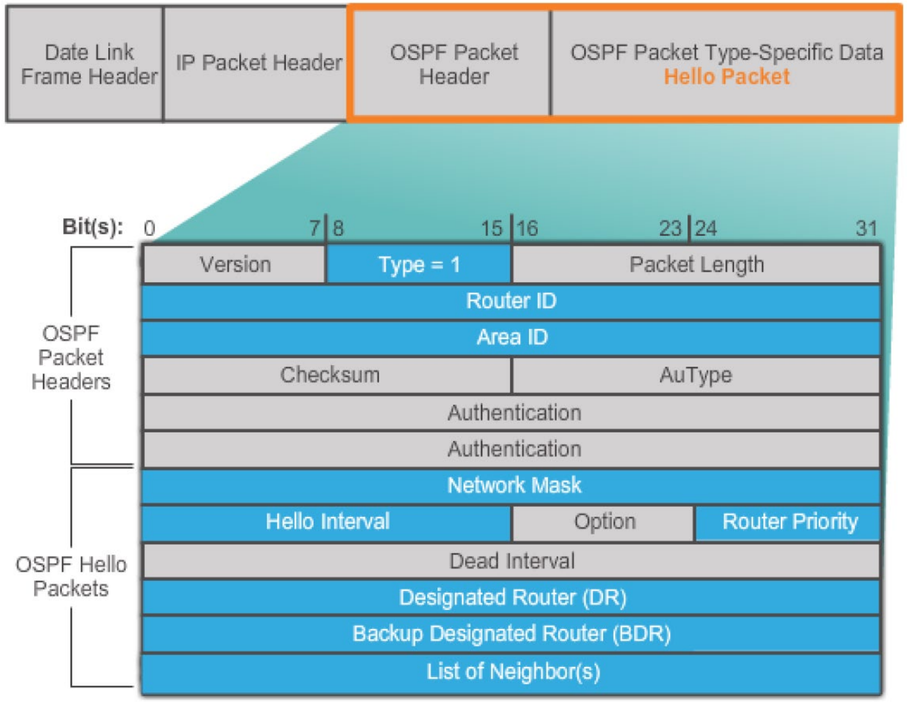
OSPF Messages (continued)

- Hello Packet
  - OSPF Type 1 packet = Hello packet:
    - Discover OSPF neighbors and establish neighbor adjacencies.
    - Advertise parameters on which two routers must agree to become neighbors.
    - Elect the Designated Router (DR) and Backup Designated Router (BDR) on multiaccess networks like Ethernet and Frame Relay.

OSPF Hello Packet Content



OSPF Messages (continued)

- Hello Packet Intervals
  - 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. Example: Frame Relay)
    - 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 the down neighbor out all OSPF enabled interfaces
    - Cisco's default is 4 times the Hello interval

OSPF Messages (continued)

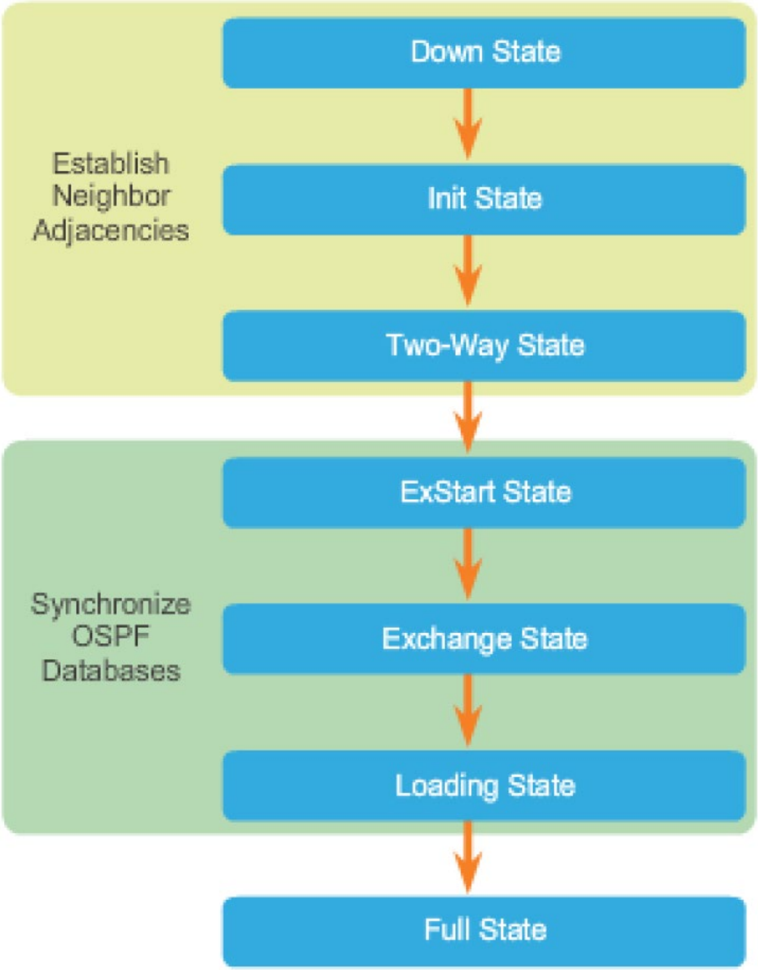
- Link-State Updates
  - A LSU contains one or more LSAs.
  - LSAs contain route information for destination networks.

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

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

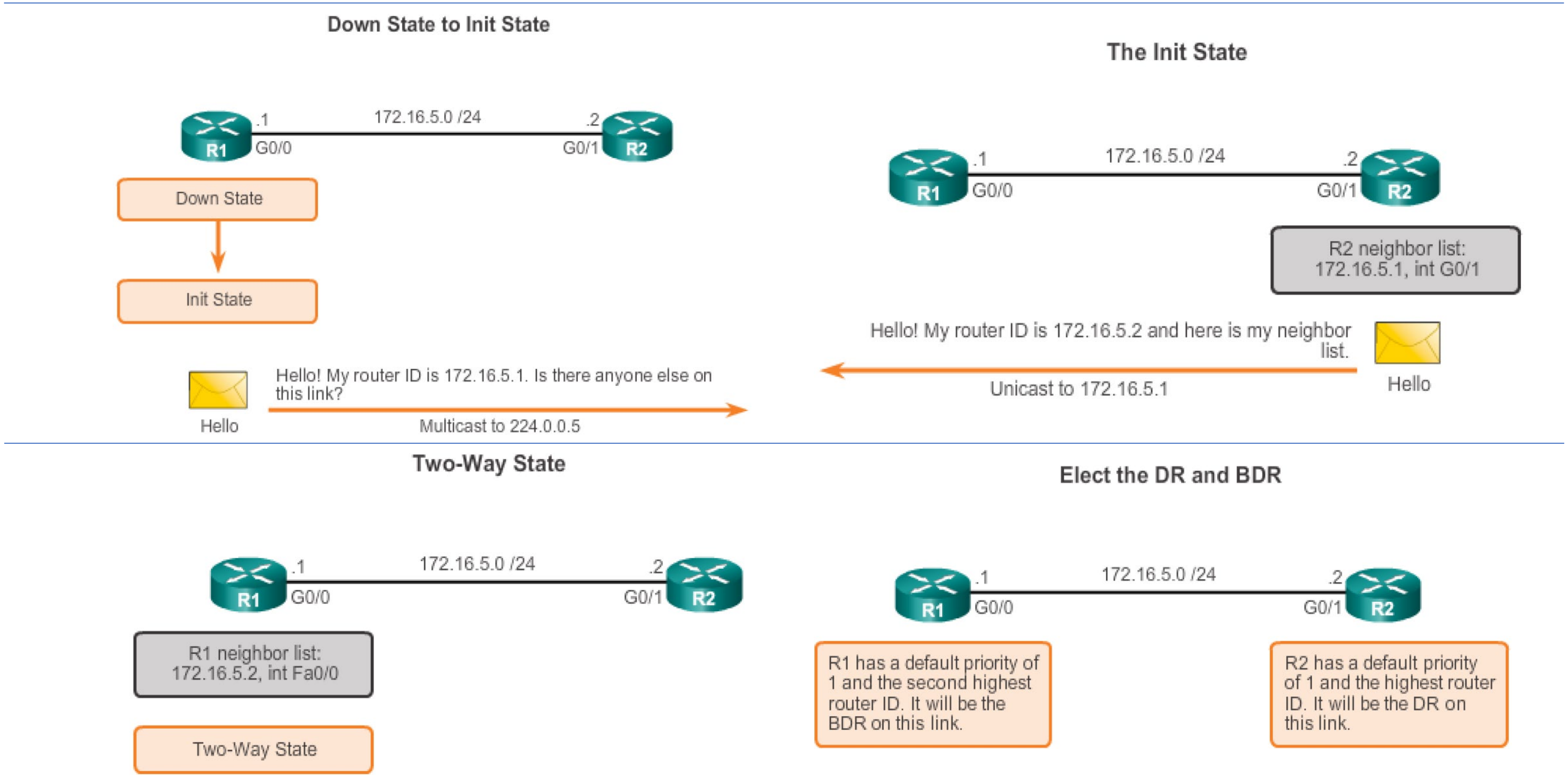
OSPF Operation

- OSPF Operational States
  - 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 (continued)

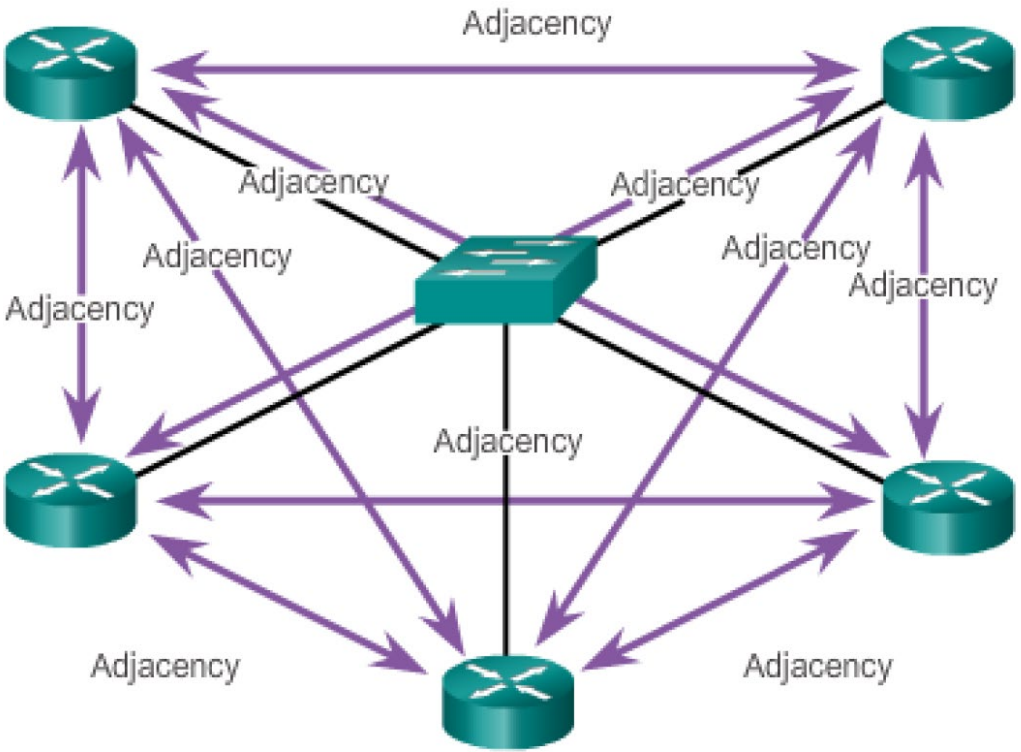
- Establish Neighbor Adjacencies



OSPF Operation (continued)

- OSPF DR and BDR
  - On transit networks a DR is used to limit the amount of LSA update information flooded on the network
  - The router with the highest priority is elected DR
  - If all priorities are equal the router with the highest router ID is elected the DR
  - If a router is given priority 0 it will not participate in the DR election process
- Adjacency Rules
  - The rules for the adjacency depends on the network type
  - On point-to-point network:
    - Router becomes adjacent with the router at other end of the link - no designated router

Creating Adjacencies With Every Neighbor



Number of Adjacencies = N(N-1)/2

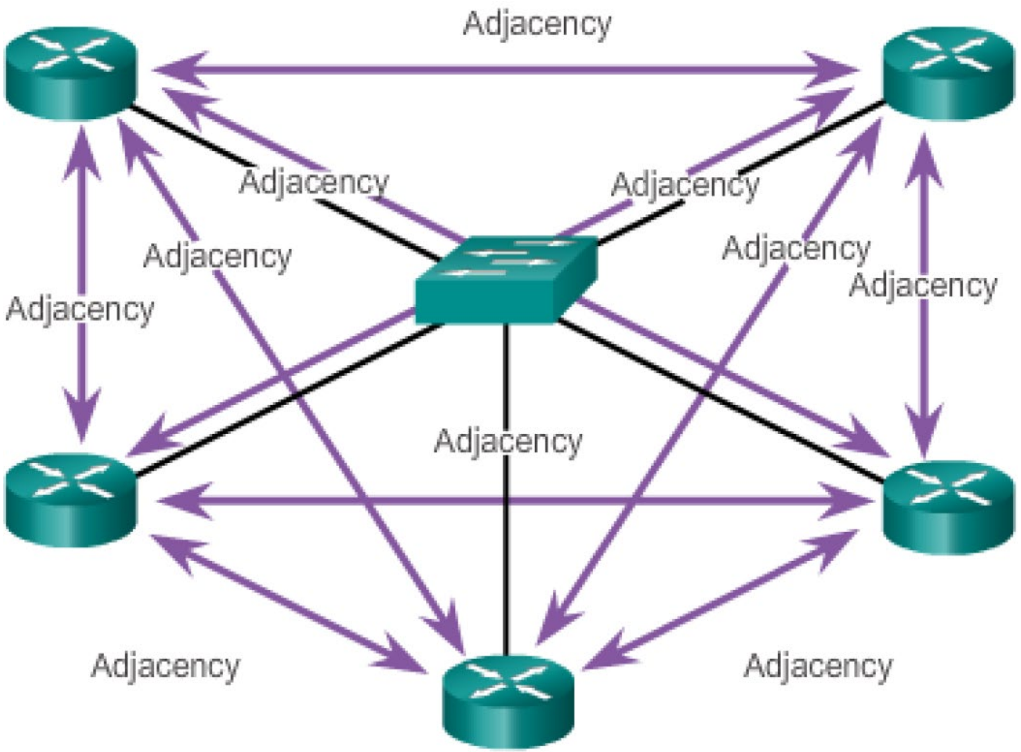
Example with 5 routers:

5(5-1)/2 =10

OSPF Operation (continued)

- Adjacency Rules (continued)
  - On multi-access networks:
    - If no DR is present, router becomes the DR
    - If no BDR is present, router becomes the BDR and forms an adjacency with the DR
    - If DR and BDR exist, routers become adjacent to both
  - All routers form a full adjacency with the DR and the BDR
  - All other routers stay in a 2 way adjacency state
    - Cisco calls these **DRothers**
  - There is a DR elected for all networks that have interfaces configured to be broadcast networks
  - If a DR has been elected and a router with a higher priority is connected to the broadcast network no election will take place

Creating Adjacencies With Every Neighbor

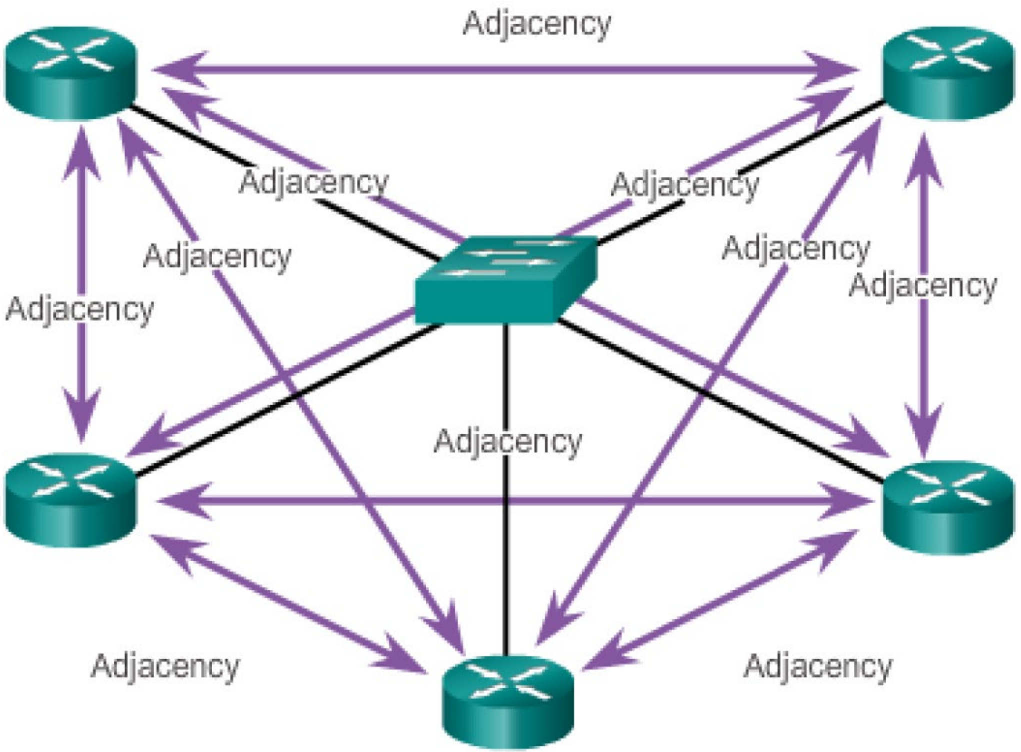


Number of Adjacencies = N(N-1)/2
Example with 5 routers:
5(5-1)/2 =10

OSPF Operation (continued)

- Designated Router
  - DR/BDR Election
  - Occurs as soon as 1st router has its interface enabled on a multi-access network
    - When a DR is elected it remains as the DR until one of the following occurs
    - The DR fails
    - The OSPF process on the DR fails
    - The multiaccess interface on the DR fails
    - An election is forced by the administrator
      - By changing setting and forcing an election you can change the DR and BDR of your network

Creating Adjacencies With Every Neighbor



Number of Adjacencies = N(N-1)/2
Example with 5 routers:
5(5-1)/2 =10

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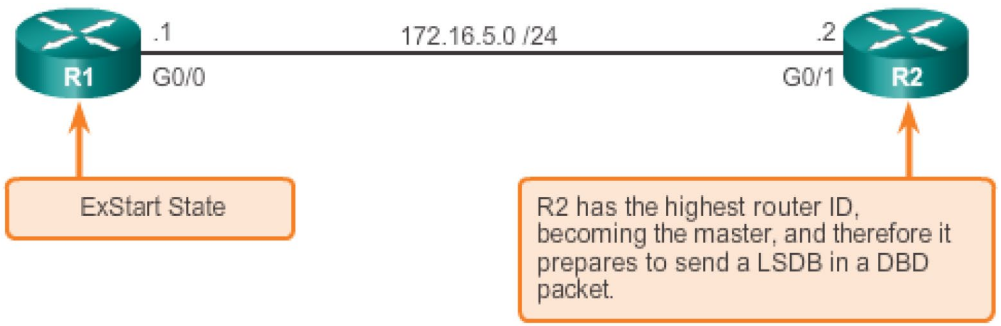
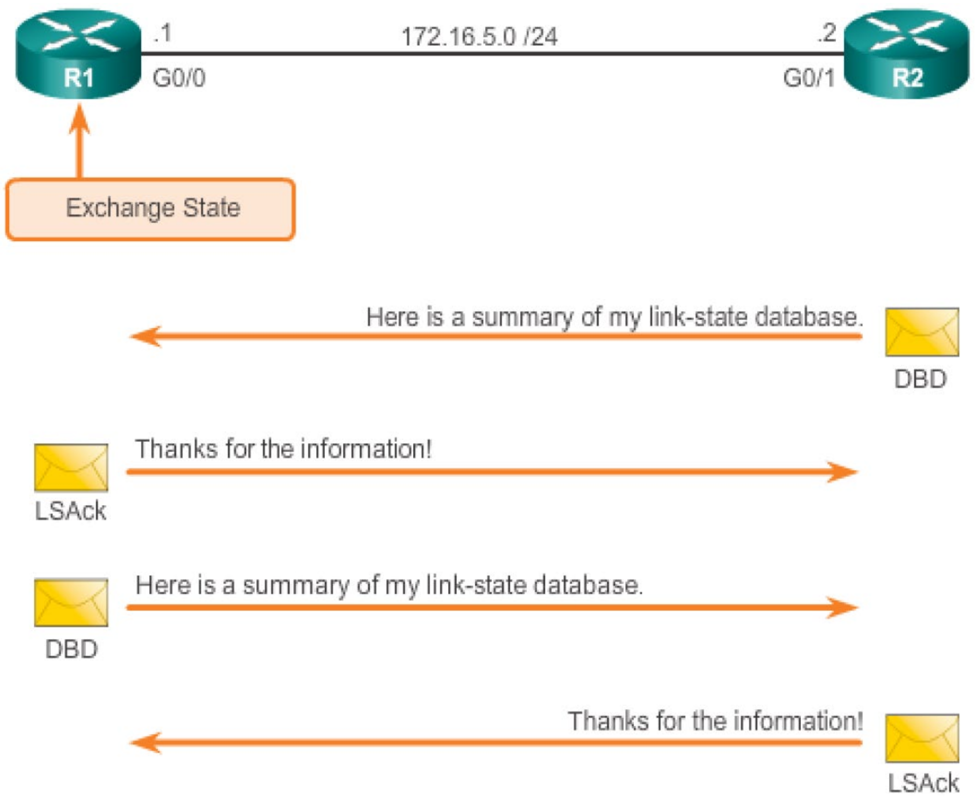
OSPF Operation (continued)

- Synchronizing OSPF Database

Decide Which Router Sends the First BDB



Exchange DBD Packets



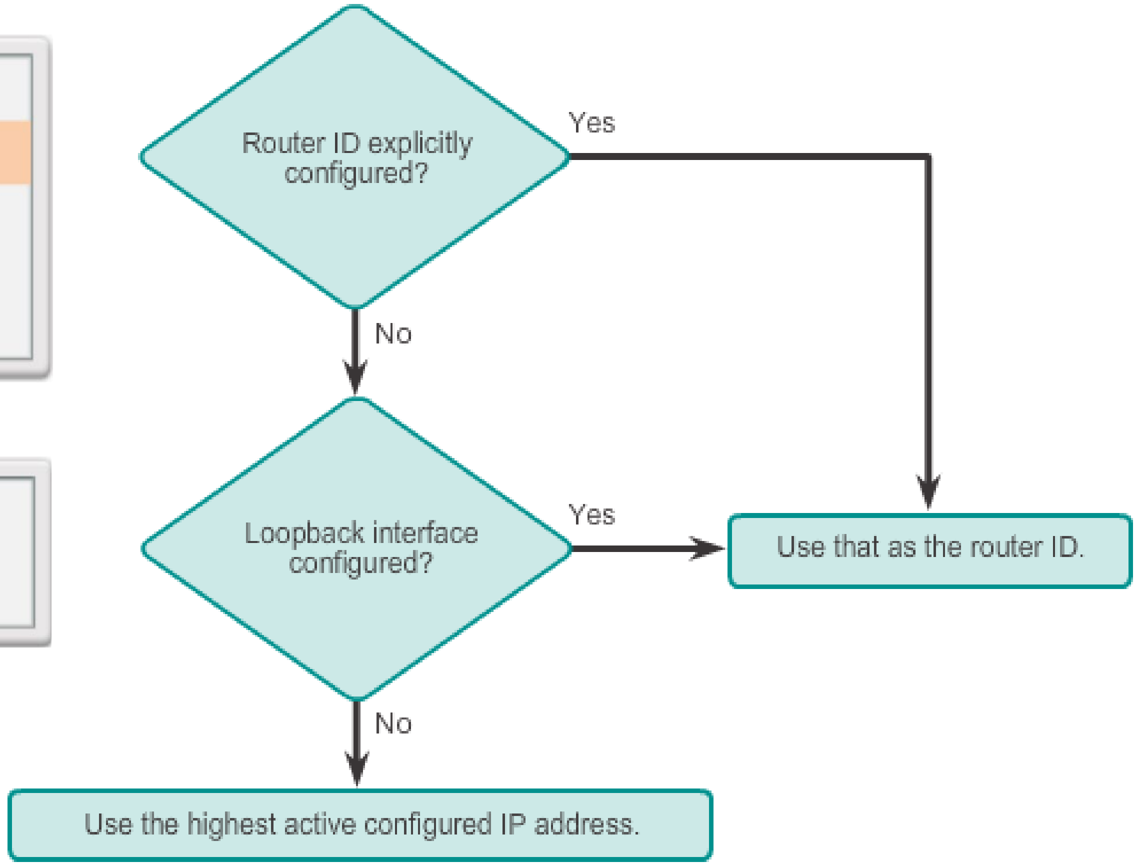
OSPF Router ID

- Router IDs
  - 32bit address (dotted decimal notation) example 1.1.1.1
  - Looks like an IPv4 address but is not

```
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#
```

Router ID Order of Precedence



Configure Single-area OSPFv2

- The network Command
  - Enter into the router config… **router ospf <AS number>**
    - What is an **AS number**?
      An **A**utonomous **S**ystem (**AS**) is a group of networks under a single administrative control which could be an Internet Service Provider (ISP) or a large Enterprise Organization. An Interior Gateway Protocol (IGP) refers to a routing protocol that handles routing within a single autonomous system.
  - Enter the network command, one line per network to be advertised.

```
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#
```

  - R1(config-router)# network **172.16.1.0** **0.0.0.255** area 0
    Network ID **Reverse Mask**
  - A reveres mask is the exact opposite of a regular mask and can be found easily by subtracting the mask from 255.255.255.255

	255 . 255 . 255 . 255	
-	255 . 255 . 255 . 0	/ 24
	0 . 0 . 0 . 255	
	255 . 255 . 255 . 255	
-	255 . 255 . 255 . 252	/ 30
	0 . 0 . 0 . 3	
	255 . 255 . 255 . 255	
-	255 . 255 . 255 . 192	/ 26
	0 . 0 . 0 . 63	

Configure Single-area OSPFv2 (continued)

- Passive Interface
  - By default, OSPF messages are forwarded out all OSPF-enabled interfaces. However, these messages really only need to be sent out interfaces connecting to other OSPF-enabled routers.
  - Sending out unneeded messages on a LAN affects the network in three ways:
    - Inefficient Use of Bandwidth
    - Inefficient Use of Resources
    - Increased Security Risk
  - The Passive Interface feature helps limiting the scope of routing updates advertisements.
- Configuring Passive Interfaces
  - Use the passive-interface router configuration mode command to prevent the transmission of routing messages through a router interface, but still allow that network to be advertised to other routers.

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

OSPF Cost

- OSPF Metric = Cost

Cost=*reference bandwidth*/*interface bandwidth*
(default reference bandwidth is 10^8)
Cost =100,000,000 bps/*interface bandwidth in bps*

Interface Type	Reference Bandwidth in bps		Default Bandwidth in bps	Cost
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

Same Cost due to Reference Bandwidth

- OSPF Accumulates Costs
  - Cost of an OSPF route is the accumulated value from one router to the destination network.

```
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#
```

Verify OSPF

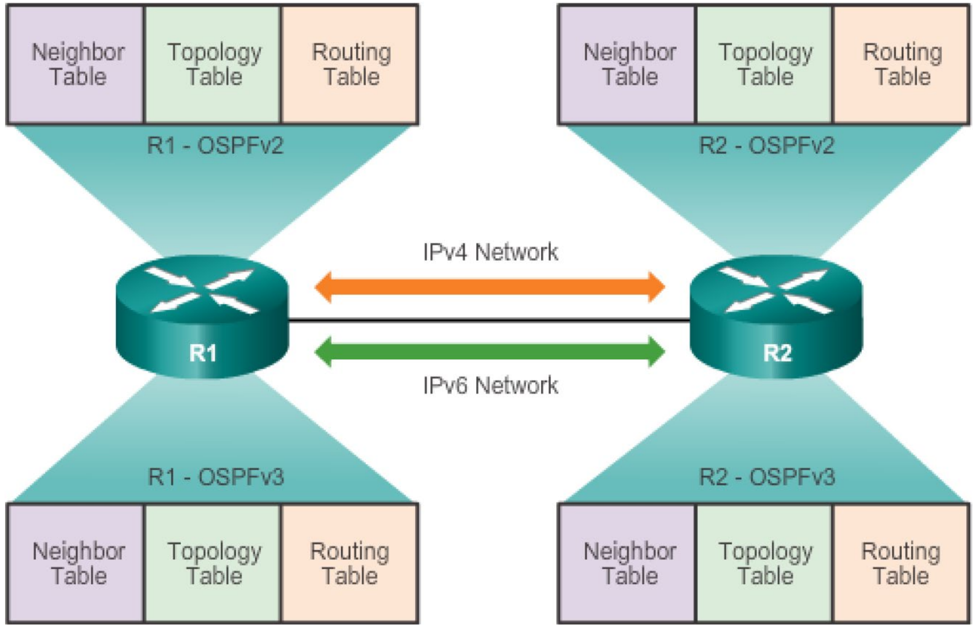
- Verify OSPF Process Information

```
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)
```

- Verify OSPF Interface Settings

```
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#
```

OSPFv2 vs. OSPFv3



Differences Between OSPFv2 to OSPFv3

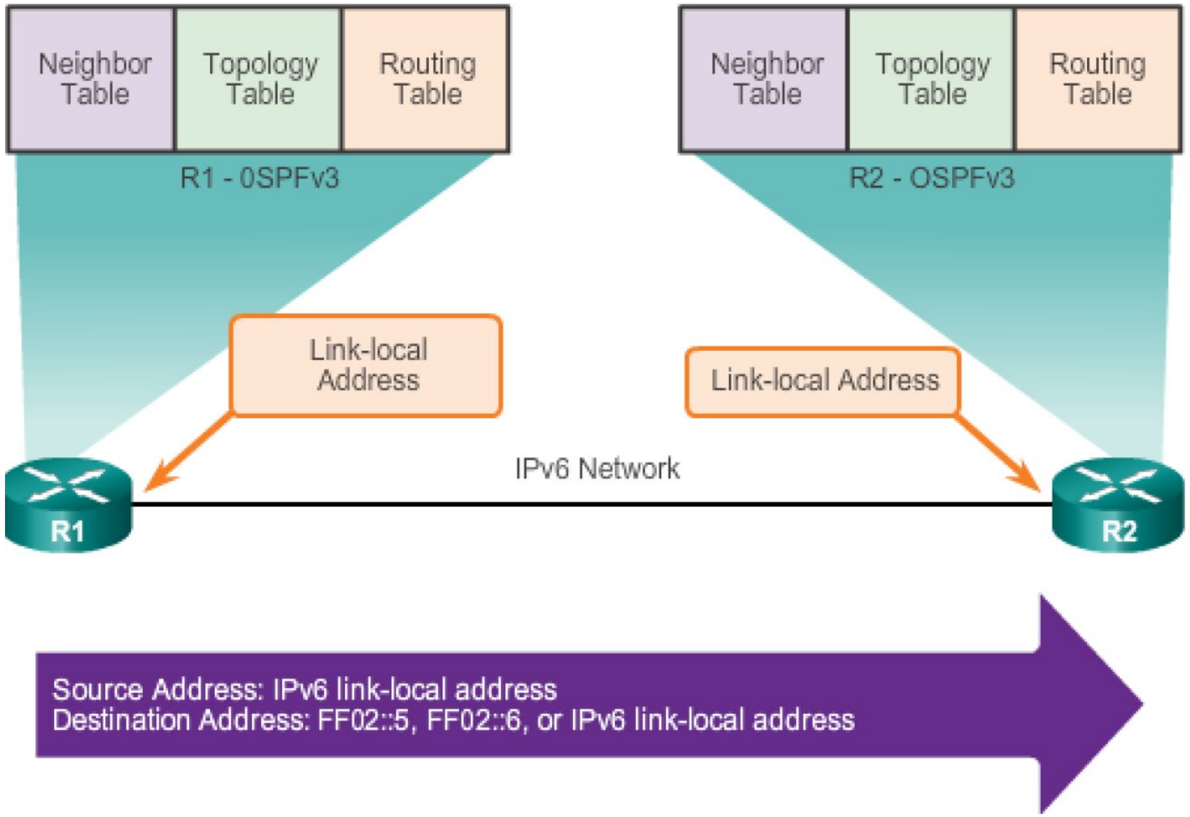
	OSPFv2	OSPFv3
Advertises	IPv4 networks	IPv6 prefixes
Source Address	IPv4 source address	IPv6 link-local address
Destination Address	Choice of: • Neighbor IPv4 unicast address • 224.0.0.5 all-OSPF-routers multicast address • 224.0.0.6 DR/BDR multicast address	Choice of: • Neighbor IPv6 link-local address • FF02::5 all-OSPFv3-routers multicast address • FF02::6 DR/BDR multicast address
Advertise Networks	Configured using the **`network`** router configuration command	Configured using the **`ipv6 ospf process-id area-id`** interface configuration command
IP Unicast Routing	IPv4 unicast routing is enabled by default.	IPv6 unicast forwarding is not enabled by default. The **`ipv6 unicast-routing`** global configuration command must be configured.
Authentication	Plain text and MD5	IPv6 authentication

Similarities Between OSPFv2 to OSPFv3

OSPFv2 and OSPFv3	
Link-State	Yes
Routing Algorithm	SPF
Metric	Cost
Areas	Supports the same two-level hierarchy
Packet Types	Same Hello, DBD, LSR, LSU and LSAck packets
Neighbor Discovery	Transitions through the same states using Hello packets
DR and BDR	Function and election process is the same
Router ID	32-bit router ID: determined by the same process in both protocols

OSPFv2 vs. OSPFv3 (continued)

- Link-Local Addresses



Configuring OSPFv3

- OSPFv3 Network Topology

- Steps to configure OSPFv3
  1. Enable IPv6 unicast routing (**ipv6 unicast-routing**).
  2. (Optional) Configure link-local address (**ipv6 address fe80::1 link-local**)
  3. Configure a 32-bit router ID in OSPFv3 router configuration mode using the **router-id** command
  4. (Optional) configure routing specifics such as adjusting the reference bandwidth
  5. (Optional) configure OSPFv3 interface specific settings. For example, adjust the interface bandwidth.
  6. Enable IPv6 routing by using the **ipv6 ospf xx area xx** command in the interface

```
R1(config)#ipv6 unicast-routing
R1(config)#
R1(config)#ipv6 router ospf 10
R1(config-rtr)#router-id 1.1.1.1
R1(config-rtr)#exit
R1(config)#
R1(config)#interface Gig 0/0
R1(config-if)#description R1 to R2
R1(config-if)#ipv6 address 2001:db8:cafe:A001::1/64
R1(config-if)#ipv6 address fe80::1 link-local
R1(config-if)#ipv6 ospf 10 area 10
R1(config-if)#no shut
R1(config-if)#exit
R1(config)#
R1(config)#interface ser 0/0/1
R1(config-if)#description R1 to R3
R1(config-if)#ipv6 address 2001:db8:cafe:A002::1/64
R1(config-if)#clock rate 128000
R1(config-if)#ipv6 address fe80::1 link-local
R1(config-if)#ipv6 ospf 10 area 10
R1(config-if)#no shut
R1(config-if)#exit
R1(config)#
R1(config)#interface Gig 0/1
R1(config-if)#description R1 to R4
R1(config-if)#ipv6 address 2001:db8:cafe:A003::1/64
R1(config-if)#ipv6 address fe80::1 link-local
R1(config-if)#ipv6 ospf 10 area 10
R1(config-if)#ipv6 ospf cost 1800
R1(config-if)#no shut
R1(config-if)#exit
R1(config)#
```

Configuring OSFPv3 (continued)

- Link-Local Addresses
  - These were automatically generated
    - Manually assigned can be much shorter (ipv6 address **fe80::1** link-local)

```
R1# show ipv6 interface brief
Em0/0                      [administratively down/down]
    unassigned
GigabitEthernet0/0         [up/up]
    FE80::32F7:DFF:FEA3:DA0
    2001:DB8:CAFE:1::1
GigabitEthernet0/1         [administratively down/down]
    unassigned
Serial0/0/0                [up/up]
    FE80::32F7:DFF:FEA3:DA0
    2001:DB8:CAFE:A001::1
Serial0/0/1                [up/up]
    FE80::32F7:DFF:FEA3:DA0
    2001:DB8:CAFE:A003::1
R1#
```

- Link-local addresses are automatically created when an IPv6 global unicast address is assigned to the interface (required).
  - Global unicast addresses are not required.
  - Cisco routers create the link-local address using FE80::/10 prefix and the EUI-64 process unless the router is configured manually,
  - EUI-64 involves using the 48-bit Ethernet MAC address, inserting FFFE in the middle and flipping the seventh bit. For serial interfaces, Cisco uses the MAC address of an Ethernet interface.
  - Notice in the figure that all three interfaces are using the **same link-local address**.

Configuring OSFPv3 (continued)

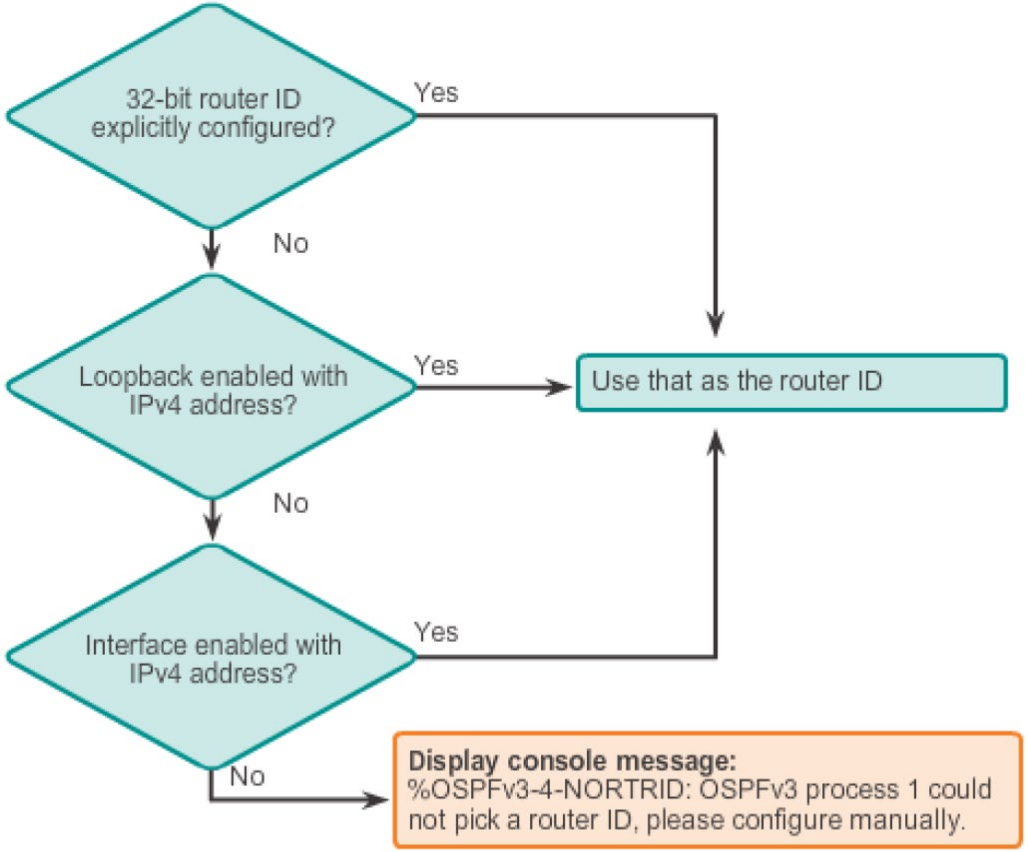
- Assigning Link-Local Addresses
  - Manually configuring the link-local address provides the ability to create an address that is recognizable and easier to remember.

```
R1(config)# interface GigabitEthernet 0/0
R1(config-if)# ipv6 address fe80::1 link-local
R1(config-if)# exit
R1(config)# interface Serial0/0/0
R1(config-if)# ipv6 address fe80::1 link-
R1(config-if)# exit
R1(config)# interface Serial0/0/1
R1(config-if)# ipv6 address fe80::1 link-
R1(config-if)#
```

```
R1# show ipv6 interface brief
Em0/0                  [administratively down/down]
    unassigned
GigabitEthernet0/0     [up/up]
    FE80::1
    2001:DB8:CAFE:1::1
GigabitEthernet0/1     [administratively down/down]
    unassigned
Serial0/0/0            [up/up]
    FE80::1
    2001:DB8:CAFE:A001::1
Serial0/0/1            [up/up]
    FE80::1
    2001:DB8:CAFE:A003::1
R1#
```

Configuring OSFPv3 (continued)

- Configuring the OSPFv3 Router ID
  - Must have one of the following 32 bit IDs
    - Routed ID
    - IPv4 Loopback address
    - IPv4 interface address
  - If none of the above are available on an IPv6 router…. Routing will not work!
  - If you have OSPF working and you what to change the **router-id** you will need to run the command **clear ipv6 ospf process** after changing the router-id.



Configuring OSFPv3 (continued)

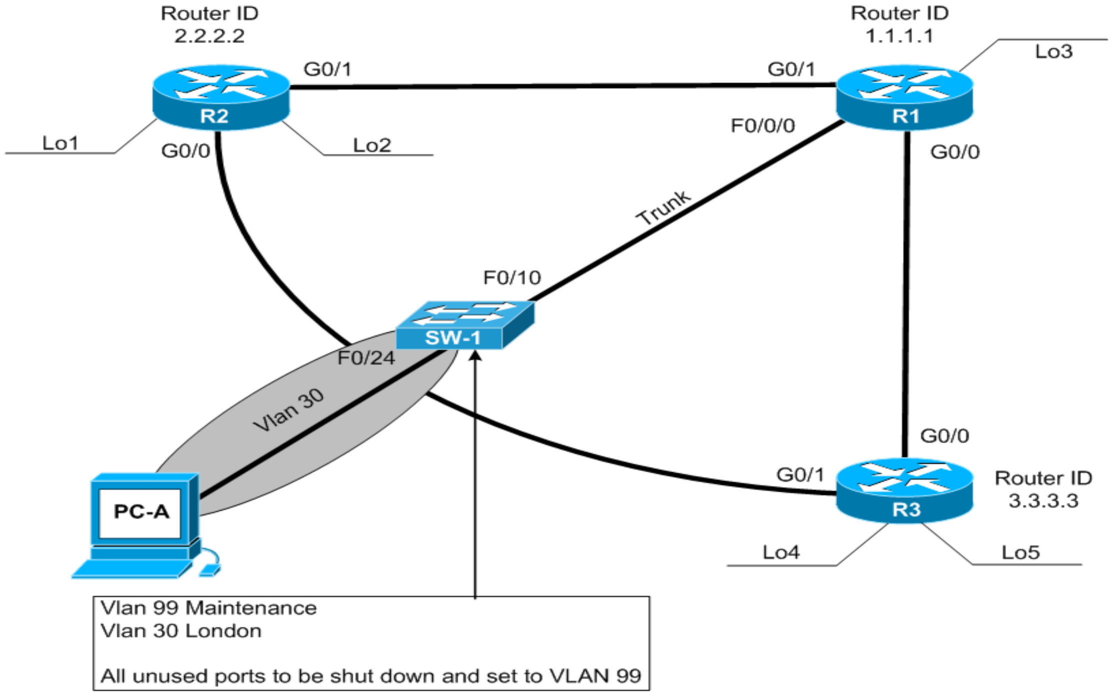
- Enabling OSPFv3 on Interfaces
  - Instead of using the network router configuration mode command to specify matching interface addresses, OSPFv3 is configured directly on the interface.
  - As with RIPng (IPv6) to start the routing (advertising) process , it is done on the interface **not** in the "**ipv6 router ospf 10**" section of the programing interface.

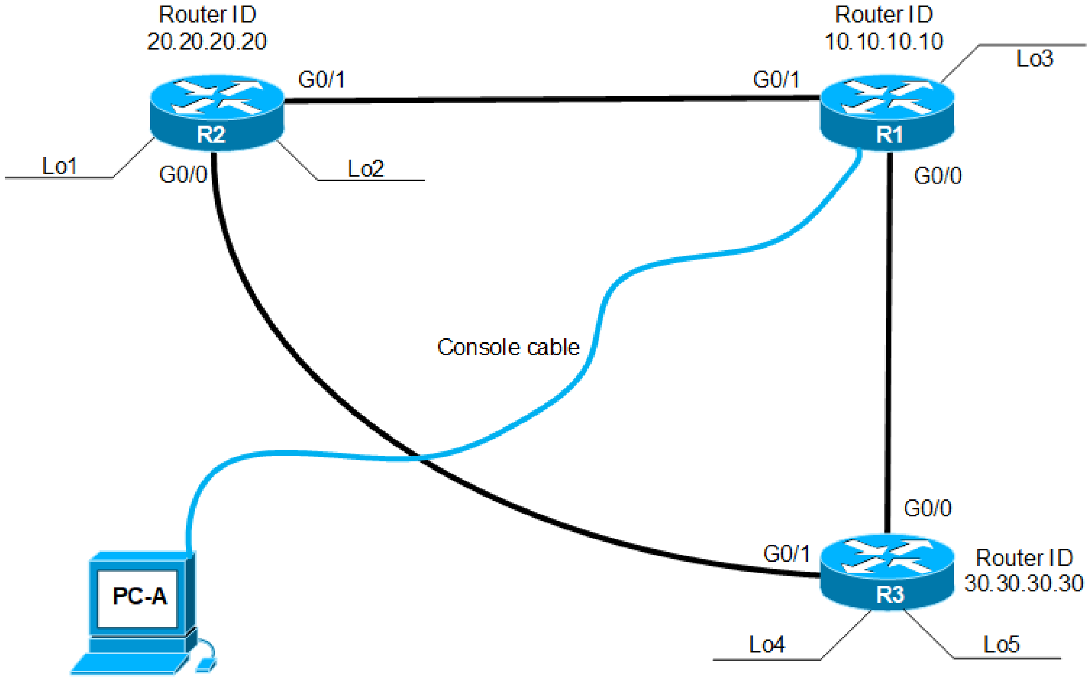
```
R1(config)# interface GigabitEthernet 0/0
R1(config-if)# ipv6 ospf 10 area 0
R1(config-if)#
R1(config-if)# interface Serial0/0/0
R1(config-if)# ipv6 ospf 10 area 0
R1(config-if)#
R1(config-if)# interface Serial0/0/1
R1(config-if)# ipv6 ospf 10 area 0
R1(config-if)#
R1(config-if)# end
R1#
R1# show ipv6 ospf interfaces brief
Interface   PID    Area      Intf ID   Cost     State    Nbrs F/C
Se0/0/1     10     0           7       15625    P2P      0/0
Se0/0/0     10     0           6       647      P2P      0/0
Gi0/0       10     0           3         1      WAIT     0/0
R1#
```

- Verify OSPFv3 Neighbors/Protocol Settings
  - A few command to verify that OSPF is working
    - **Show ip/ipv6 ospf neighbor**
    - **Show ip/ipv6 protocols**
    - **Show ip/ipv6 ospf interface** (**brief**)
    - **Show ip/ipv6 route** (**ospf**)

The items in "()" brackets above are optional to the command and may not work in Packet Tracer.

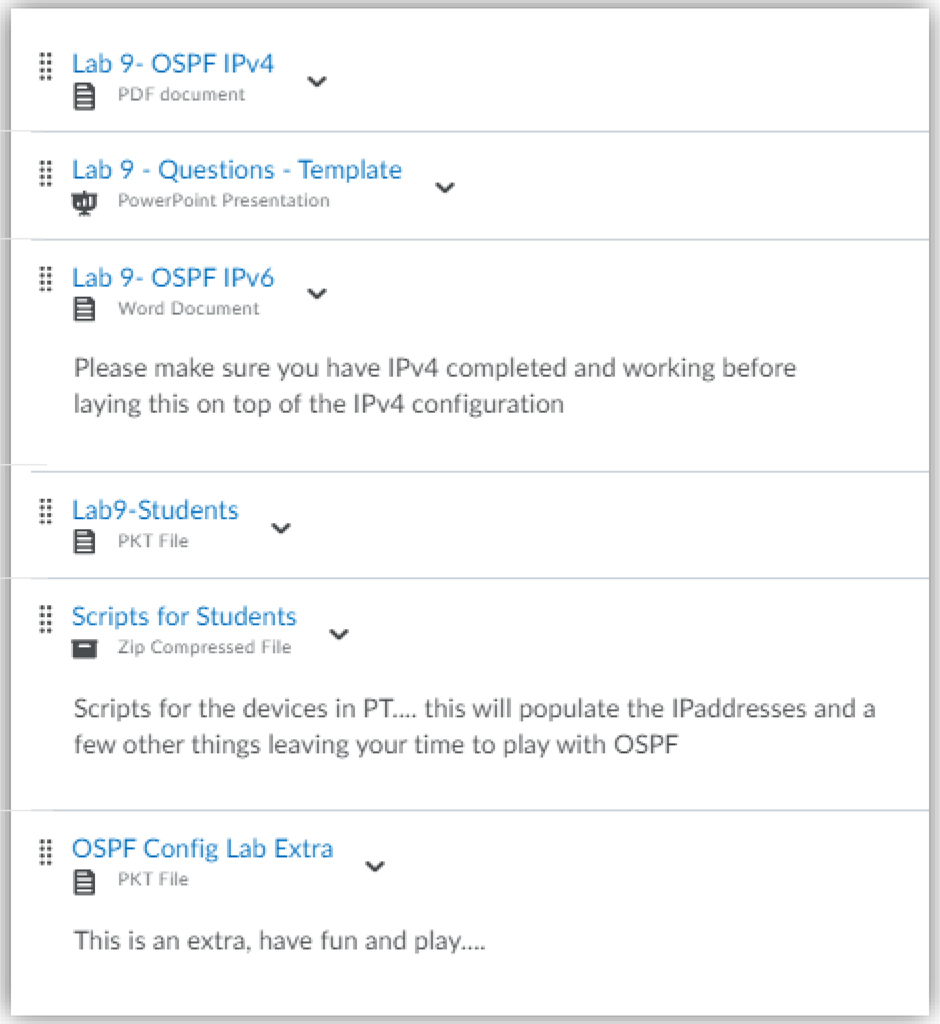
Lab


Router ID
2.2.2.2
Router ID
1.1.1.1
R2
R1
G0/1
G0/1
Lo3
Lo1
G0/0
Lo2
F0/0/0
G0/0
Trunk
F0/10
SW-1
F0/24
Vlan 30
G0/0
G0/1
Router ID
3.3.3.3
R3
PC-A
Lo4
Lo5
Vlan 99 Maintenance
Vlan 30 London
All unused ports to be shut down and set to VLAN 99


Router ID
20.20.20.20
Router ID
10.10.10.10
R2
R1
G0/1
G0/1
Lo3
Lo1
G0/0
Lo2
G0/0
Console cable
G0/0
G0/1
Router ID
30.30.30.30
R3
PC-A
Lo4
Lo5

Lab (continued)

- Todays Lab
  - IPv4 version of todays lab
  - Todays Lab Questions to be answered
  - IPv4 version of the lab must be completed and working before you lay the IPv6 on top of these devices
  - Packet Tracer file for you to use, preconfigured hardware in place
  - IPv4 &IPv6 scripts to be copied on to the devices in PT to setup IPaddresses and a few other things to leave more time to play with OSPF
  - Extra PT file to play with



QUESTIONS

?