Link-State Routing Protocols

Routing Protocols and Concepts – Chapter 10

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10.0.1 Introduction

- Describe the basic features & concepts of link-state routing protocols.
- List the benefits and requirements of link-state routing protocols.

10.0.1 Introduction

In this chapter, you will learn to:

- Describe the basic features and concepts of link-state routing protocols.
- List the benefits and requirements of link-state protocols.

- **Distance vector** routing protocols are like road signs because routers must make preferred path decisions based on a **distance or metric to a network.**

- **Link-state** routing protocols take a different approach. Link-state routing protocols are more like a road map because they **create a topological map of the network** and each router uses this map to determine the shortest path to each network. Just as you refer to a map to find the route to another town, link-state routers use a map to determine the preferred path to reach another destination.

10.1.1 Link State Routing Protocols

	Interior Gateway Protocols				Exterior Gateway Protocols
	Distance Vector Routing Protocols		Link State Routing Protocols		Path Vector
Classful	**RIP**	IGRP			EGP
Classless	**RIPv2**	**EIGRP**	**OSPFv2**	IS-IS	BGPv4
IPv6	RIPng	**EIGRP** for IPv6	OSPFv3	**IS-IS** for IPv6	**BGPv4** for IPv6

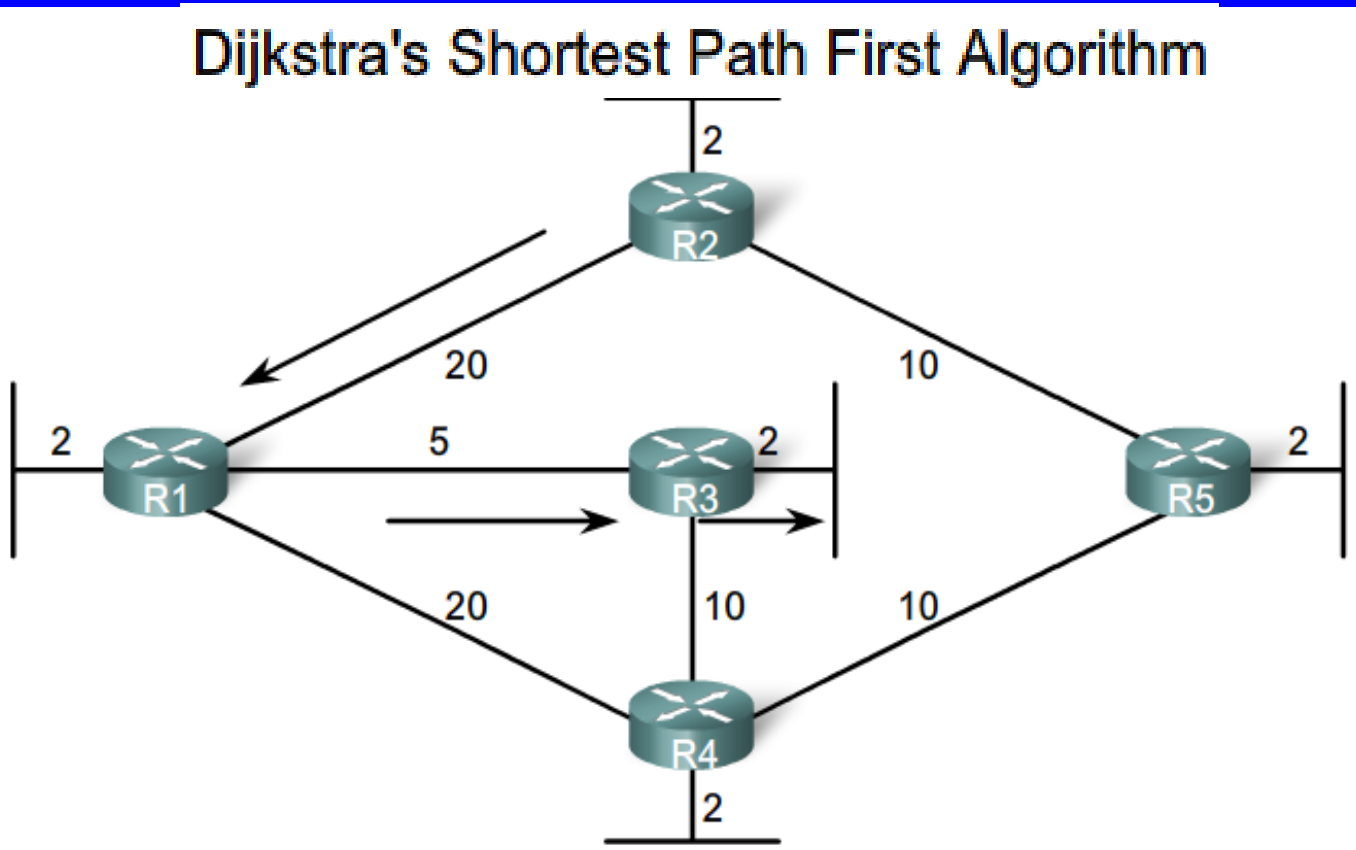
- Link state routing protocols

  -Also known as shortest path first algorithms

  -These protocols built around Dijkstra's SPF

Open Shortest Path First (OSPF)
Intermediate System-to-Intermediate System (IS-IS)

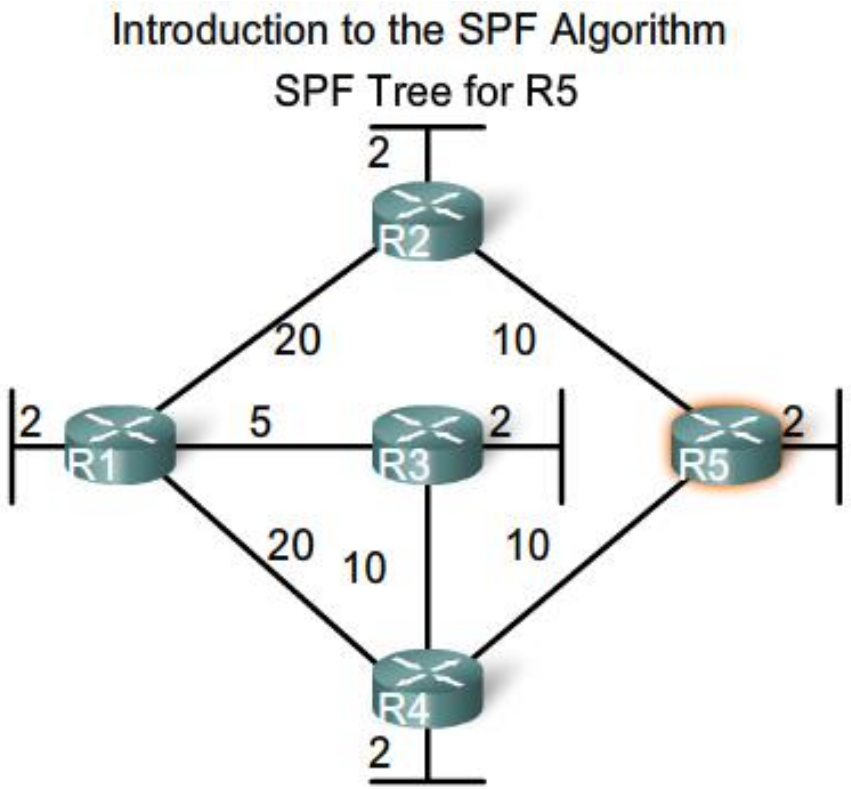
10.1.2 Introduction to the SPF Algorithm



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

This algorithm accumulates costs along each path, from source to destination. Although, Dijkstra's algorithm is known as the shortest path first algorithm, this is in fact the purpose of every routing algorithm.

10.1.2 Introduction to the SPF Algorithm



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

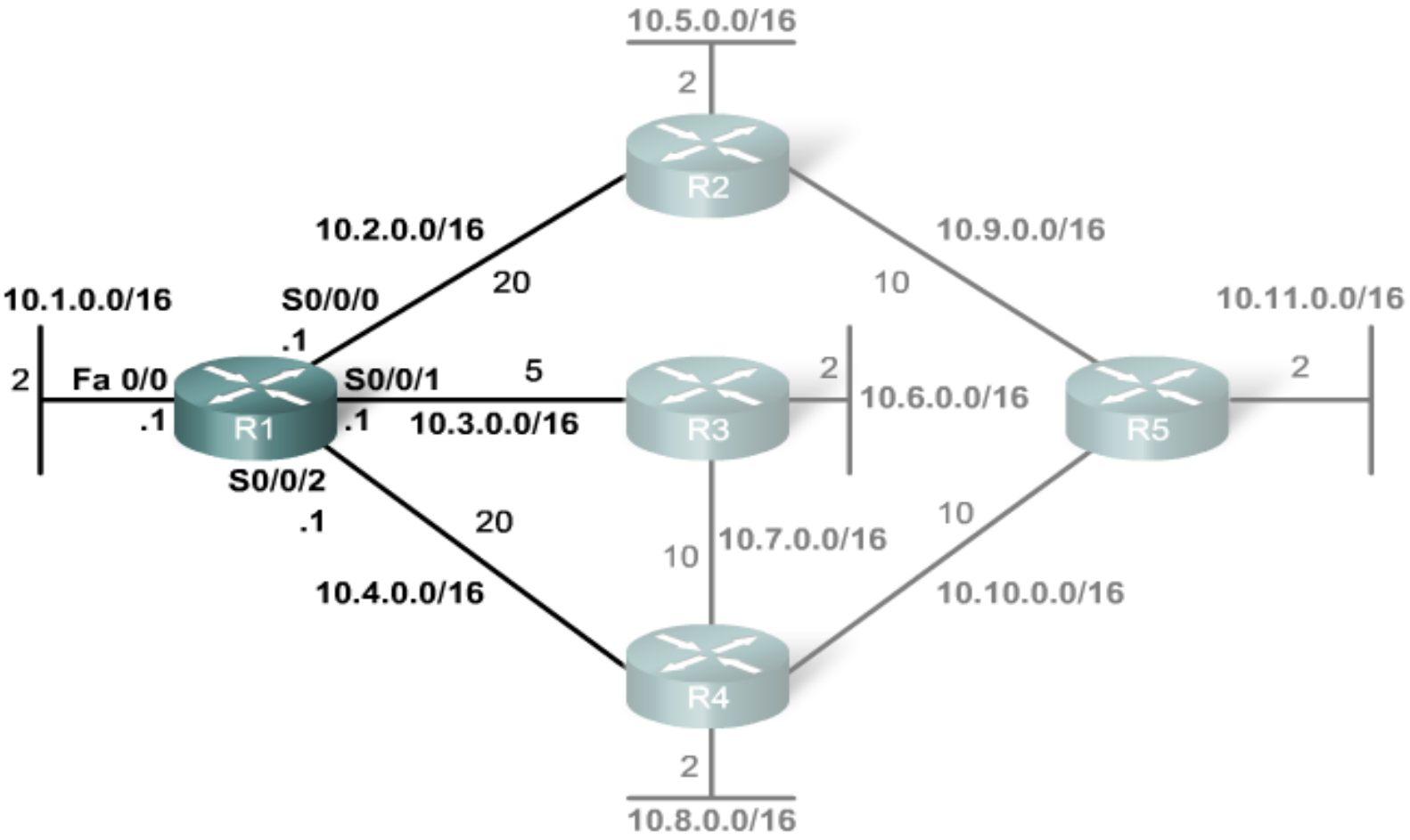
The shortest path to a destination is not necessarily the path with the least number of hops

10.1.3 Link State Routing Process

Link-State Routing Process

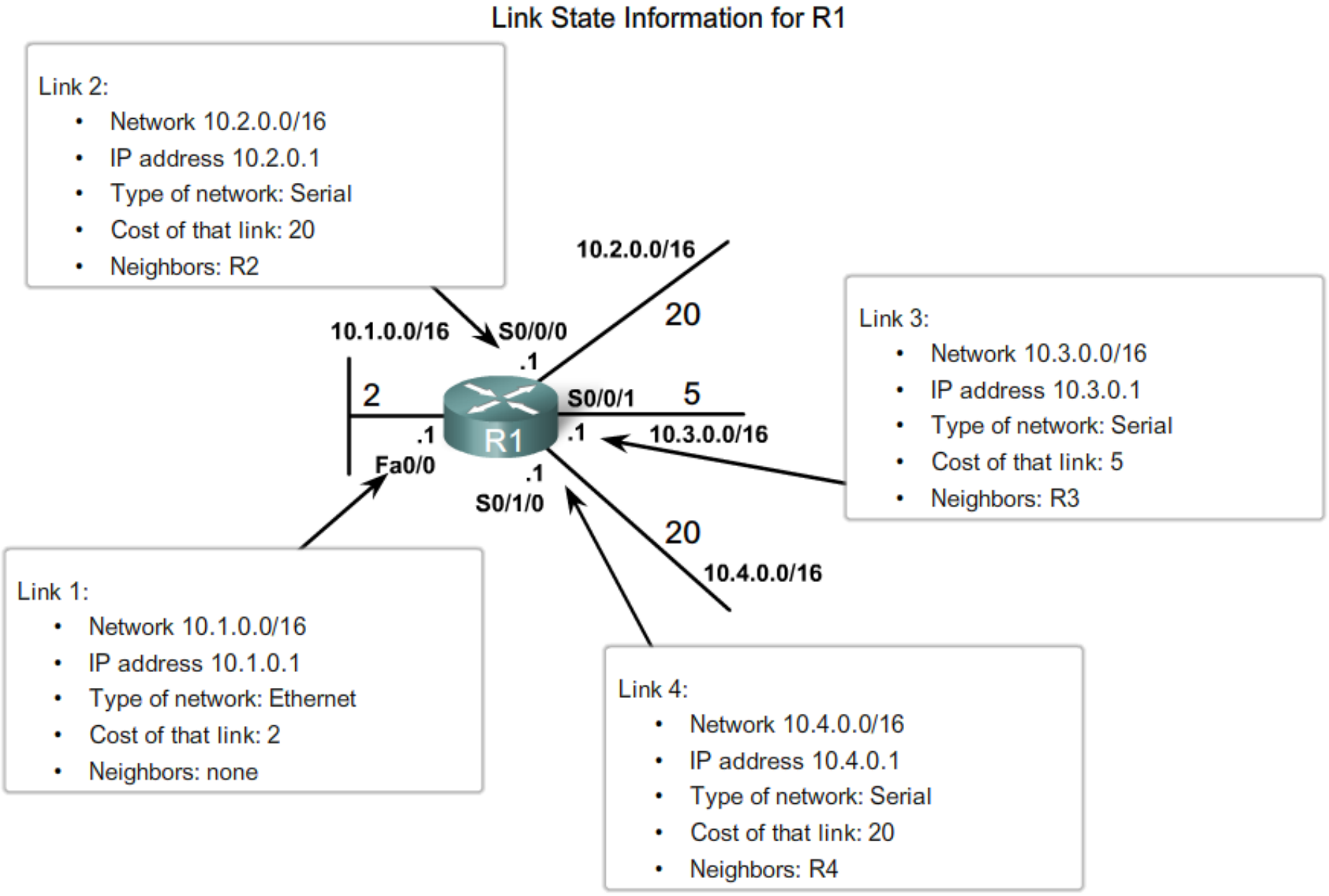
1. Each router learns about each of its own directly connected networks.
2. Each router is responsible for "saying hello" to its neighbors on directly connected networks.
3. Each router builds a Link State Packet (LSP) containing the state of each directly connected link.
4. Each router floods the LSP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

10.1.4 Learning About Directly Connected Networks



- **Directly Connected Networks**
- Link - This is an interface on a router
- Link state - This is the information about the state of the links

10.1.4 Learning About Directly Connected Networks

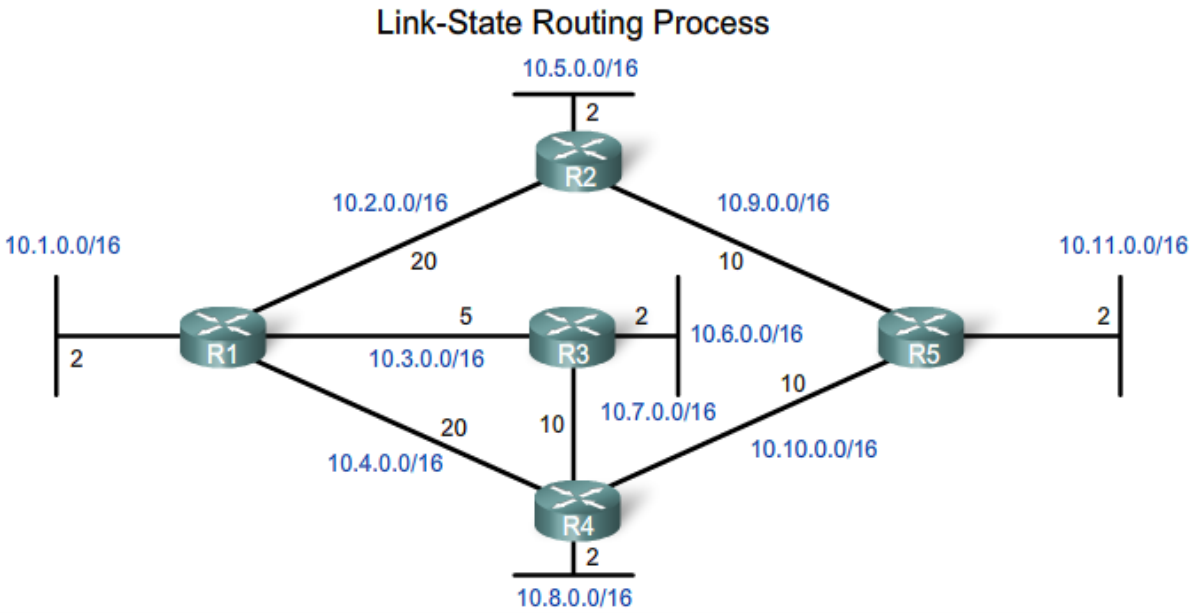


10.1.5 Sending Hello Packets to Neighbors

Sending Hello Packets to Neighbors

- Link state routing protocols use a hello protocol

  Purpose of a hello protocol: -*To discover neighbors (that use the same link state routing protocol) on its link*



1. Each router learns about each of its own directly connected networks.
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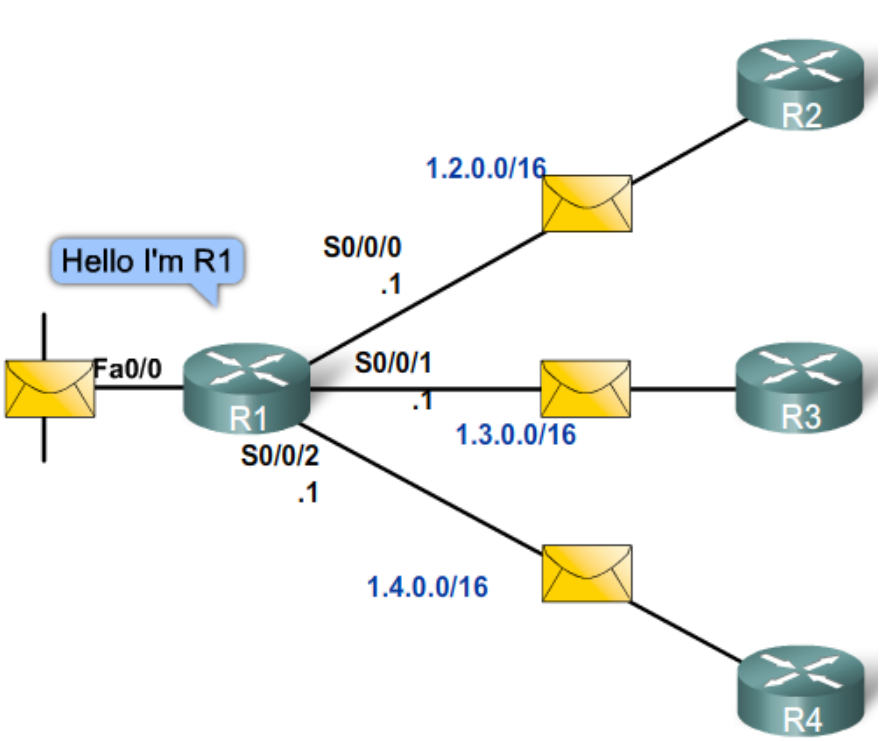

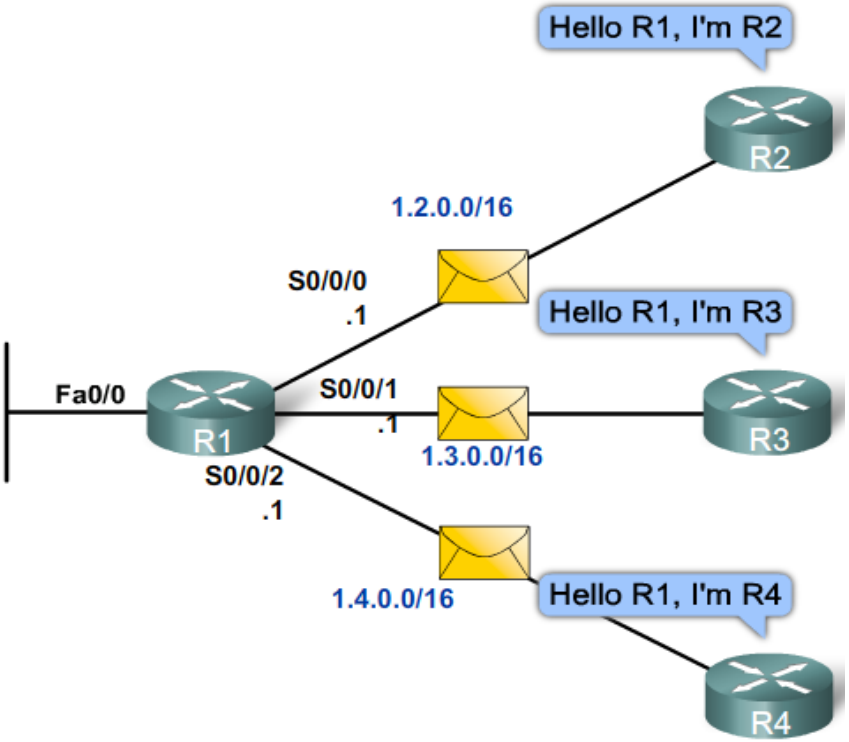

Sending Hello Packets to Neighbors

- Connected interfaces that are using the same link state routing protocols will exchange hello packets.
- Once routers learn it has neighbors they form an adjacency
- -2 adjacent neighbors will exchange hello packets
- -These packets will serve as a keep alive function

10.1.6 Building the Link State Packet

Building the Link State Packet

- Each router builds its own Link State Packet (LSP)

Contents of LSP:

-State of each directly connected link

-Includes information about neighbors such as neighbor ID, link type, & bandwidth.

Link-State Routing Process

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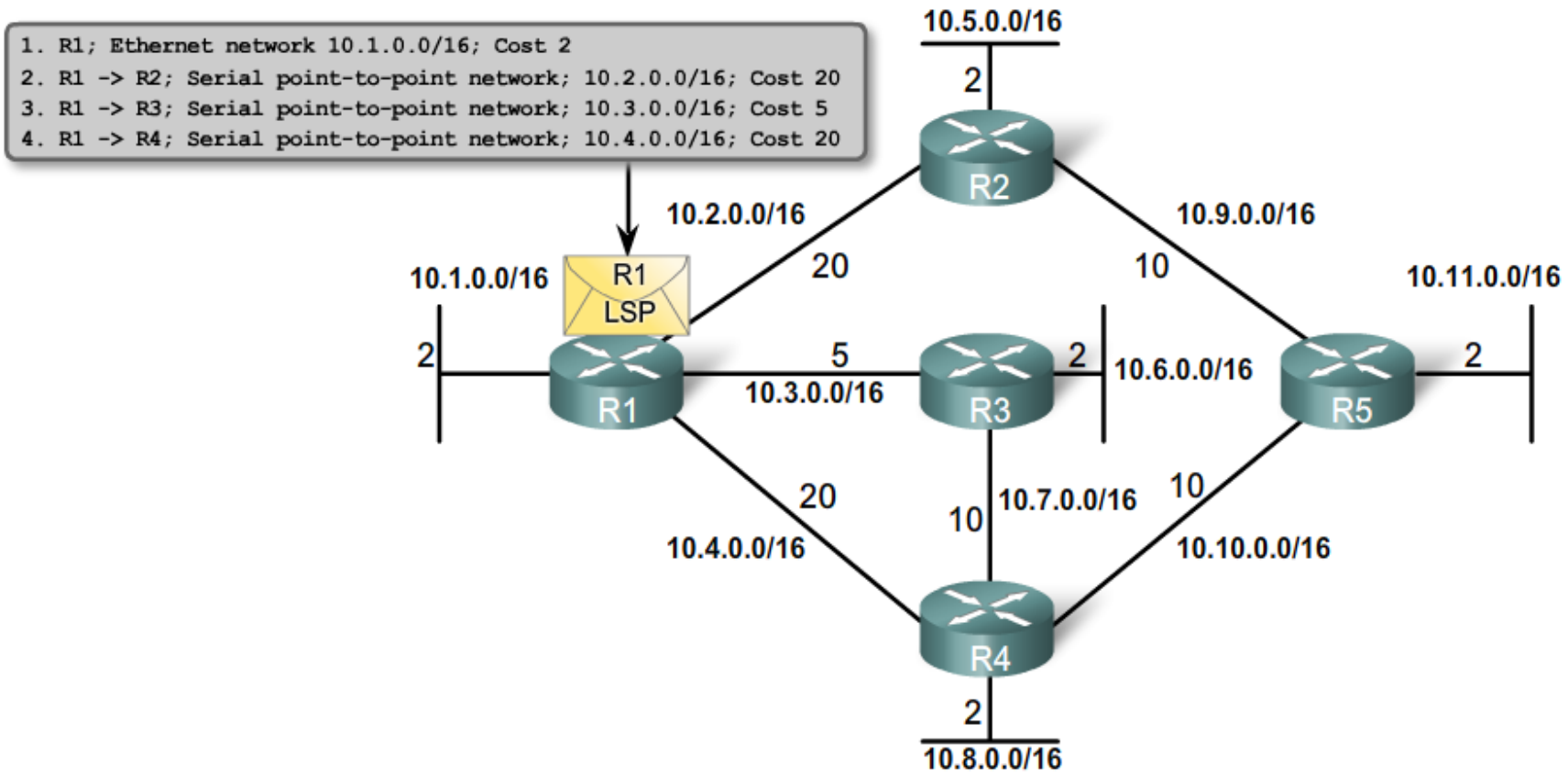


Each router builds its own Link State Packet (LSP)

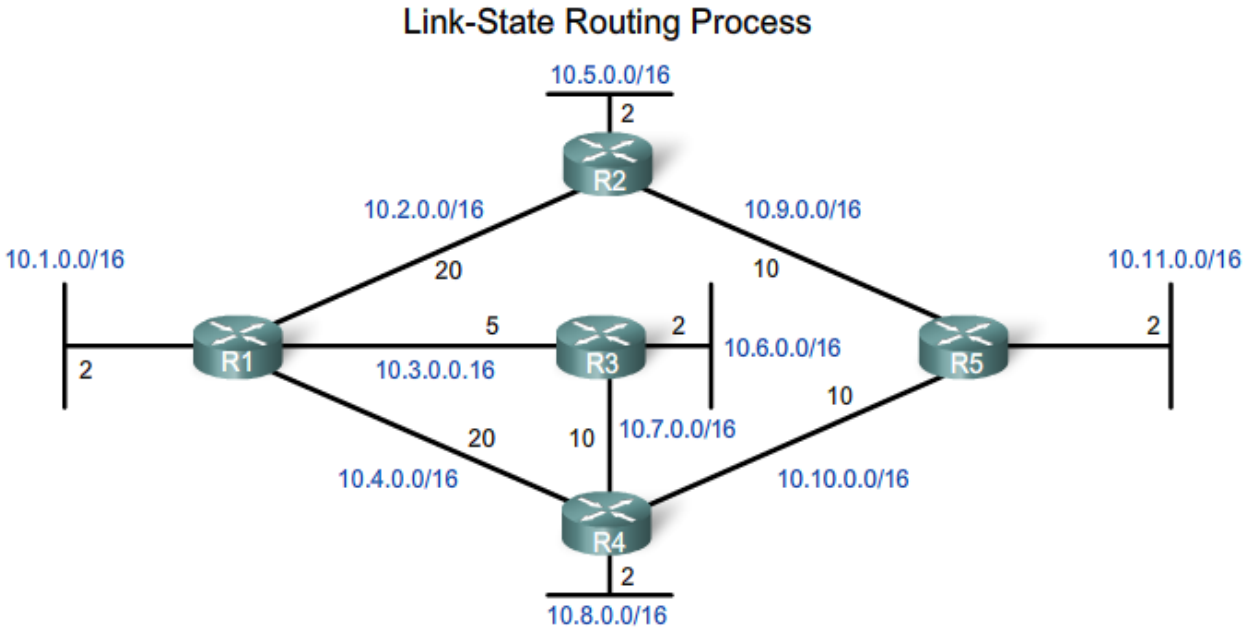
-State of each directly connected link

-Includes information about neighbors such as neighbor ID, link type, & bandwidth.

10.1.7 Flooding LSPs to Neighbors

- Once LSP are created they are forwarded out to neighbors.

  -After receiving the LSP the neighbor continues to forward it throughout routing area.



Link-State Routing Process

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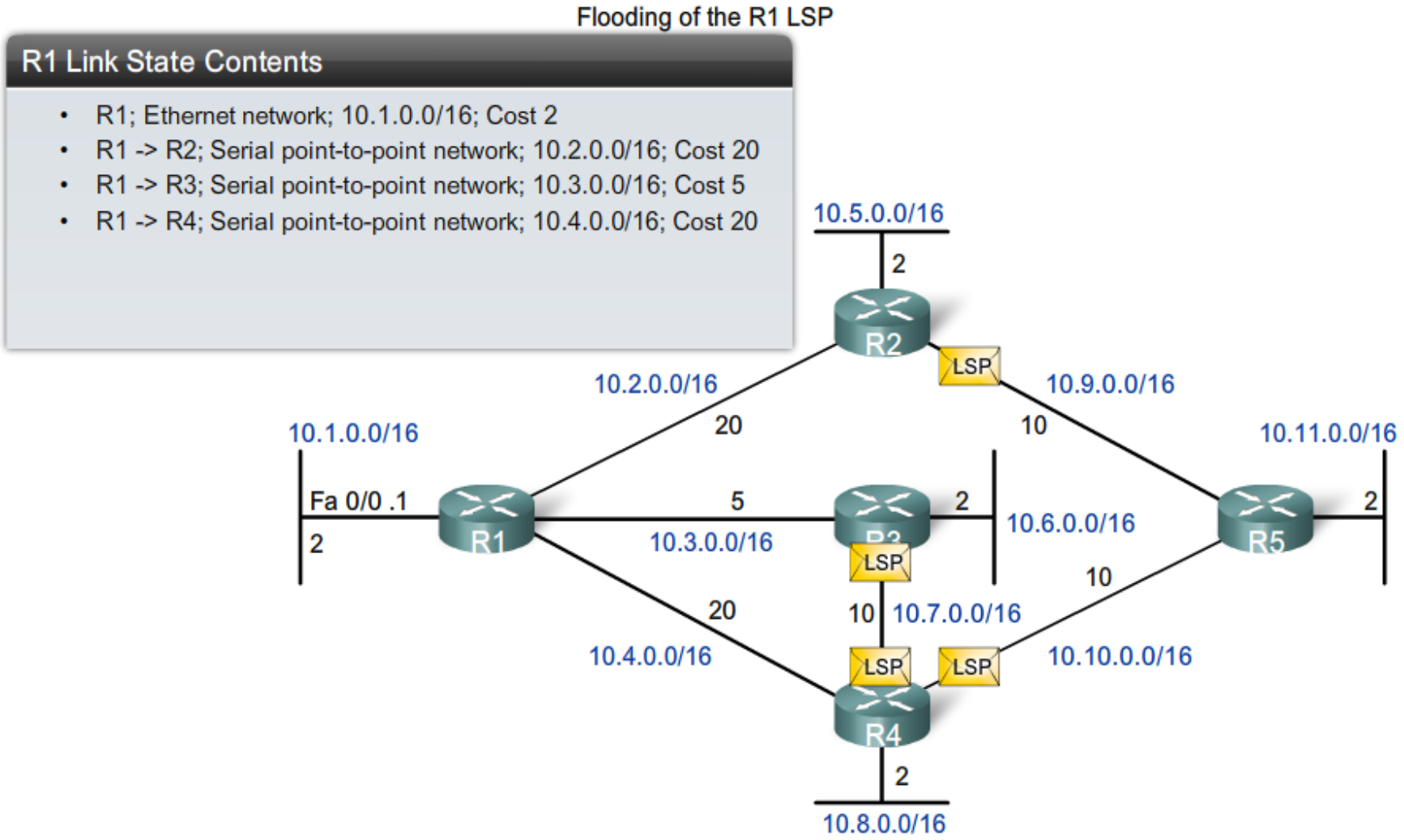
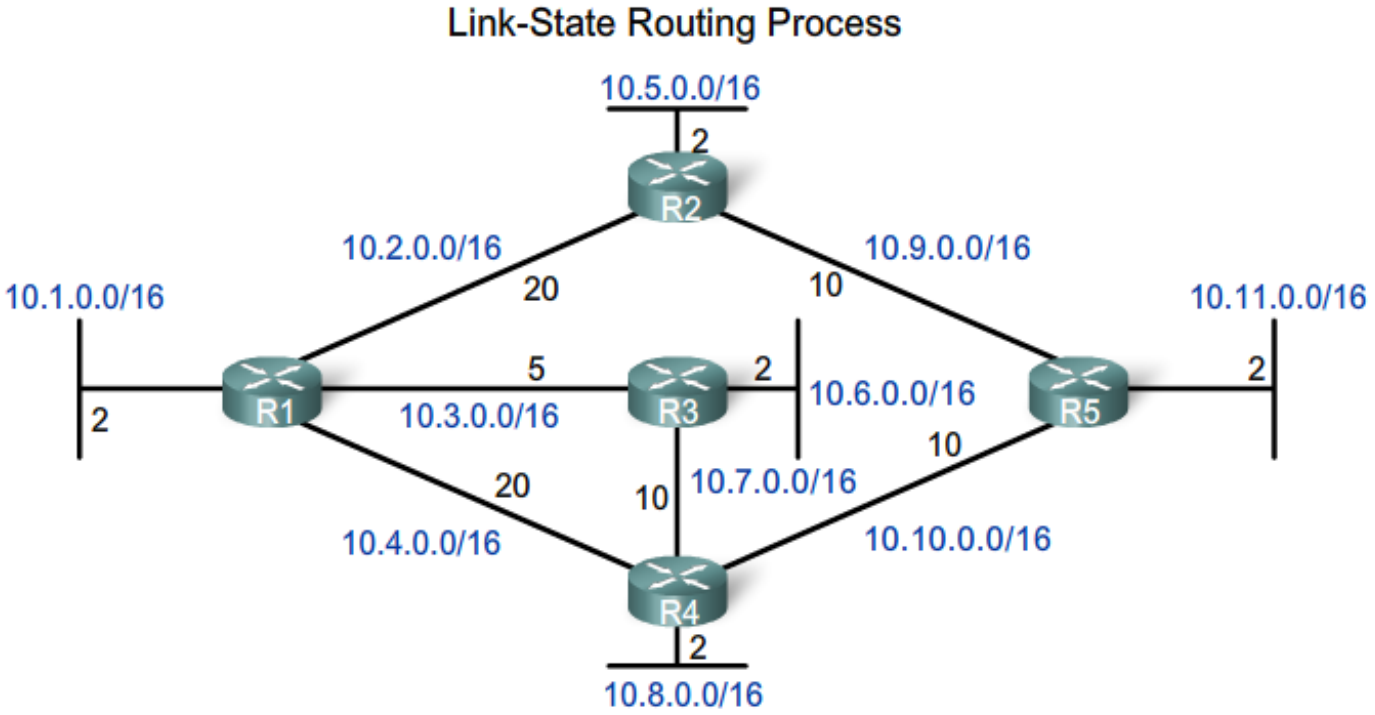
10.1.7 Flooding LSP to Neighbors



- LSPs are sent out under the following conditions
  - -Initial router start up or routing process
  - -When there is a change in topology

10.1.8 Constructing the Link State Database



Link-State Routing Process

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4. Each router floods the LSP to all neighbors, who then store all LSPs received in a database.
5. *Each router uses the database to construct a complete map of the topology and computes the best path to each destination network.*

- Routers use a database to construct a topology map of the network

10.1.8 Constructing the Link State Database

R1s Link-State Database

LSPs from R2:
- Connected to neighbor R1 on network 10.2.0.0/16, cost of 20
- Connected to neighbor R5 on network 10.9.0.0/16, cost of 10
- Has a network 10.5.0.0/16, cost of 2

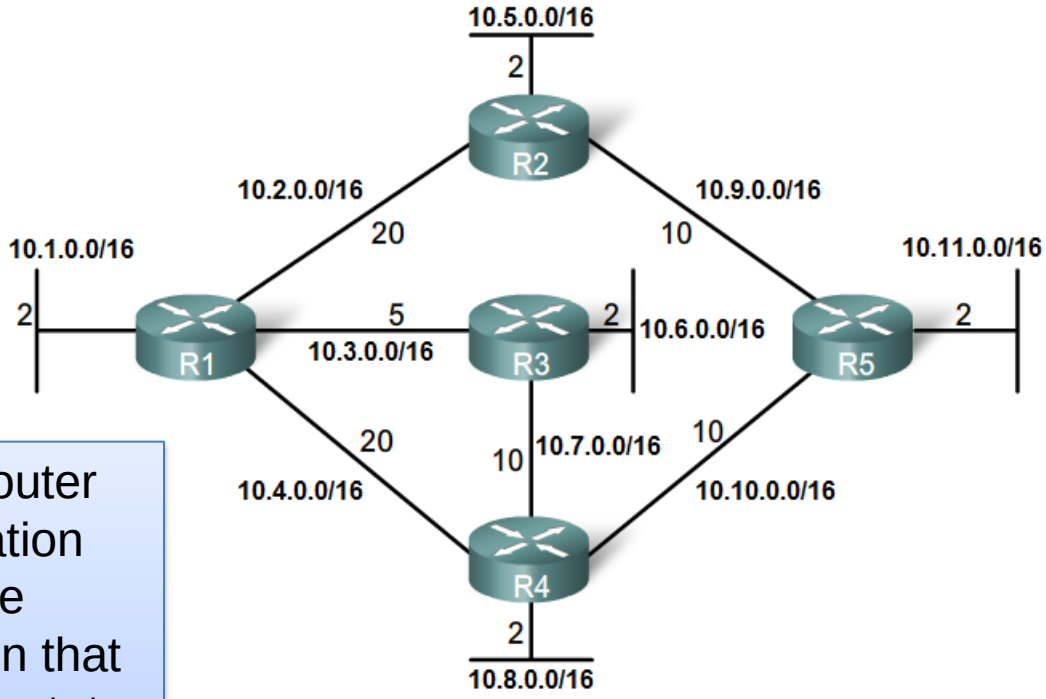
LSPs from R3:
- Connected to neighbor R1 on network 10.3.0.0/16, cost of 5
- Connected to neighbor R4 on network 10.7.0.0/16, cost of 10
- Has a network 10.6.0.0/16, cost of 2

LSPs from R4:
- Connected to neighbor R1 on network 10.4.0.0/16, cost of 20
- Connected to neighbor R3 on network 10.7.0.0/16, cost of 10
- Connected to neighbor R5 on network 10.10.0.0/16, cost of 10
- Has a network 10.8.0.0/16, cost of 2

LSPs from R5:
- Connected to neighbor R2 on network 10.9.0.0/16, cost of 10
- Connected to neighbor R4 on network 10.10.0.0/16, cost of 10
- Has a network 10.11.0.0/16, cost of 2

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

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



As a result of the flooding process, router R1 has learned the link-state information for each router in its routing area. The figure shows the link-state information that R1 has received and stored in its link-state database. Notice that R1 also includes its own link-state information in the link-state database

10.1.9 Shortest Path First – SPF Tree

R1 Link State Database

R1 Links-states:

- Connected to neighbor R2 on network 10.2.0.0/16, cost of 20
- Connected to neighbor R3 on network 10.3.0.0/16, cost of 5
- Connected to neighbor R4 on network 10.4.0.0/16, cost of 20
- Has a network 10.1.0.0/16, cost of 2

LSPs from R2:

- Connected to neighbor R1 on network 10.2.0.0/16, cost of 20
- Connected to neighbor R5 on network 10.9.0.0/16, cost of 10
- Has a network 10.5.0.0/16, cost of 2

LSPs from R3:

- Connected to neighbor R1 on network 10.3.0.0/16, cost of 5
- Connected to neighbor R4 on network 10.7.0.0/16, cost of 10
- Has a network 10.6.0.0/16, cost of 2

LSPs from R4:

- Connected to neighbor R1 on network 10.4.0.0/16, cost of 20
- Connected to neighbor R3 on network 10.7.0.0/16, cost of 10
- Connected to neighbor R5 on network 10.10.0.0/16, cost of 10
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LSPs from R5:

- Connected to neighbor R2 on network 10.9.0.0/16, cost of 10
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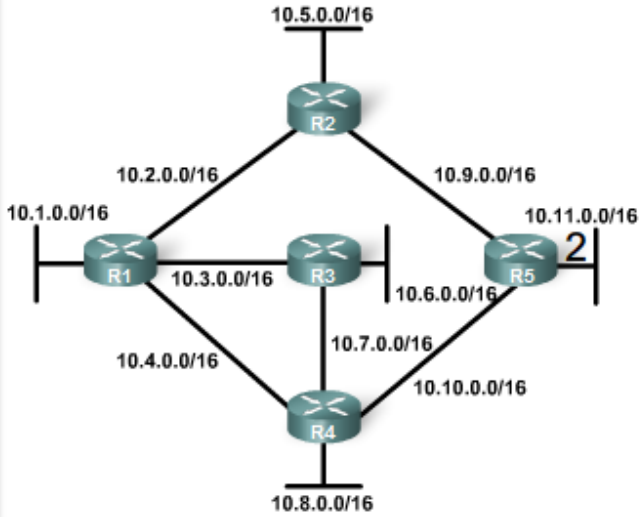
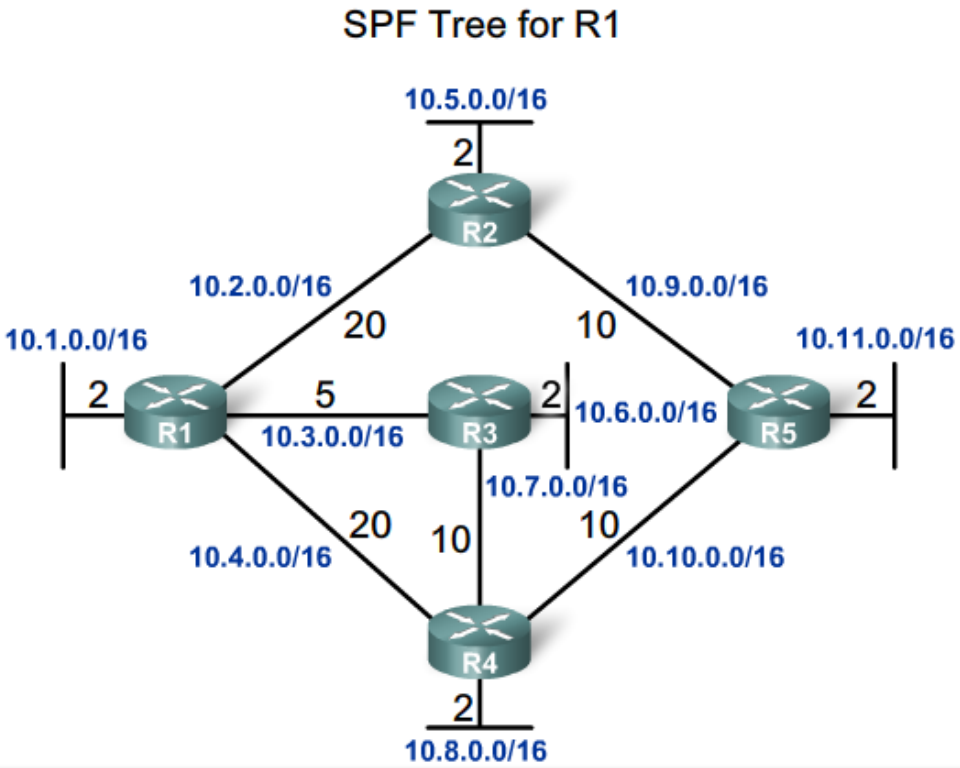
Processing the R5 LSPs



R1's current topology only includes its neighbors. However, using the link-state information from all other routers, R1 can now begin to construct an SPF tree of the network with itself at the root of the tree.

10.1.9 Shortest Path First – SPF Tree



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

- Determining the shortest path

  The shortest path to a destination determined by adding the costs & finding the lowest cost

10.1.9 Shortest Path First – SPF Tree

R1 Routing Table

SPF Information

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

R1 Routing Table

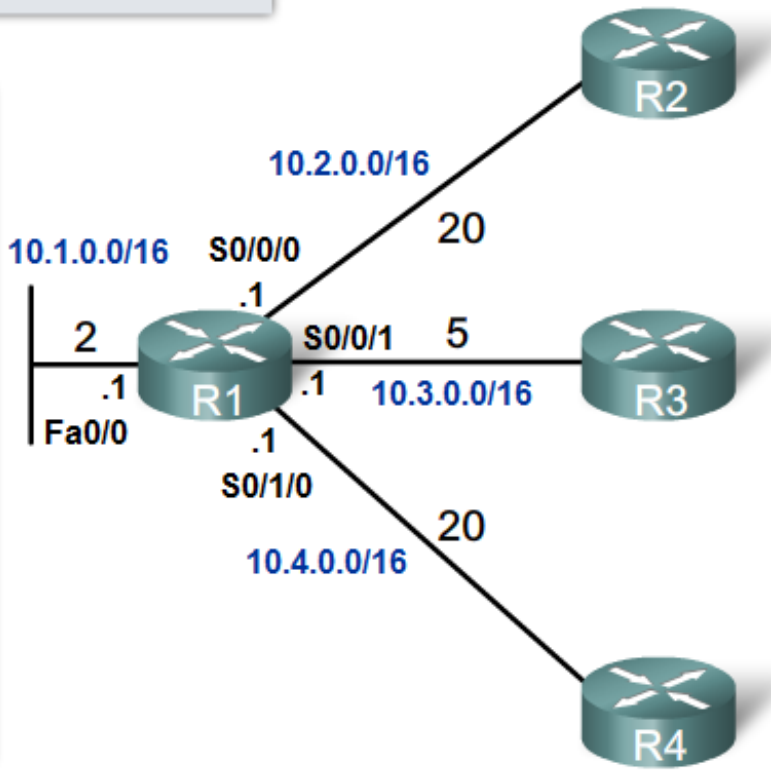
Directly Connected Networks

- 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

- Using SPF to construct a routing table



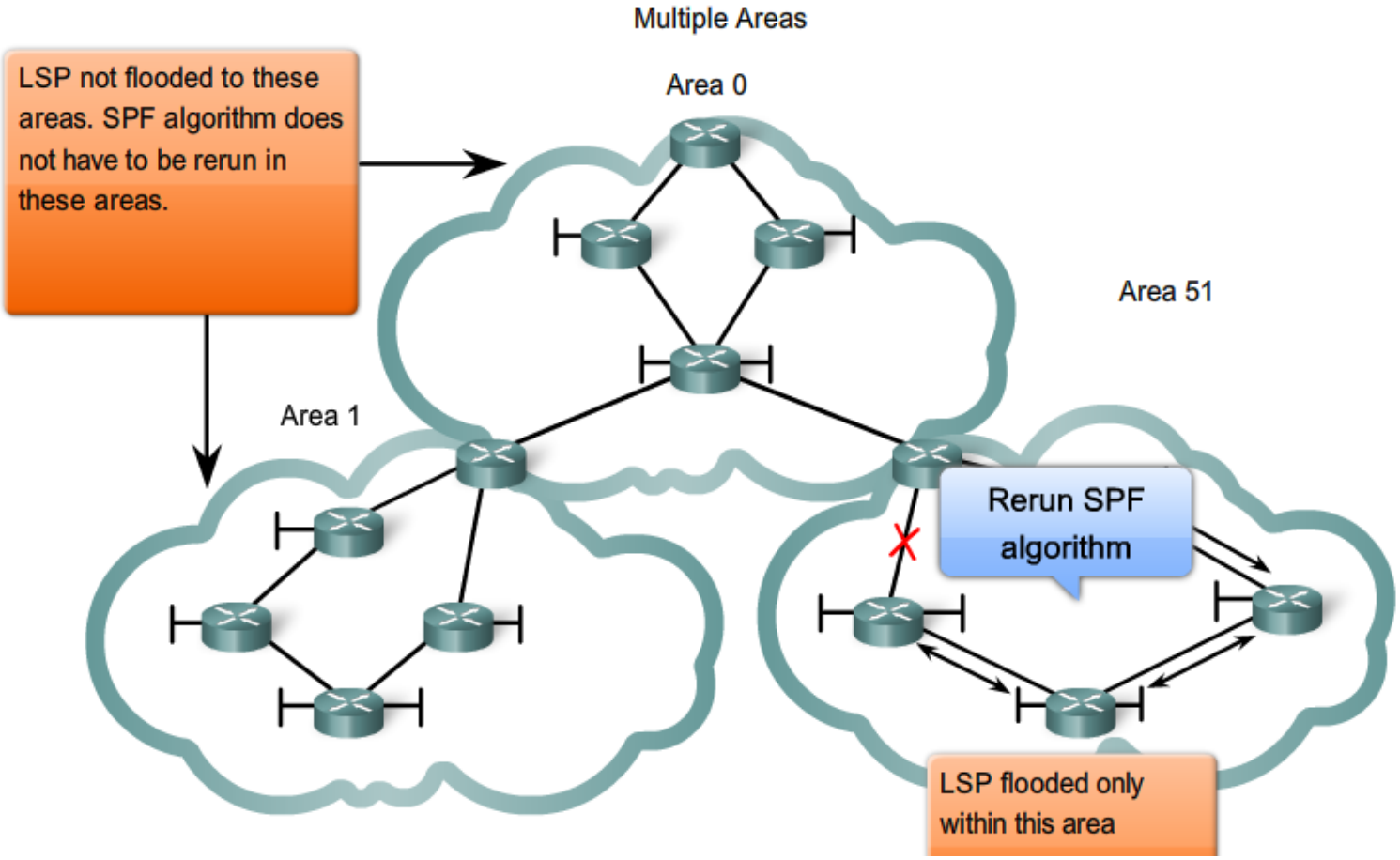
10.2.1 Advantages of a Link State Routing Protocol

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.

Routing protocol	Builds Topological map	Router can independently determine the shortest path to every network.	Convergence	A periodic/ event driven routing updates	Use of LSP
Distance vector	No	No	Slow	Generally No	No
Link State	Yes	Yes	Fast	Generally Yes	Yes

10.2.2 Requirements of the Link State Protocol



Modern link-state routing protocols are designed to minimize the effects on memory, CPU, and bandwidth. The use and configuration of multiple areas can reduce the size of the link-state databases. Multiple areas can also limit the amount of link-state information flooding in a routing domain and send LSPs only to those routers that need them

10.2.2 Requirements of the Link State Protocol

Requirements for using a link state routing protocol

- Memory requirements

  Typically link state routing protocols use more memory

- Processing Requirements

  More CPU processing is required of link state routing protocols

- Bandwidth Requirements

  Initial startup of link state routing protocols can consume lots of bandwidth

10.2.3 Comparasons of Link State Protocols

OSPF

- OSPFv2: OSPF for IPv4 networks (RFC 1247 and RFC 2328)
- OSPFv3: OSPF for IPv6 networks (RFC 2740)
- OSPFv2 discussed in chapter 11

IS-IS

- ISO 10589
- Integrated IS-IS, Dual IS-IS supports IP networks
- Used mainly by ISPs and carriers
- Discussed in CCNP

Two link-state routing protocols used for routing IP today:

10.3.1 Summary and Review

- Link State Routing protocols are also known as Shortest Path First protocols
- Summarizing the link state process

1. -Routers 1ST learn of directly connected networks
2. -Routers then say “hello” to neighbors
3. -Routers then build link state packets
4. -Routers then flood LSPs to all neighbors
5. -Routers use LSP database to build a network topology map & calculate the best path to each destination

10.3.1 Summary and Review

- Link

  An interface on the router

- Link State

  Information about an interface such as

  -IP address

  -Subnet mask

  -Type of network

  -Cost associated with link

  -Neighboring routers on the link

10.3.1 Summary and Review

- Link State Packets

  After initial flooding, additional LSP are sent out when a change in topology occurs

- Examples of link state routing protocols

  -Open shortest path first

  -IS-IS

10.3.1 Summary and Review