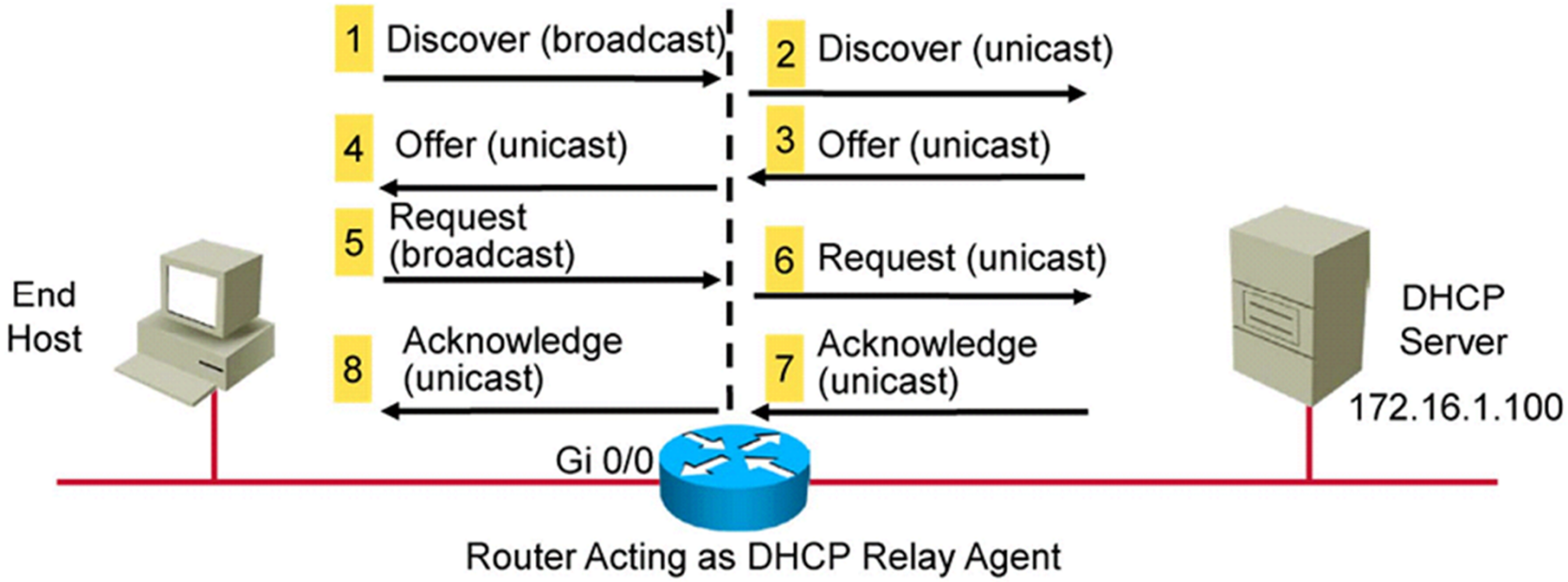
DHCP Relay Agent (Cont.)




```
Branch(config-if)# ip helper-address 172.16.1.100
```

- Enables DHCP relay agent on a local interface

Summary

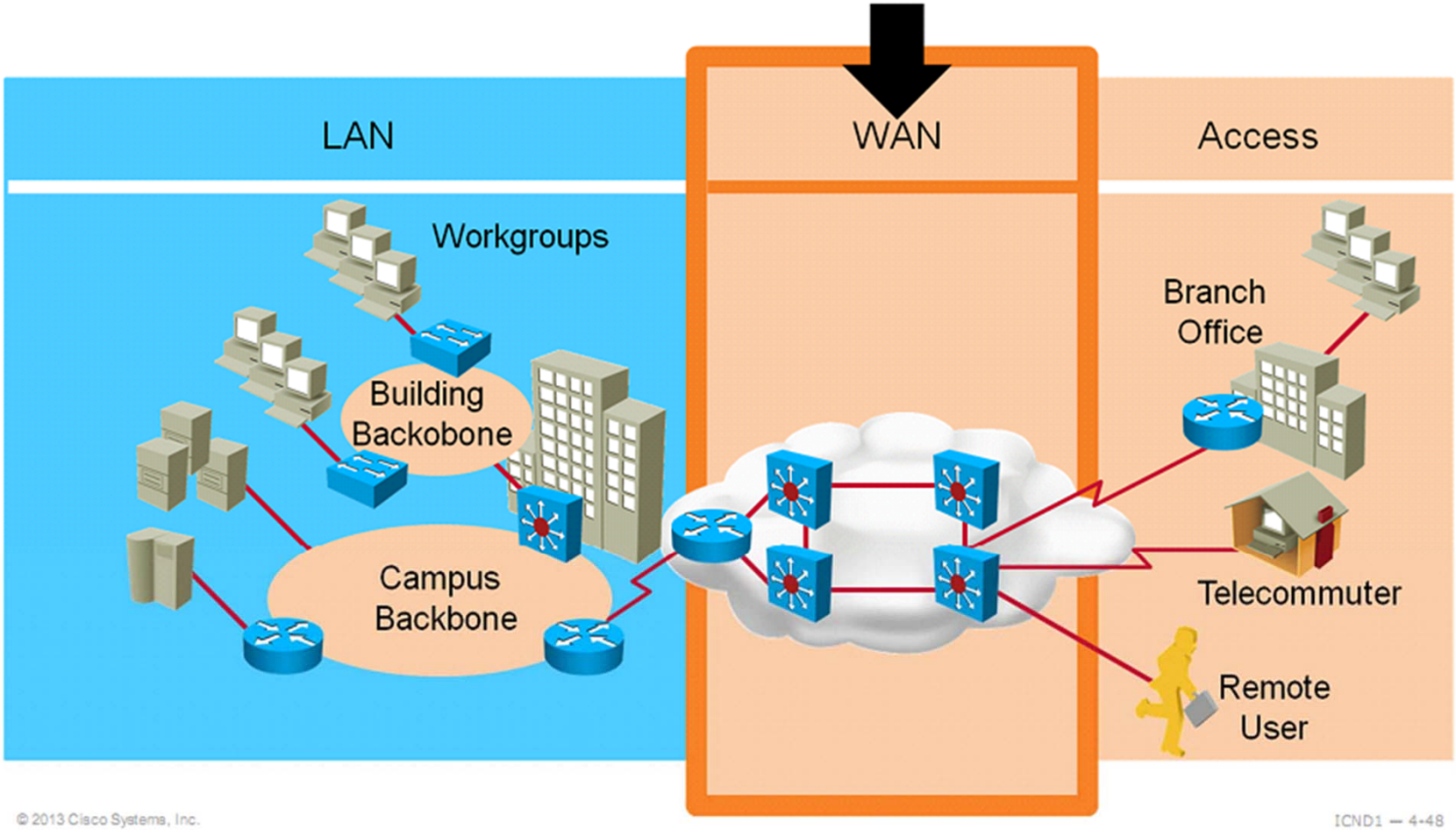
- A DHCP server provides dynamic IP address assignment to end hosts, reducing errors and the time that is needed to administer address assignment.
- Before a client obtains an IP address from a DHCP server, it exchanges DHCP discover, offer, request, and acknowledge messages with the DHCP server.
- Both Cisco routers and Cisco Catalyst switches can be configured as DHCP servers.
- Use the verification commands **show ip dhcp pool**, **show ip dhcp binding**, and **show ip dhcp conflict** to monitor a DHCP server.
- When a centralized DHCP server is in use, configure DHCP relay agent functionally using the **ip helper-address** interface configuration command.

Introducing WAN Technologies

Building a Medium-Sized Network

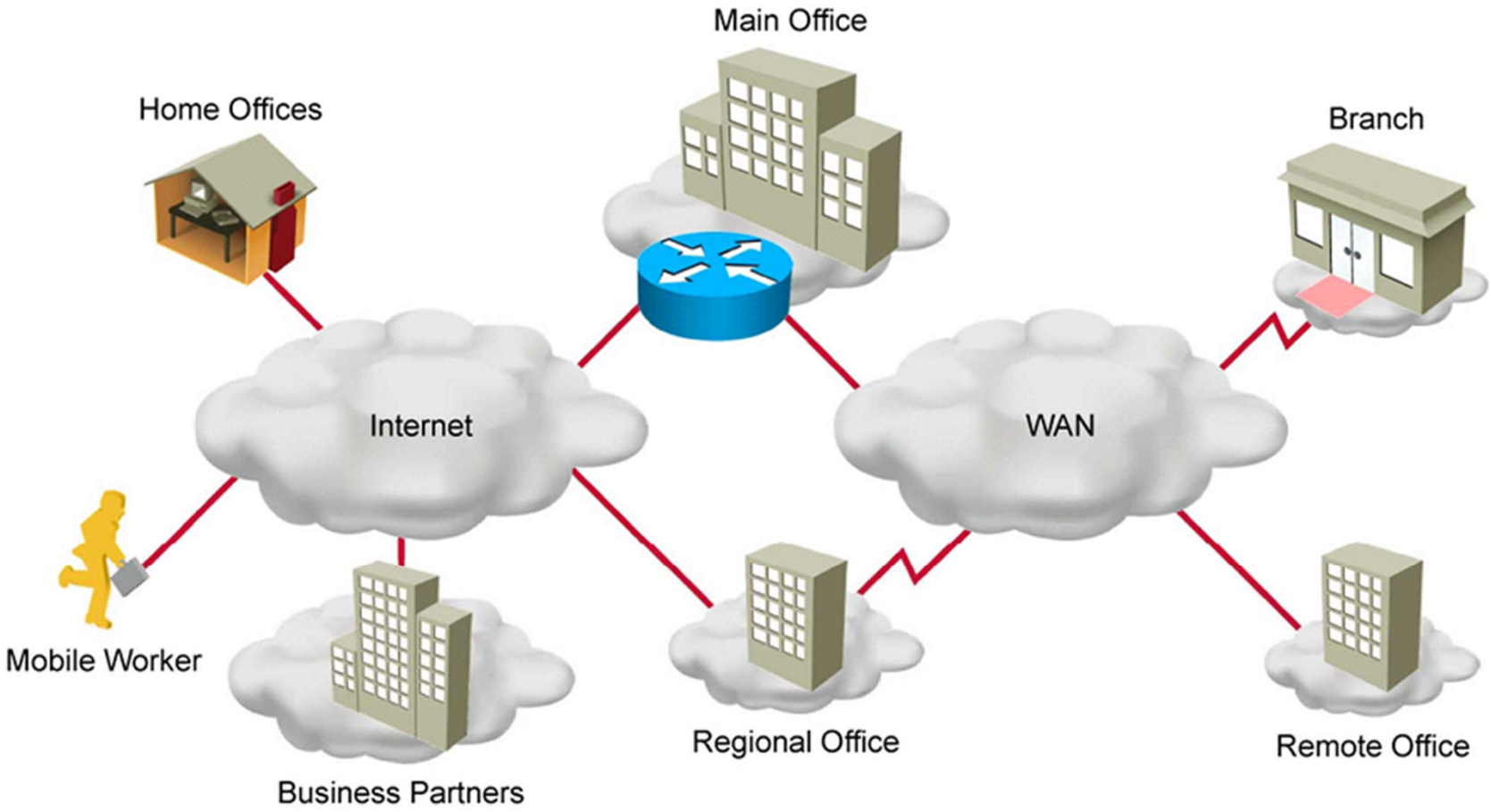
Introducing WANs

What is a WAN?



Introducing WANs (Cont.)

Why are WANs needed?

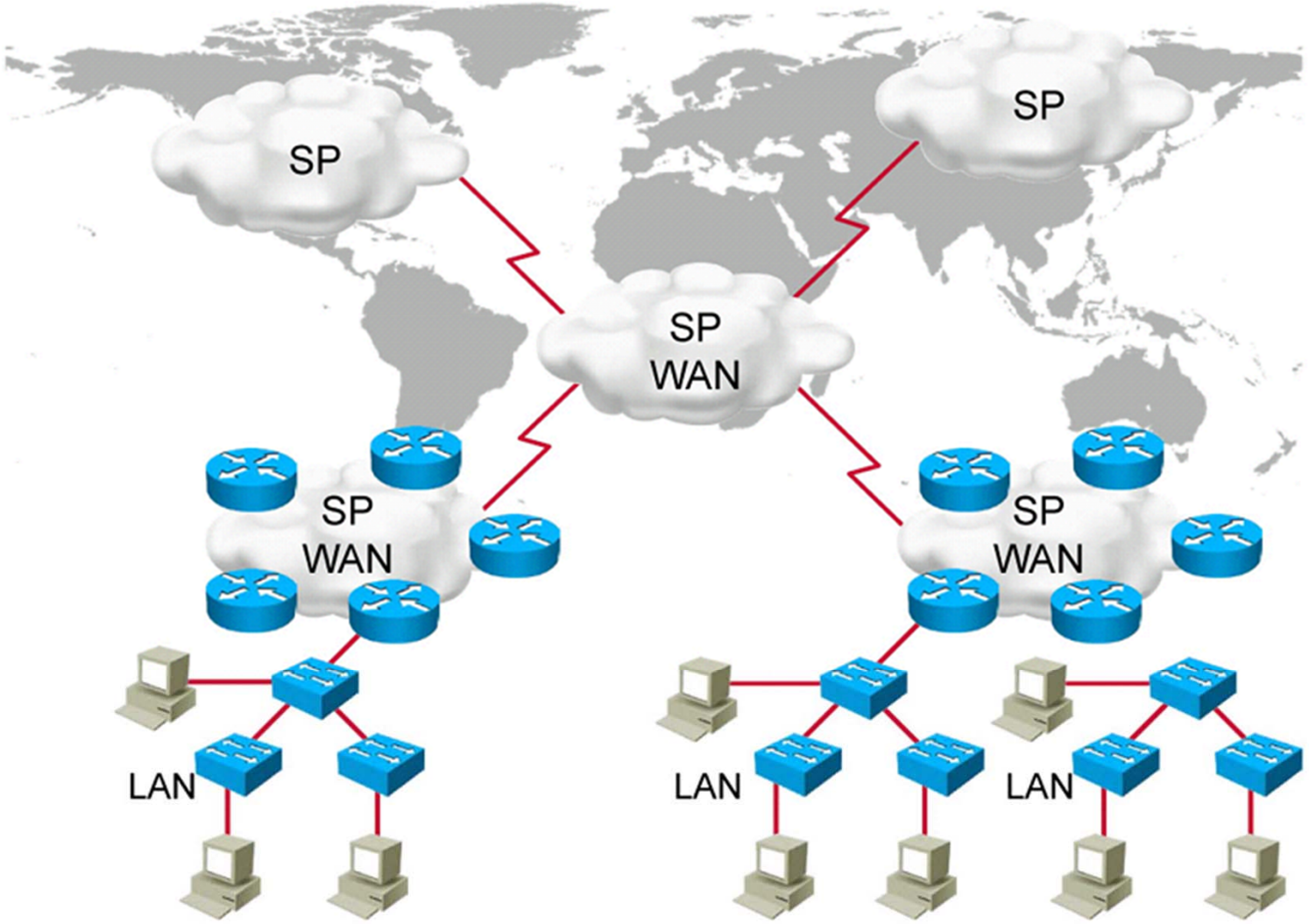


WANs vs. LANs

WAN = A collection of LANs

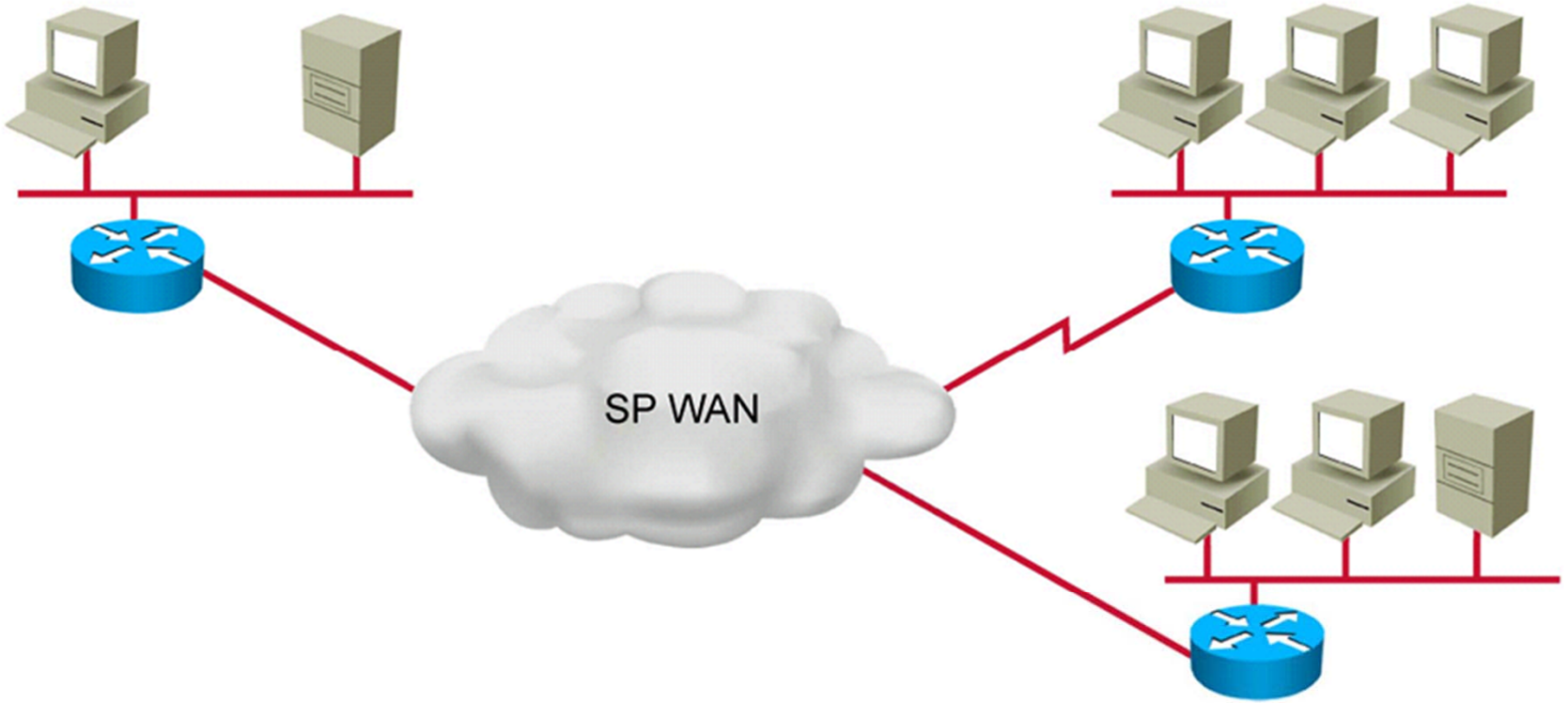
	WANs	LANs
Area	Wide geographic area	Single building or small geographic area
Ownership	Subscription to outside service provider	Owned by organization
Cost	Recurring	Fixed

WANs vs. LANs (Cont.)

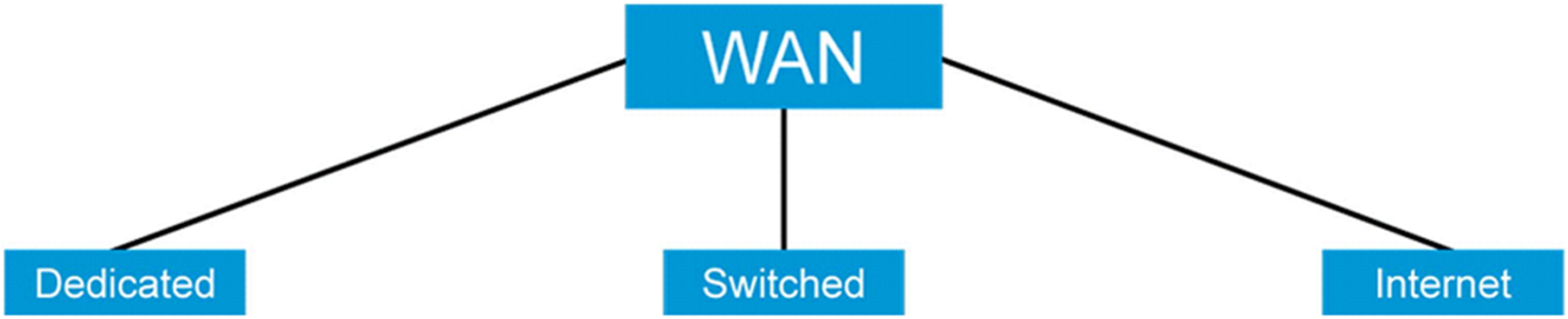


Role of Routers in WANs

WANs vs. LANs



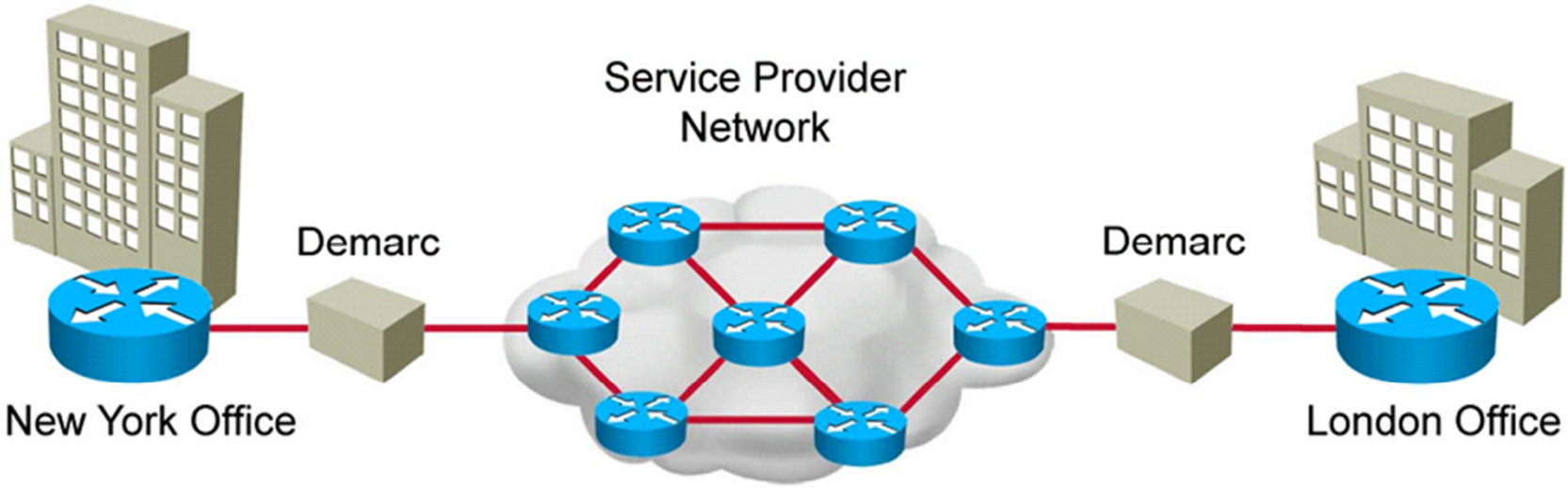
WAN Communication Link Options



Point-to-Point Connectivity

Ethernet emulation:

- Simple
- Affordable
- Flexible



Configuring a Point-to-Point Link

Configuring the Branch router with an IP address and interface description


```
Branch(config)#interface GigabitEthernet0/1
Branch(config-if)#ip address 192.168.1.1 255.255.255.252
Branch(config-if)#description WAN Link to HQ
Branch(config-if)#no shutdown
```

- Use ping to verify end-to-end connectivity

Summary

- A WAN allows the transmission of data across broad geographic distances.
- A WAN is a collection of LANs, and routers play a central role in transmitting data through WANs.
- There are three WAN communication link options: dedicated communication links, switched communication links, and public connections.
- A common type of WAN connectivity is the point-to-point connection that emulates Ethernet.
- Configuring an interface for emulated Ethernet WAN connectivity consists of setting the IP address and enabling the interface.

Introducing Dynamic Routing Protocols

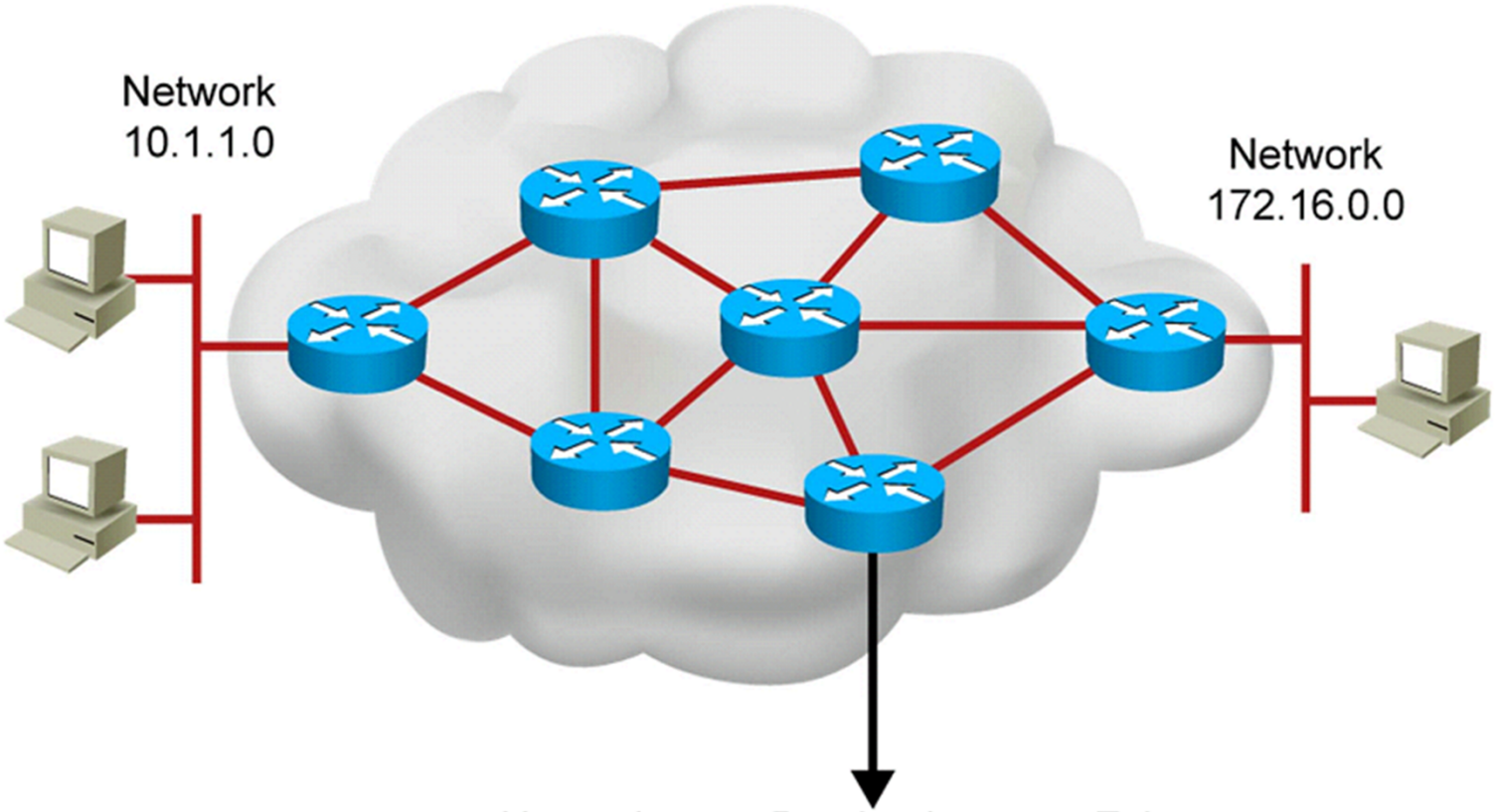
Building a Medium-Sized Network

Purpose of Dynamic Routing Protocols

Dynamic routing protocol characteristics follow:

- Routing protocols are sets of processes, algorithms, and messages that are used to exchange routing information.
- After directly connected routes have been installed, a router populates its routing table with the best paths to remote destinations, as chosen by the routing protocol.
- After the path is determined, a router can route to the learned networks.

Purpose of Dynamic Routing Protocols (Cont.)



Network Protocol	Destination Network	Exit Interface
EIGRP	10.1.1.0	FA0/1
OSPF	172.16.0.0	FA0/2

Purpose of Dynamic Routing Protocols (Cont.)

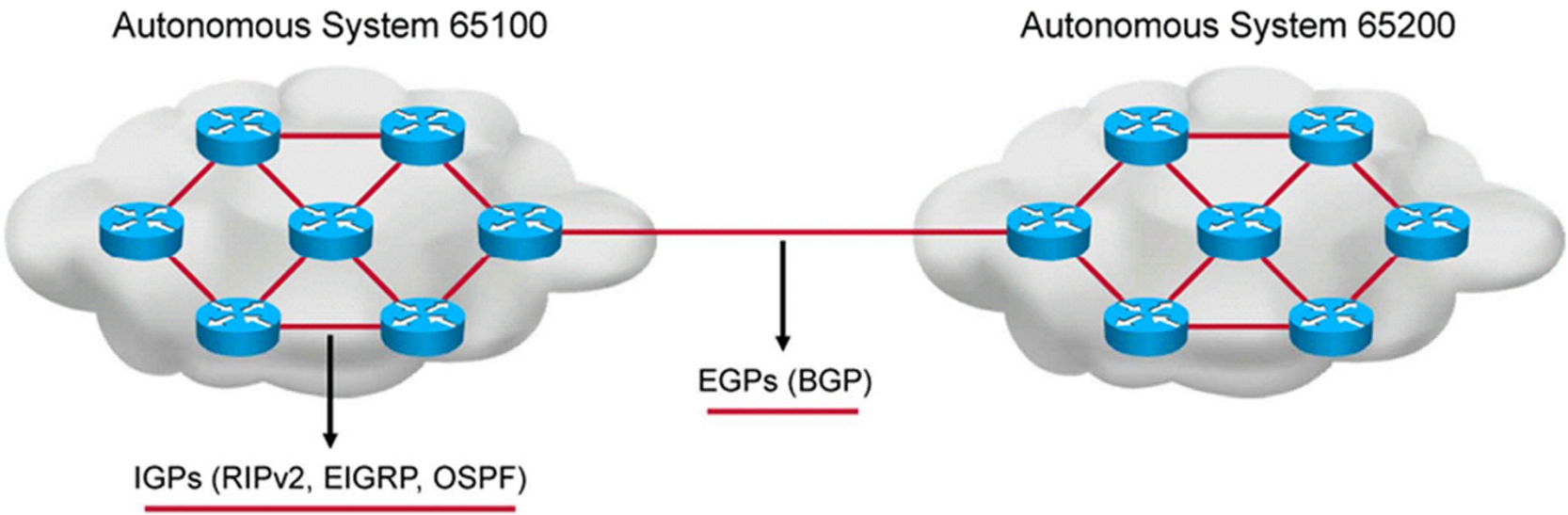
Dynamic routing protocols do as follows:

- Discover remote networks
- Maintain up-to-date routing information
- Choose the best path to destination networks
- Find a new best path if the current path is no longer available

Interior and Exterior Routing Protocols

Characteristics of autonomous systems:

- An AS is a collection of networks within a common administrative domain.
- IGPs operate within an AS.
- EGPs connect different autonomous systems.



Distance Vector and Link-State Routing Protocols

The types of dynamic routing protocols follow:

- **Distance vector:** RIP
- **Advanced distance vector:** EIGRP
- **Link-state:** OSPF and IS-IS

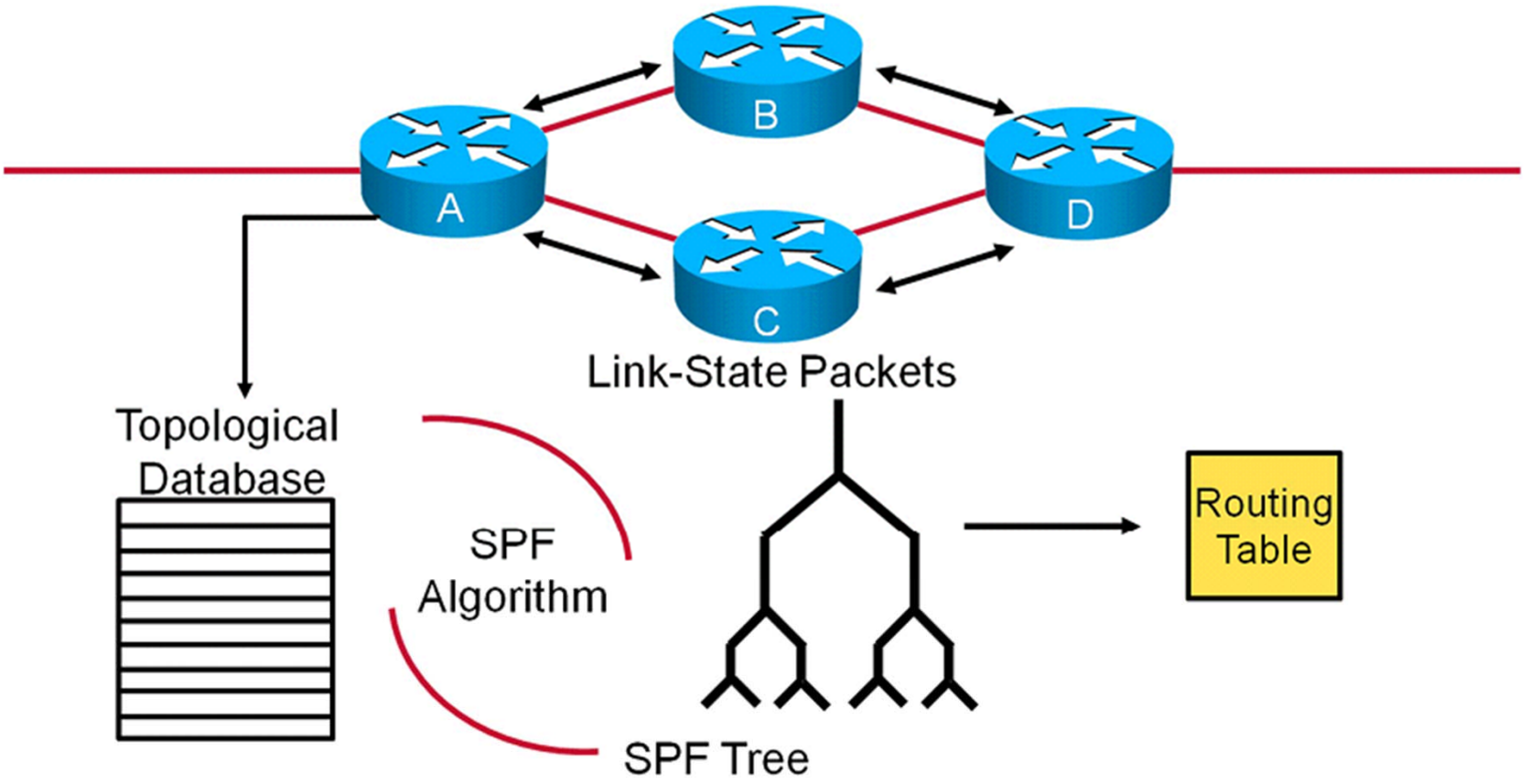
Understanding Link-State Routing Protocols

Characteristics of link-state routing protocols follow:

- A complete view of the network topology is created.
- Updates are sent when there is a link change.
- They are associated with SPF calculations.
- They use the link-state information to do as follows:
  - Create a topology map.
  - Select the best path to all destination networks in the topology.

Understanding Link-State Routing Protocols (Cont.)

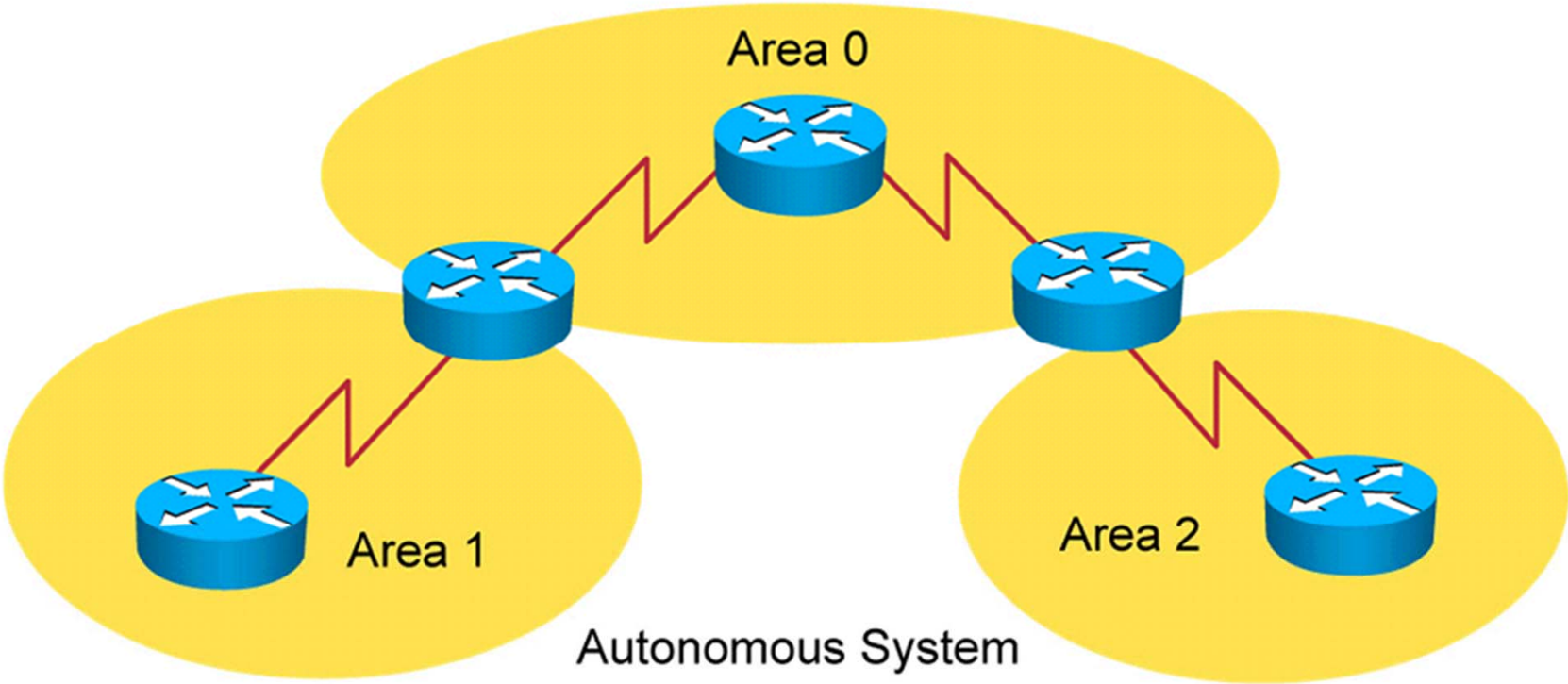
Link-state protocol components:



Understanding Link-State Routing Protocols (Cont.)

Hierarchical routing:

- Consists of areas and autonomous systems



Summary

- Routing protocols are a set of processes, algorithms, and messages that are used to exchange routing information.
- IGPs operate within an AS, while EGPs connect different autonomous systems.
- The distance vector routing approach determines the direction (vector) and distance to any link in the internetwork.
- Routers running link-state routing protocols maintain their own view of the network, so the router is less likely to propagate incorrect information that is provided by another router.

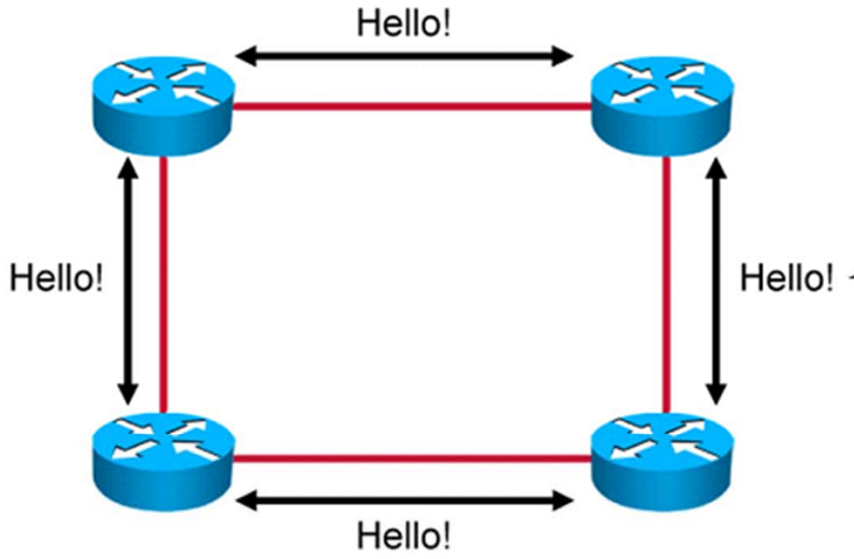

Implementing OSPF
Building a Medium-Sized Network
© 2013 Cisco Systems, Inc.
ICND1 — 4-69

Introducing OSPF

- Developed by the IETF
- Creates a neighbor relationship by exchanging hello packets
- Propagates LSAs rather than routing table updates:
  - Link: Router interface
  - State: Description of an interface and its relationship to neighboring routers
- Floods LSAs to all OSPF routers in the area, not just directly connected routers
- Pieces together all of the LSAs that are generated by the OSPF routers to create the OSPF link-state database
- Uses the SPF algorithm to calculate the shortest path to each destination and places it in the routing table

OSPF Adjacencies

- OSPF routers first establish adjacencies.
- Hello packets are periodically sent to multicast address 224.0.0.5.
- Routers must agree on certain information inside the hello packet before an adjacency can be established.

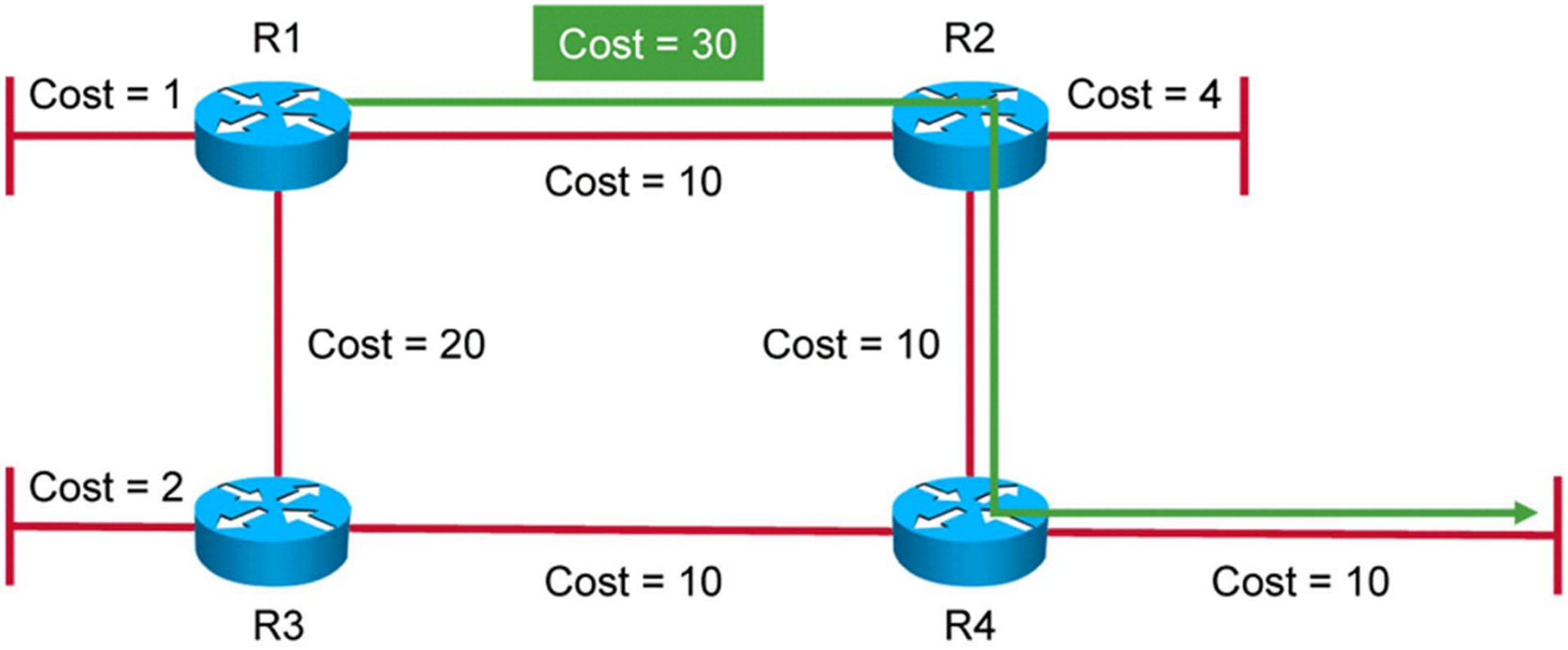


Router ID
Hello/Dead Interval*
Neighbors
Area ID*
Router Priority
DR IP Address
BDR IP Address
Authentication Data*

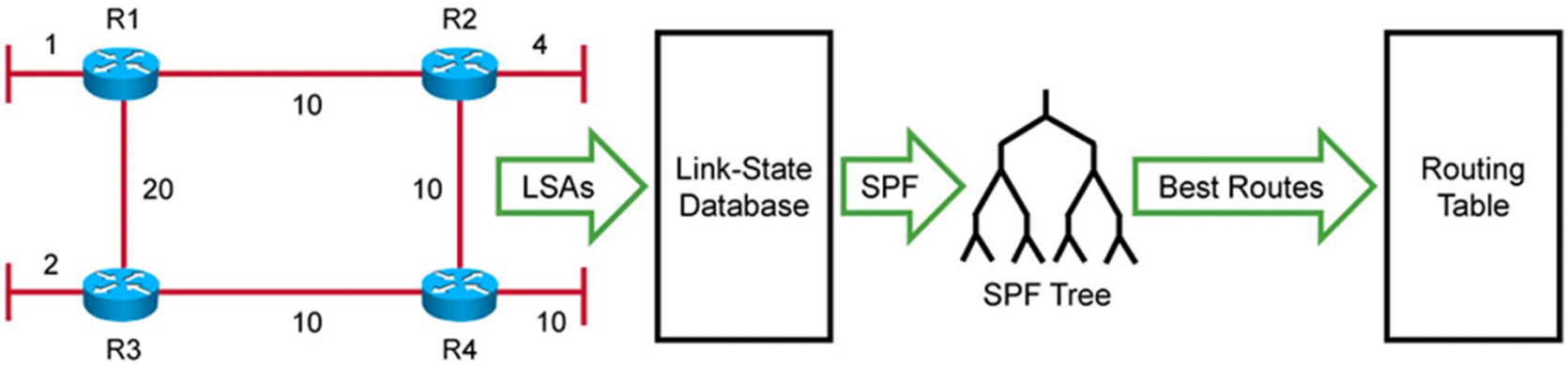
*Must Match on Neighbor

SPF Algorithm

- OSPF uses a path cost as a metric.
- By default, cost is calculated based on interface bandwidth.
- Cost = Reference bandwidth / interface bandwidth, where reference bandwidth is 100 Mb/s.



SPF Algorithm (Cont.)



R1 SPF Tree		
Destination	**Shortest Path**	**Cost**
R2 LAN	R1 to R2	14
R3 LAN	R1 to R3	22
R4 LAN	R1 to R4	30

Router ID

- The number by which the router is known to OSPF can be set manually using the **router-id** command.
- If **router-id** is not configured, the highest IP address on the active loopback interface at the moment of OSPF process startup is selected as the router ID.
- If there is no active loopback interface, then the router selects the highest IP address on the active interface at the moment of OSPF process startup.

Router ID (Cont.)

```
RouterX#show ip protocols

Routing Protocol is "ospf 100"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 10.2.2.2
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4

<output omitted>
```

- Verifies the device OSPF router ID

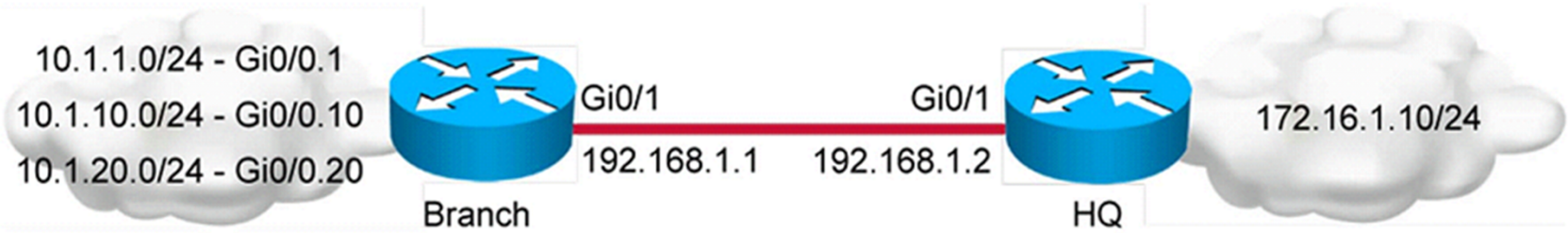
Configuring Single-Area OSPF


```
Branch(config)#router ospf 1
Branch(config-router)#network 10.0.0.0 0.255.255.255 area 0
```

```
Branch(config)#interface GigabitEthernet 0/1
Branch(config-if)#ip ospf 1 area 0
```

- Configures OSPF on the Branch router

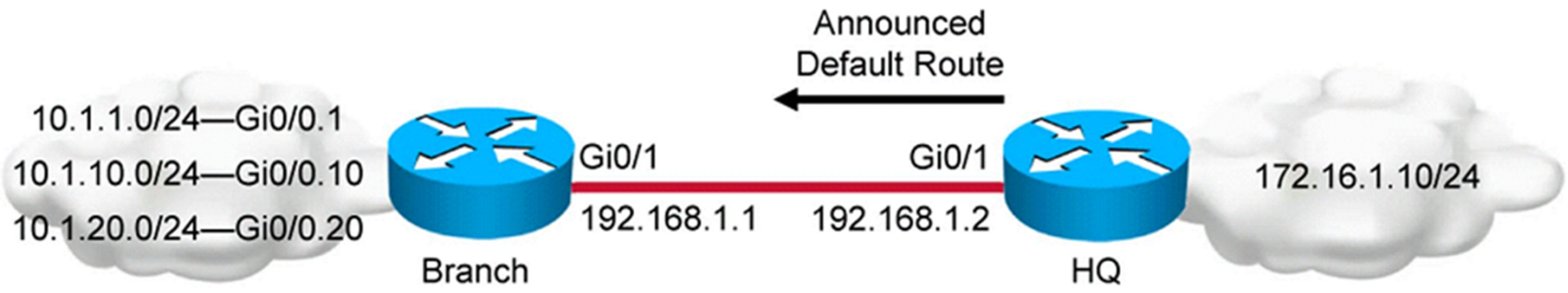
Configuring Single-Area OSPF (Cont.)




```
Branch(config)#router ospf 1
Branch(config-router)#passive-interface GigabitEthernet 0/0.1
```

- Configures the passive interface on GigabitEthernet 0/0.1 on the Branch router.

Configuring Single-Area OSPF (Cont.)



- The HQ router announces the default route through OSPF.

Verifying OSPF Configuration

```
Branch#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    10.0.0.0 0.255.255.255 area 0
  Routing on Interfaces Configured Explicitly (Area 0):
    GigabitEthernet0/1
  Passive Interface(s):
    GigabitEthernet0/0.1
  Routing Information Sources:
    Gateway         Distance      Last Update
    1.1.1.1              110      00:50:43
  Distance: (default is 110)
```

- Verifies that OSPF on the Branch router is routing for all networks that it needs to

Verifying OSPF Configuration (Cont.)

```
Branch#show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Gi0/0.1      1     0               10.1.1.1/24        1     DR    0/0
Gi0/1        1     0               192.168.1.1/24     1     BDR   1/1
Gi0/0.20     1     0               10.1.20.1/24       1     DR    0/0
Gi0/0.10     1     0               10.1.10.1/24       1     DR    0/0
```

- Shows which interfaces are enabled for the OSPF routing process

Verifying OSPF Configuration (Cont.)

```
Branch#show ip ospf neighbor

Neighbor ID   Pri    State      Dead Time    Address         Interface
1.1.1.1         1    FULL/DR    00:00:36     192.168.1.2     GigabitEthernet0/1
```

- Shows OSPF neighbors

Verifying OSPF Configuration (Cont.)

```
Branch# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
<output omitted>
Gateway of last resort is 192.168.1.2 to network 0.0.0.0
O*E2  0.0.0.0/0 [110/1] via 192.168.1.2, 00:02:45, GigabitEthernet0/1
      10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C        10.1.1.0/24 is directly connected, GigabitEthernet0/0.1
L        10.1.1.1/32 is directly connected, GigabitEthernet0/0.1
C        10.1.10.0/24 is directly connected, GigabitEthernet0/0.10
L        10.1.10.1/32 is directly connected, GigabitEthernet0/0.10
C        10.1.20.0/24 is directly connected, GigabitEthernet0/0.20
L        10.1.20.1/32 is directly connected, GigabitEthernet0/0.20
      172.16.0.0/32 is subnetted, 1 subnets
O        172.16.1.100 [110/2] via 192.168.1.2, 00:56:58, GigabitEthernet0/1
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/1
L        192.168.1.1/32 is directly connected, GigabitEthernet0/1
```

- The routing table displays OSPF routes.

Summary

- OSPF is a link-state routing protocol that uses an area hierarchy.
- OSPF exchanges hello packets to establish neighbor adjacencies between routers.
- The SPF algorithm uses a cost metric to determine the best path. Lower cost indicates a better path.
- Configuration of basic OSPF requires two steps:
  - Enable the OSPF routing process.
  - Identify the networks to advertise.
- The **show ip ospf neighbor** command displays OSPF neighbor information on a per-interface basis.

Module Summary

- VLANs are independent LAN networks that address segmentation, security, and organizational flexibility.
- Inter-VLAN communication cannot occur without a Layer 3 device (a Layer 3 switch or router).
- The DHCP server provides dynamic IP address assignments to end hosts, reducing errors and the time that is needed to administer address assignment.
- A WAN is a collection of LANs, and routers play a central role in transmitting data through these networks.
- Routing protocols are a set of processes, algorithms, and messages that are used to exchange routing information.
- Configuration of basic OSPF requires two steps:
  - Enable the OSPF routing process.
  - Identify the networks to advertise.