18 单区域 OSPF

单元目标

模块标题： 单区域 OSPF 的概念

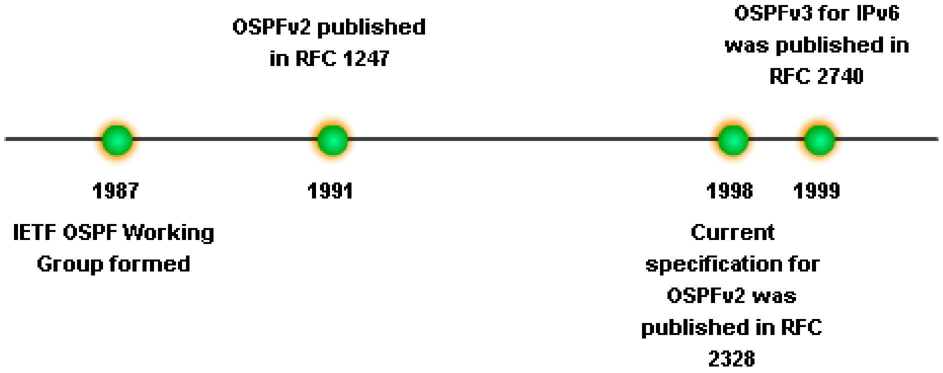
模块目标: 说明在点对点网络和广播多接入网络中，单区域OSPF的工作原理。

主题标题	主题目标
OSPF 的功能和特征	描述 OSPF 的基本功能和特征。
OSPF 数据包	描述单区域 OSPF 中使用的 OSPF 数据包类型。
OSPF 的配置	阐述单区域 OSPF 的配置。

18.1 OSPF的功能和特征

OSPF简介

- OSPF 协议是一种**链路状态路由协议**，是为了替代距离矢量路由协议 RIP 而开发的。OSPF 与 RIP 相比具有巨大优势，因为它既能**快速收敛**，又能扩展到**更大型的网络**。
- OSPF 使用了**区域**的概念。网络管理员可以把路由域划分为不同的区域，以此对路由更新流量实施控制。
  - 链路指的是路由器上的接口、两台路由器之间直连的网段，或者末节网络，比如只连接了一台路由器的以太网 LAN 。
  - 有关各条链路的状态的信息称为链路状态。链路状态信息中包含网络前缀、前缀长度和开销。



OSPF简介

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的组件（续）

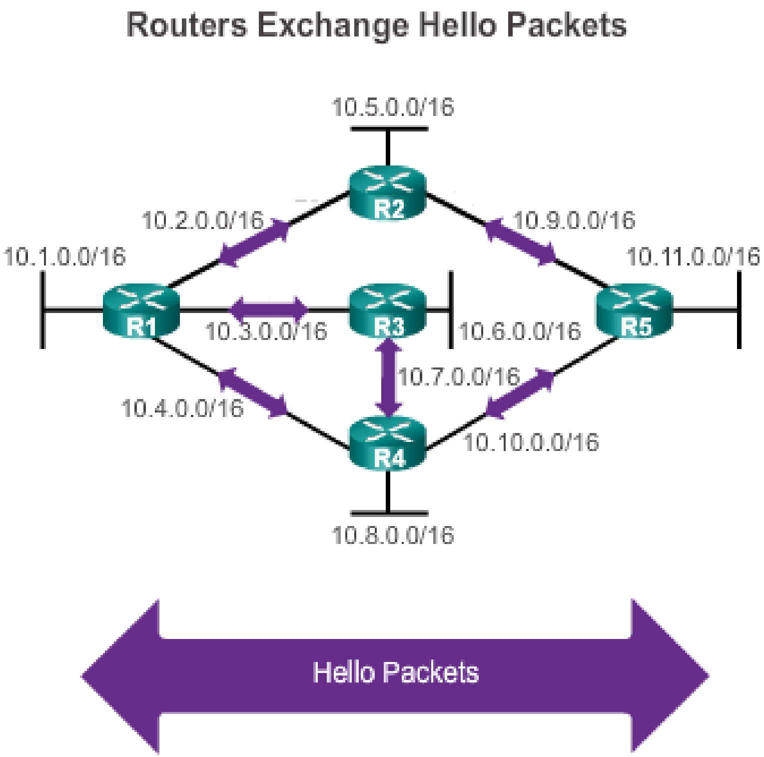
OSPF 消息是用来创建和维护三个 OSPF 数据库的，如下所示：

数据库	表	说明
邻接数据库	邻居表	•列出了已经与路由器建立了双向通信的所有邻居。 •该表对于每个路由器都是唯一的。 •我们可以使用**show ip ospf neighbor** 命令来进行查看。
链路状态数据库 (LSDB)	拓扑表	•列出网络中所有其他路由器的相关信息。 •这个数据库代表了网络拓扑。 •某个区域内的所有路由器都有相同的 LSDB。 •我们可以使用**show ip ospf database** 命令来进行查看。
转发数据库	路由表	•在链路状态数据库上运行算法时生成的路由列表。 •每台路由器的路由表都是唯一的，都包含向其他路由器发送数据包的方式和位置。 •我们可以使用**show ip route** 命令来进行查看。

OSPF的组件

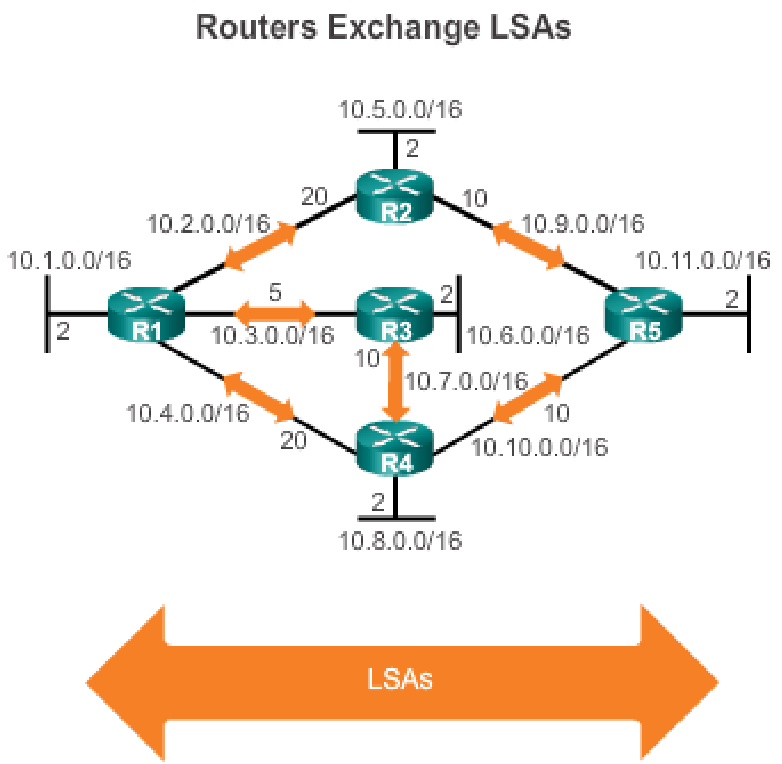
- 所有路由协议具有相似的组件。它们都使用路由协议消息来交换路由信息。这些消息有助于构建数据结构，然后使用路由算法进行处理。
- 运行OSPF的路由器之间会交换OSPF消息，它们会使用五种类型的数据包来传输路由信息。
  - Hello 数据包
  - 数据库描述数据包
  - 链路状态请求数据包
  - 链路状态更新数据包
  - 链路状态确认数据包

Link-State Operation



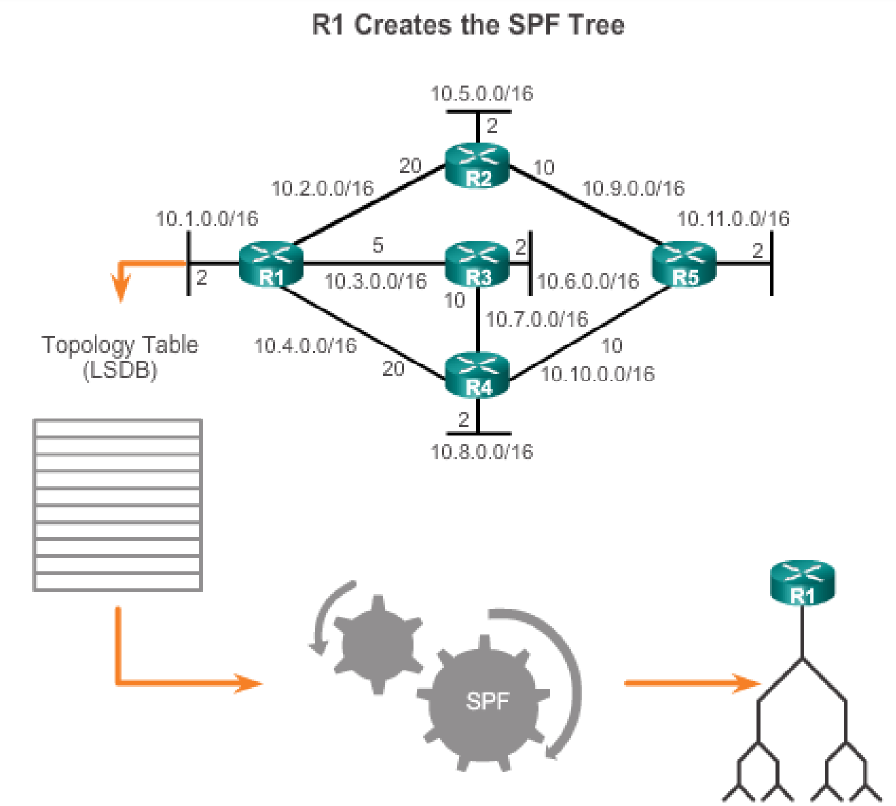
If a neighbor is present, the OSPF-enabled router attempts to establish a neighbor adjacency with that neighbor

Link-State Operation (cont.)



- 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.

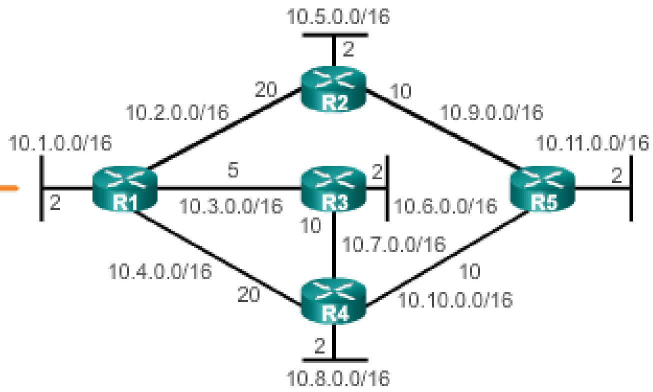
Link-State Operation



- 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.

Link-State Operation (cont.)

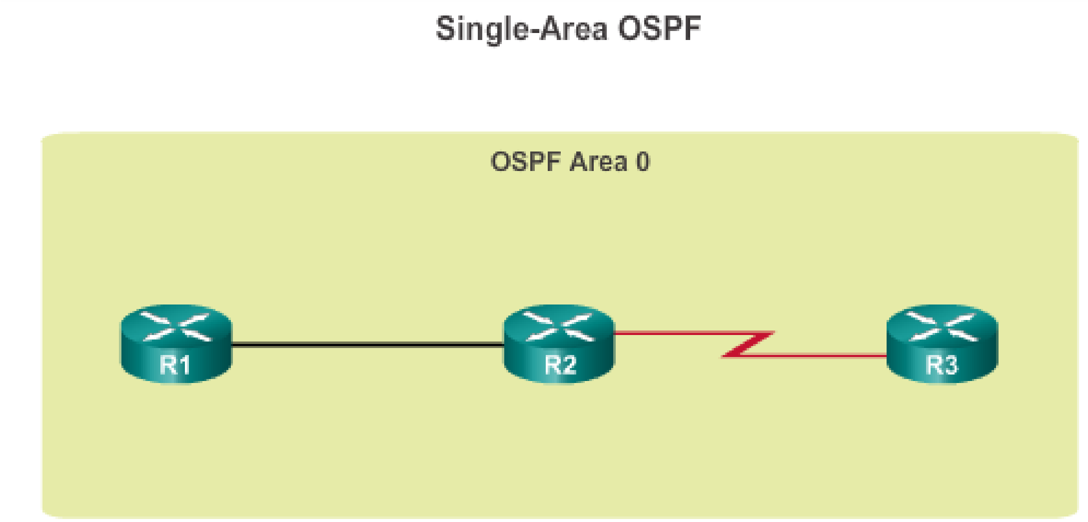
Content of the R1 SPF Tree



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.

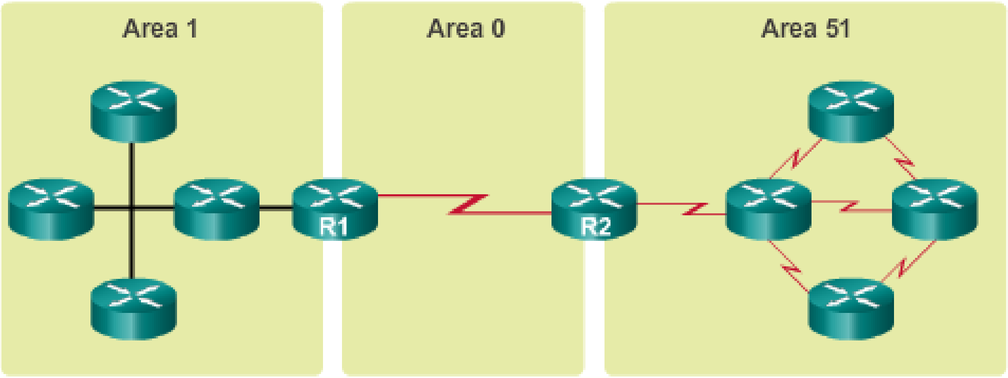
Single-area and Multiarea OSPF



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

Single-area and Multiarea OSPF

Multiarea OSPF



- 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.

- 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 the run the SPF algorithm.

18.2 OSPF 数据包

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

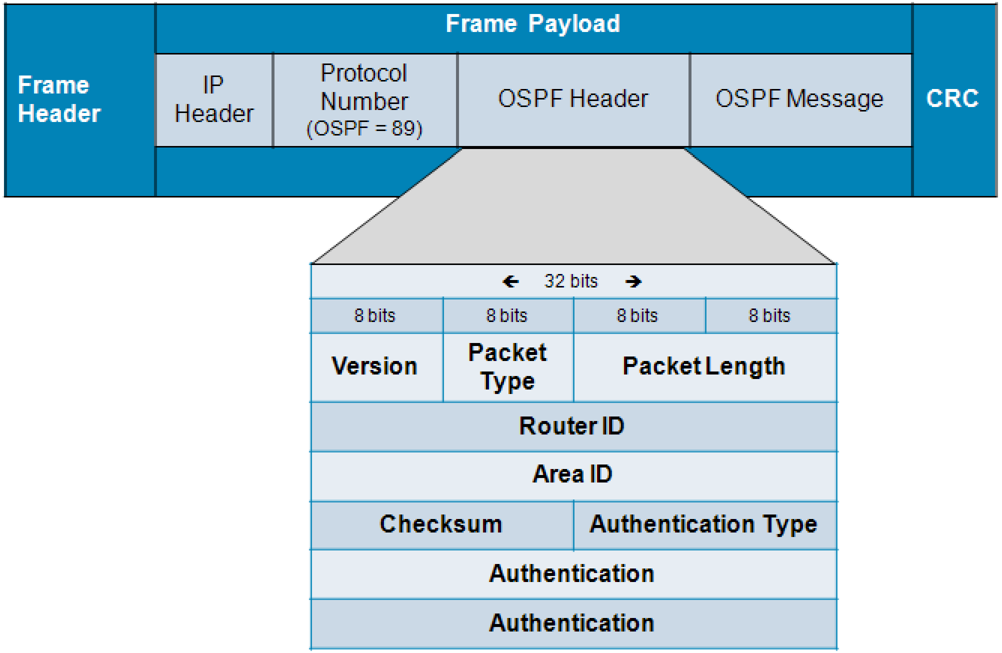
IP Packet
IP Source Address = Address of sending interface
IP Destination Address = Multicast: 224.0.0.5 or 224.0.0.6
Protocol Field = 89 for OSPF

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

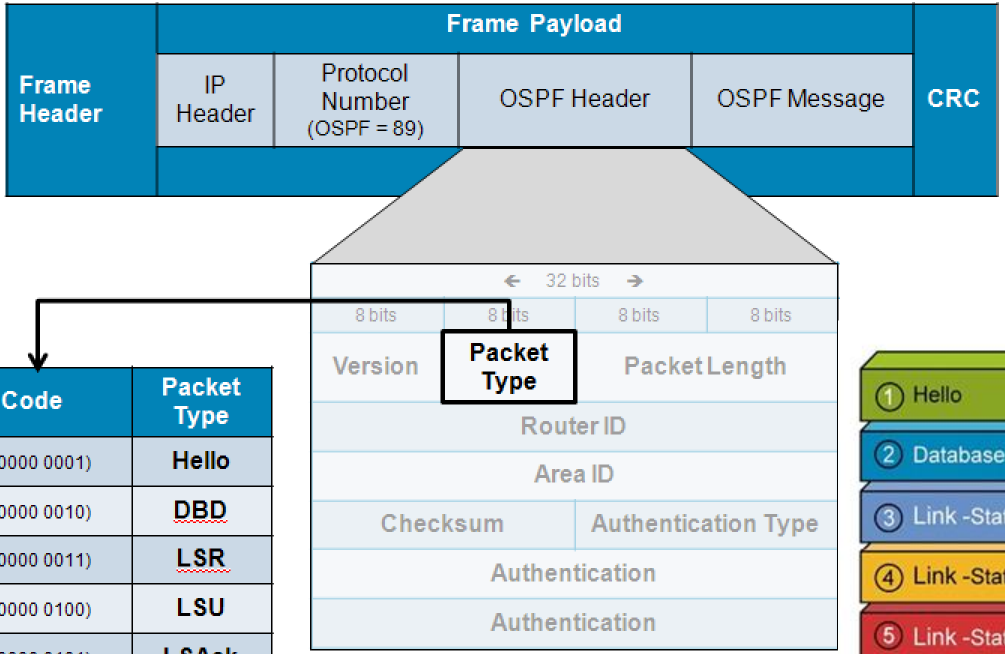
OSPF Packet Types
0x01 Hello
0x02 Database Description (DD)
0X03 Link State Request
0X04 Link State Update
0X05 Link State Acknowledgment

Encapsulating OSPF Messages

- OSPF Header



Types of OSPF Packets



Code	Packet Type
1 (0000 0001)	Hello
2 (0000 0010)	DBD
3 (0000 0011)	LSR
4 (0000 0100)	LSU
5 (0000 0101)	LSAck

Types of OSPF Packets

- Five packet types make OSPF capable of sophisticated and complex communications.

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

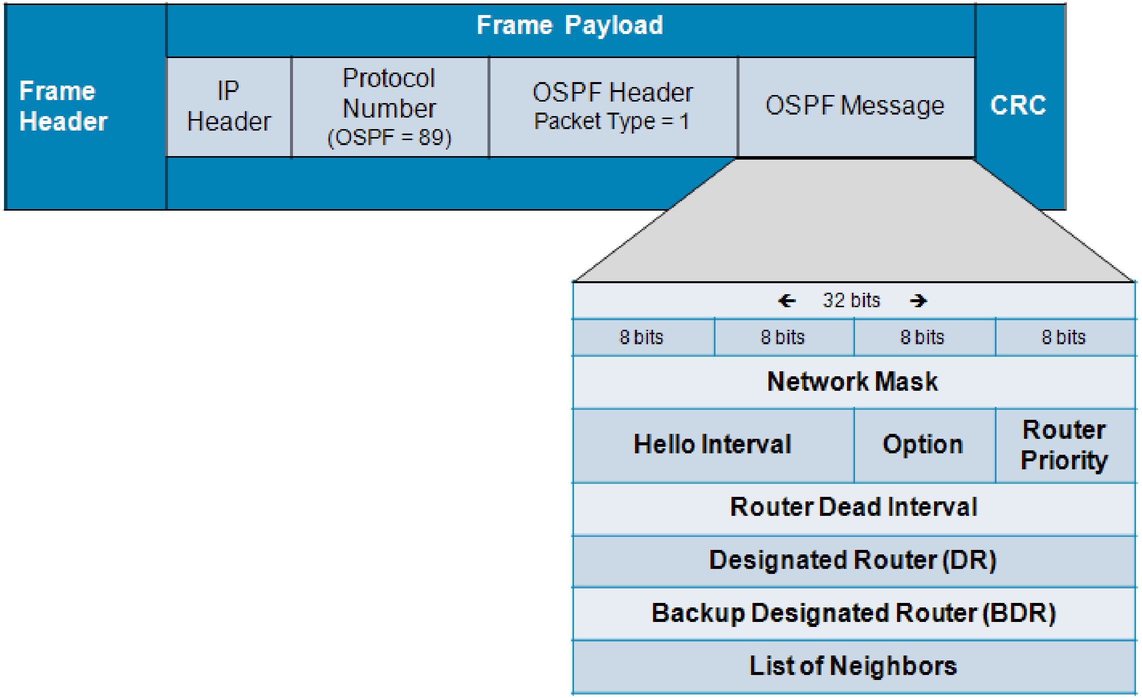
Hello Packet

OSPF Type 1 packet = Hello packet:

- Hello packets are used to:
  - Discover directly connected OSPF neighbors.
  - Establish and maintain neighbor adjacencies with these directly connected neighbors.
  - Advertise parameters on which two routers must agree to become neighbors.
  - Elect the DR and BDR on multi-access networks like Ethernet and Frame Relay.

OSPF Messages

Hello Packet (cont.)



Hello Packet Intervals

- Hello packet fields must match on neighboring routers for them to establish an adjacency:
  - Hello interval
  - Dead interval
  - Network type
  - Area id
  - Authentication type
  - Authentication password
  - Stub area flag

Hello Packet Intervals

- OSPF Hello and Dead Intervals
  - By default, Hello interval is 10 seconds on multiaccess and point-to-point segments.
  - Hello interval is 30 seconds on non-broadcast multiaccess (NBMA) segments.
  - Dead interval is a default of four times the Hello interval.
- If the Dead interval expires, OSPF will remove that neighbor from its link-state database.
- To 224.0.0.5 in IPv4 and FF02::5 in IPv6 (all OSPF routers)

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

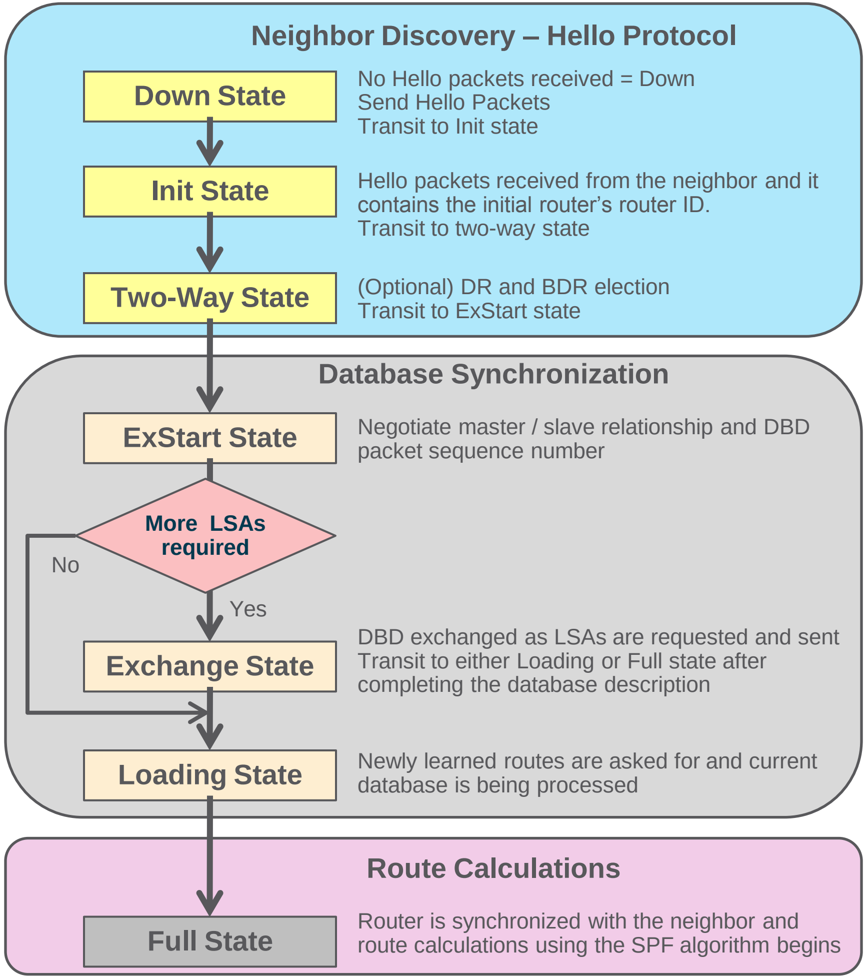
- An LSU contains one or more LSAs.
- LSAs contain route information for destination networks.

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

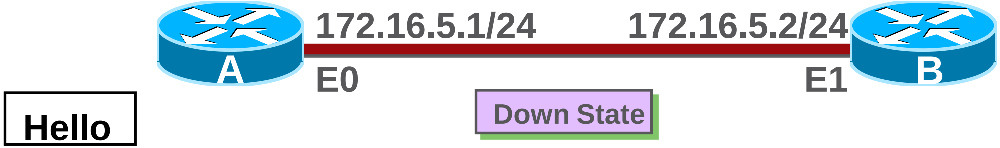
18.3 OSPF 的工作原理

OSPF States

- When an OSPF router is initially connected to a network it attempts to create adjacencies with neighbors.
- To do so, it progresses through these various states using the 5 OSPF packet types.

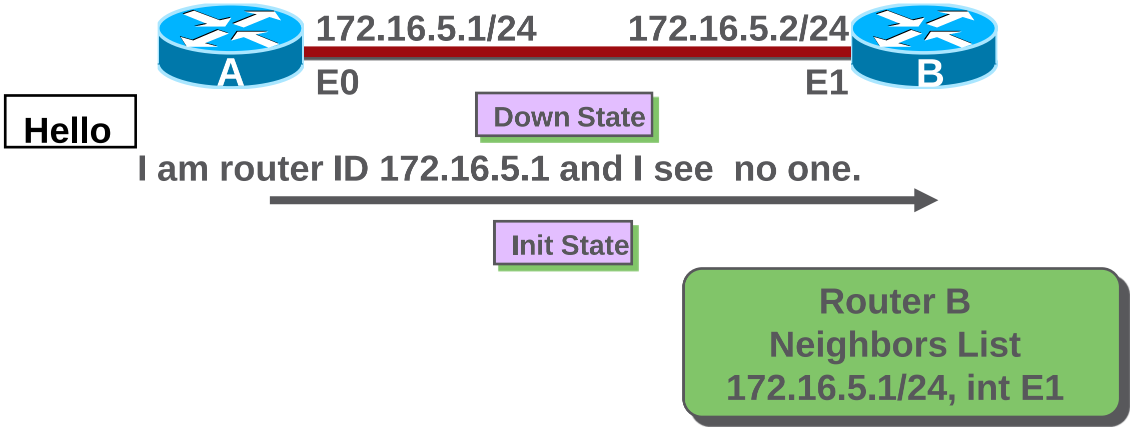


Establish Neighbor Adjacencies



Down State – No Hello received

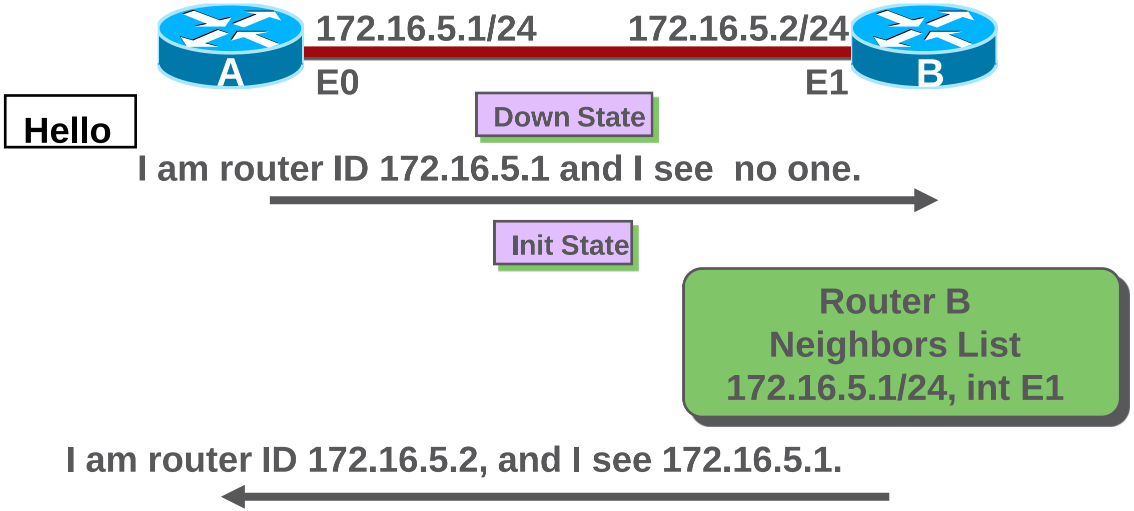
Establish Neighbor Adjacencies



A begins multicasts **OSPF Hello packets** (Des. IP **224.0.0.5**), advertising its own **Router ID**.

– Init State – Hello received, but not with this router's Router ID

Establish Neighbor Adjacencies



OSPF Operation

Establish Neighbor Adjacencies

Down State

Hello

I am router ID 172.16.5.1 and I see no one.

Init State

Router B
Neighbors List
172.16.5.1/24, int E1

I am router ID 172.16.5.2, and I see 172.16.5.1.

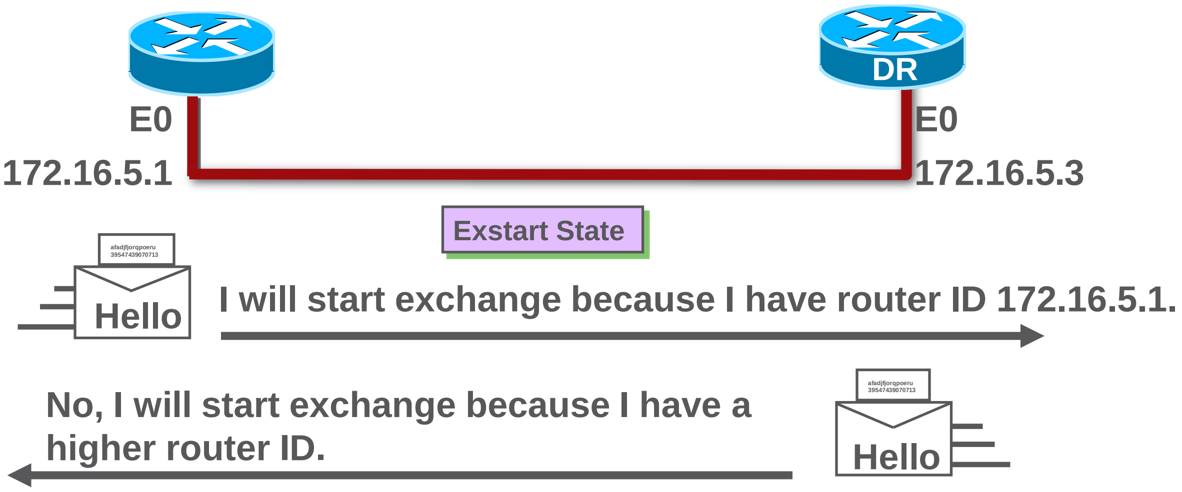
Router A
Neighbors List
172.16.5.2/24, int E0

Two-Way State

Two-way State – Hello received, and with this router's Router ID

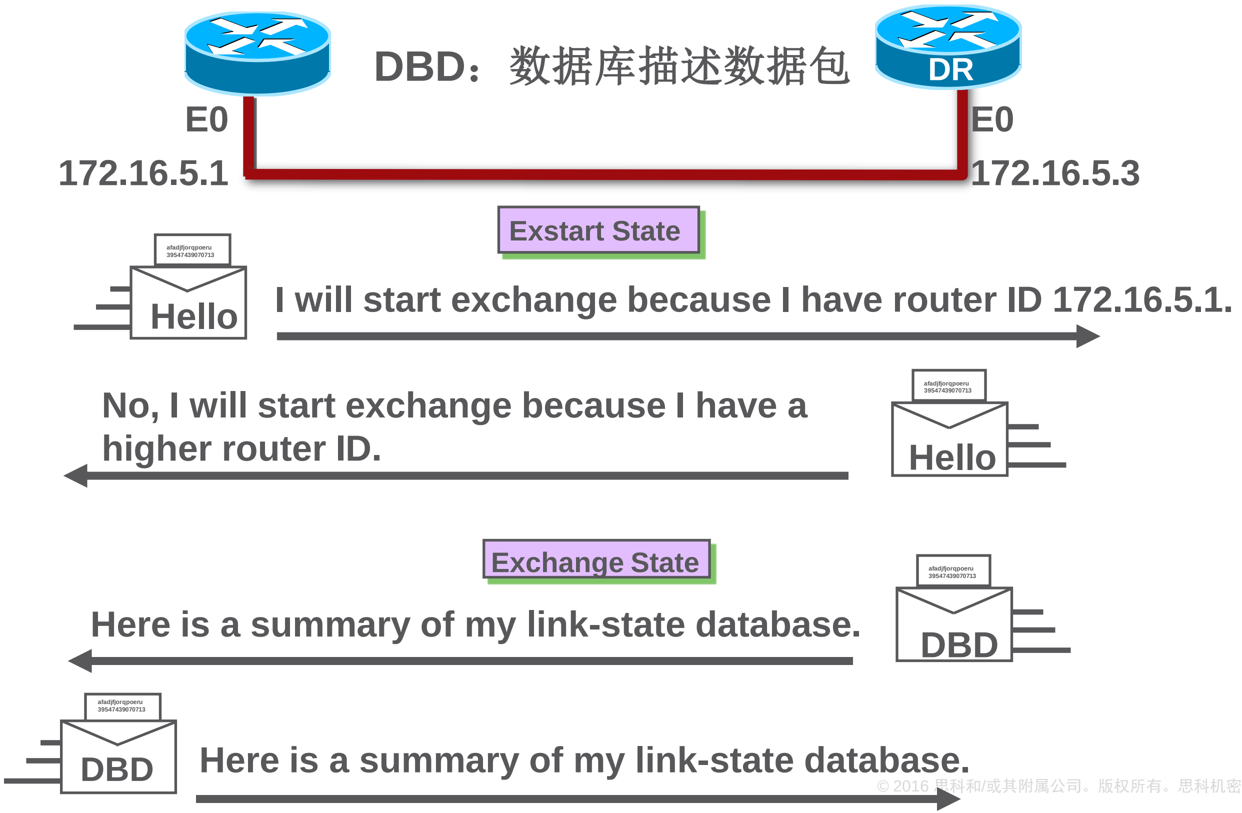
OSPF Operation

Establish Neighbor Adjacencies



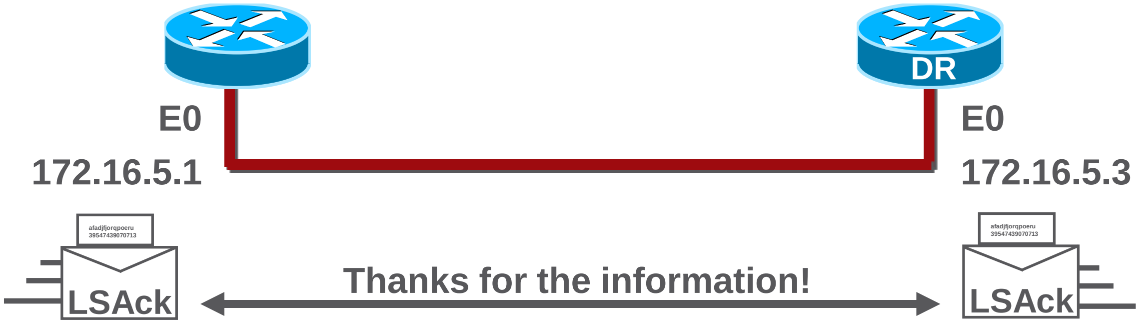
OSPF Operation

Establish Neighbor Adjacencies



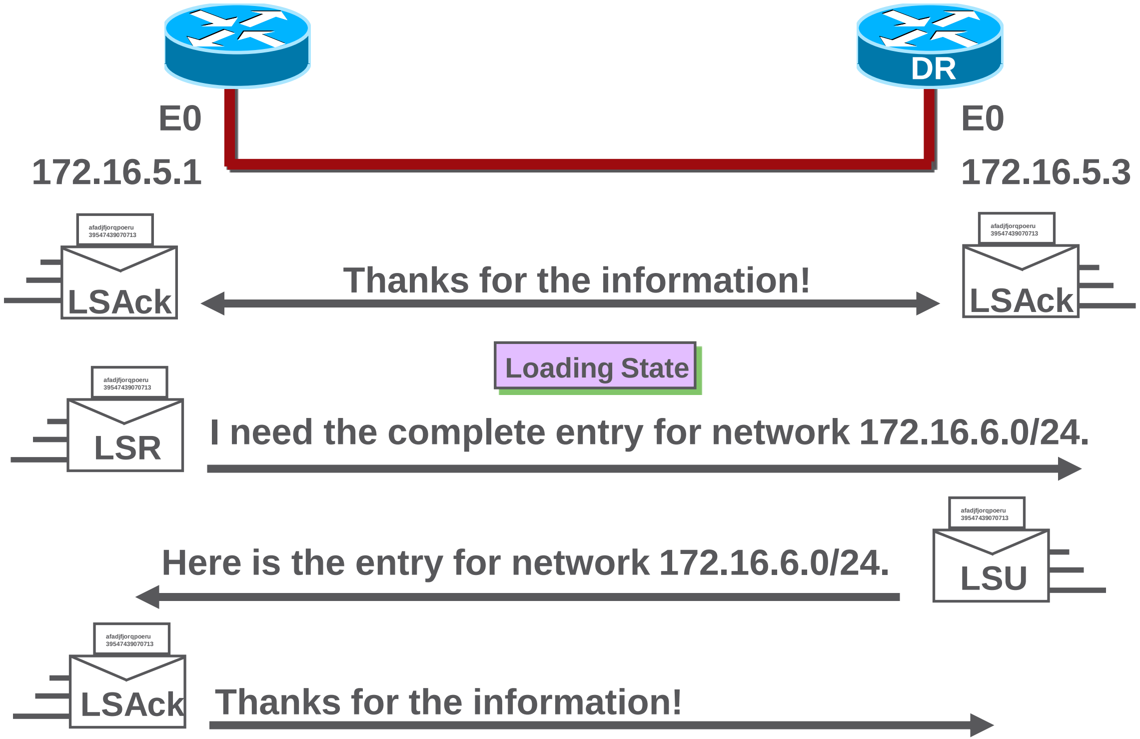
OSPF Operation

Establish Neighbor Adjacencies

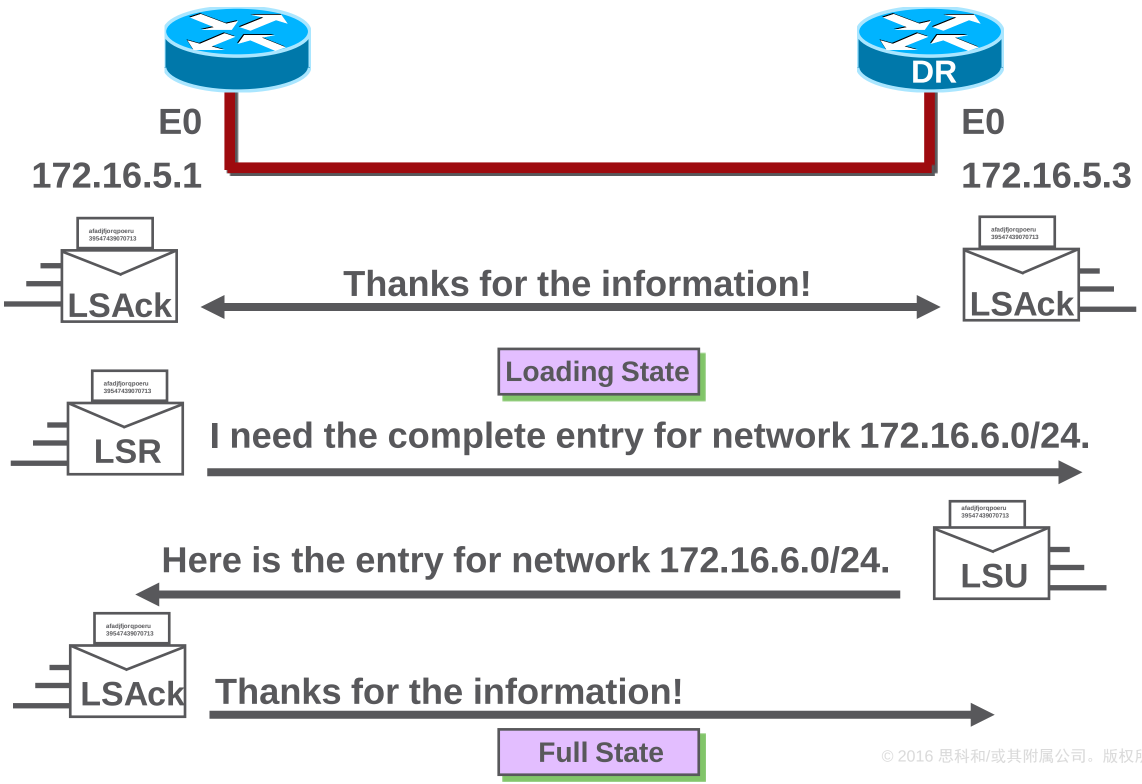


OSPF Operation

Establish Neighbor Adjacencies



Establish Neighbor Adjacencies



同步 OSPF 数据库

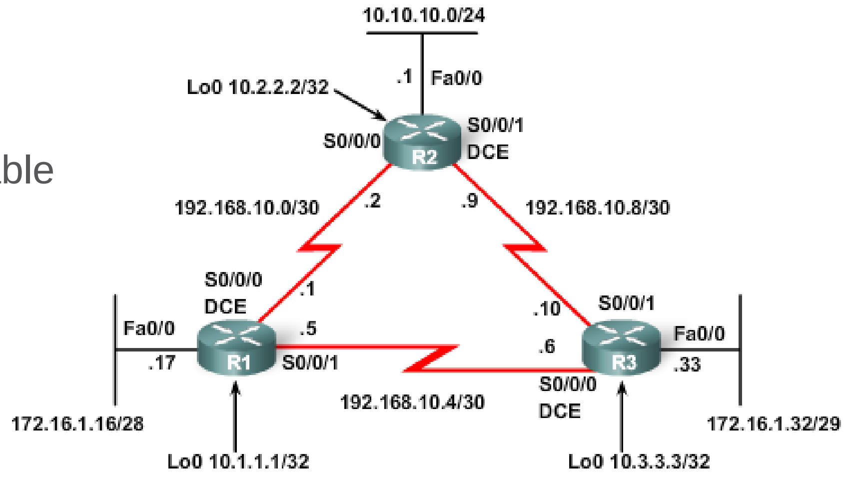
当所有 LSR 都交换完成并满足要求后，路由器就会被视为已同步并处于 full 状态。发送更新 (LSUs)：

- 发现更改时（增量更新）
- 每 30 分钟

18.4 OSPFv2配置

OSPF参考拓扑

- Topology & Addressing Table



Device	Interface	IP Address	Subnet Mask
R1	Fa0/0	172.16.1.17	255.255.255.240
	S0/0/0	192.168.10.1	255.255.255.252
	S0/0/1	192.168.10.5	255.255.255.252
R2	Fa0/0	10.10.10.1	255.255.255.0
	S0/0/0	192.168.10.2	255.255.255.252
	S0/0/1	192.168.10.9	255.255.255.252
R3	Fa0/0	172.16.1.33	255.255.255.248
	S0/0/0	192.168.10.6	255.255.255.252
	S0/0/1	192.168.10.10	255.255.255.252

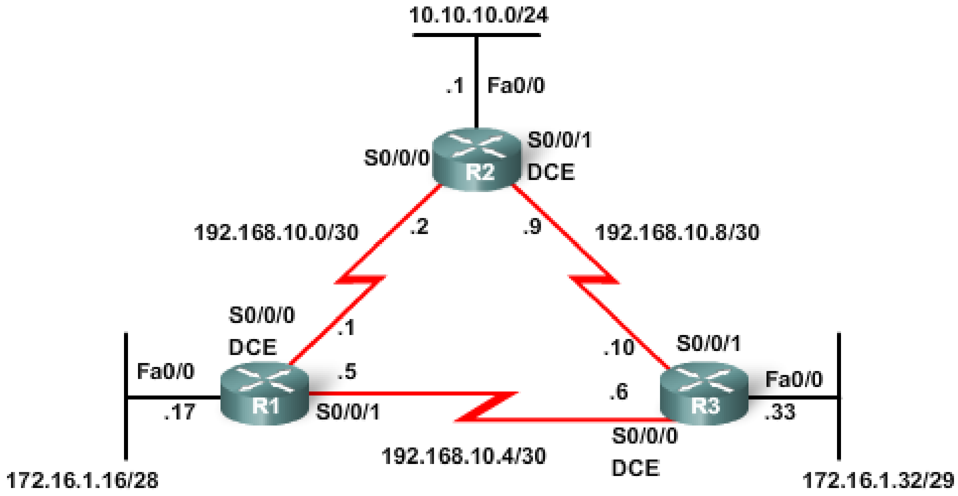
The router OSPF Command

- Enable OSPF on a router use the following command:

  R1(config)# **router ospf** *process-id*

Process id :

- A locally significant number between 1 and 65535.The process-id is locally significant, which means that it does not have to match other OSPF routers.




```
R1(config)#router ospf 1
R1(config-router)#
```

```
R2(config)#router ospf 1
R2(config-router)#
```

```
R3(config)#router ospf 1
R3(config-router)#
```

The network Command

- Configuring OSPF subnetworks use the network command:

Router(config-router)# **network** *network-address wildcard-mask* **area** *area-id*

wildcard mask:

OSPF requires the wildcard mask. the wildcard mask can be configured as the inverse of a subnet mask.

area:

OSPF area is a group of routers that share link state information. An OSPF network can also be configured as multiple areas.

area-id:

area-id refers to the OSPF area. it is good practice to use an area-id of 0 with single-area OSPF.

The network Command

- Wildcard Mask
  - Think of a wildcard mask as the inverse of a subnet mask.
  - An easy way to calculate the inverse of the subnet mask, is to subtract the subnet mask from **255.255.255.255**.

```
                                      ?                     ?

  255.255.255.255
- 255.255.255.000         - 255.255.255.240       - 255.255.252.000
  ---------------           ---------------         ---------------
  000.000.000.255
```

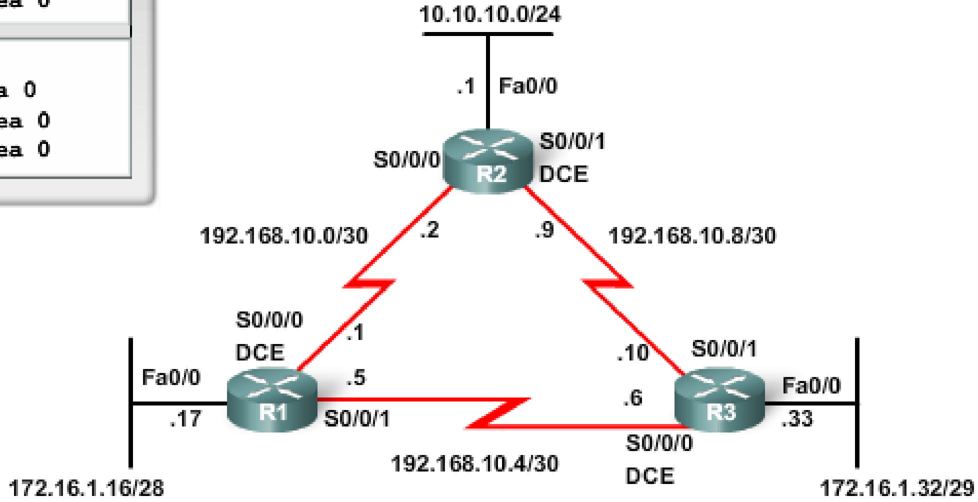
The network Command

- Configuring OSPF Subnetworks

```
R1(config)#router ospf 1
R1(config-router)#network 172.16.1.16 0.0.0.15 area 0
R1(config-router)#network 192.168.10.0 0.0.0.3 area 0
R1(config-router)#network 192.168.10.4 0.0.0.3 area 0
```

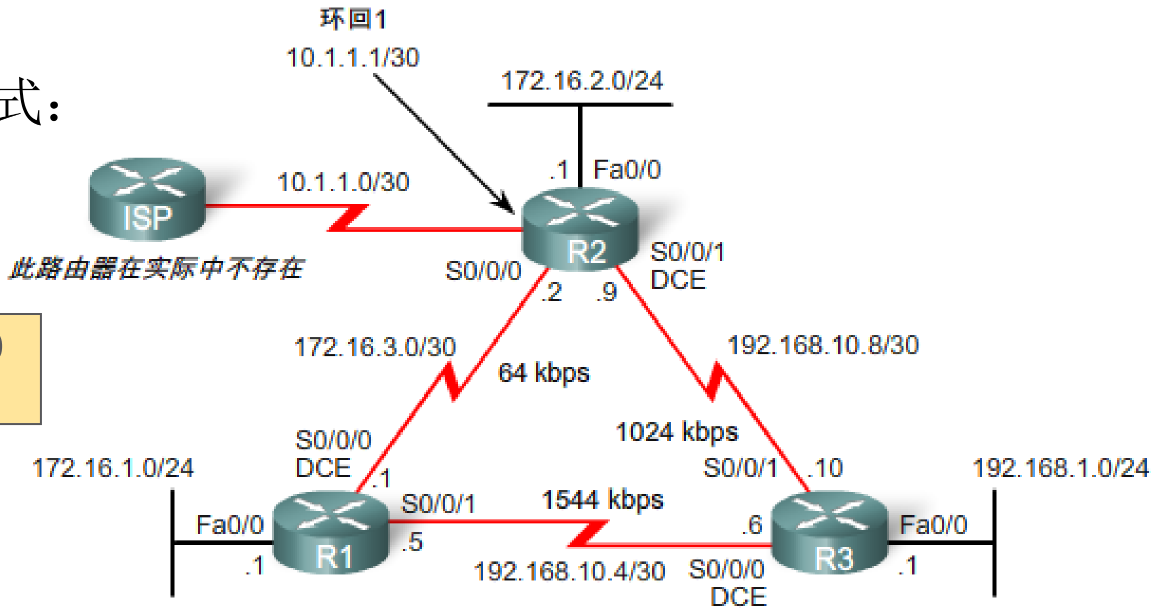
```
R2(config)#router ospf 1
R2(config-router)#network 10.10.10.0 0.0.0.255 area 0
R2(config-router)#network 192.168.10.0 0.0.0.3 area 0
R2(config-router)#network 192.168.10.8 0.0.0.3 area 0
```

```
R3(config)#router ospf 1
R3(config-router)#network 172.16.1.32 0.0.0.7 area 0
R3(config-router)#network 192.168.10.4 0.0.0.3 area 0
R3(config-router)#network 192.168.10.8 0.0.0.3 area 0
```



The network Command

- R1上配置network的方式：



A. net 172.16.0.0 0.0.255.255 a 0
net 192.168.10.0 0.0.0.255 a 0

OK!

B. net 172.16.1.0 0.0.0.255 a 0
net 172.16.3.0 0.0.0.3 a 0
net 192.168.10.4 0.0.0.3 a 0

OK!

C. net 172.16.1.1 0.0.0.0 a 0
net 172.16.3.1 0.0.0.0 a 0
net 192.168.10.5 0.0.0.0 a 0

OK!

使用ip ospf命令配置OSPF

要想直接在接口上配置OSPF，可以使用接口配置命令**ip ospf**。语法如下：

Router(config-if)# **ip ospf** *process-id* **area** *area-id*

在命令前添加**no**来删除network命令。然后进入每个接口并配置**ip ospf**命令。

```
R1(config)# router ospf 10
R1(config-router)#  no network 10.10.1.1 0.0.0.0 area 0
R1(config-router)#  no network 10.1.1.5 0.0.0.0 area 0
R1(config-router)# no network 10.1.1.14 0.0.0.0 area 0
R1(config-router)# interface GigabitEthernet 0/0/0
R1(config-if)# ip ospf 10 area 0
R1(config-if)# interface GigabitEthernet 0/0/1
R1(config-if)# ip ospf 10 area 0
R1(config-if)# interface Loopback 0
R1(config-if)# ip ospf 10 area 0
R1(config-if)#
```

Router IDs

- Determining the Router ID

—The OSPF router ID is used to uniquely identify each router in the OSPF routing domain.

Router ID is determined in the following order:

1. Use the IP address configured with the OSPF router-id command.

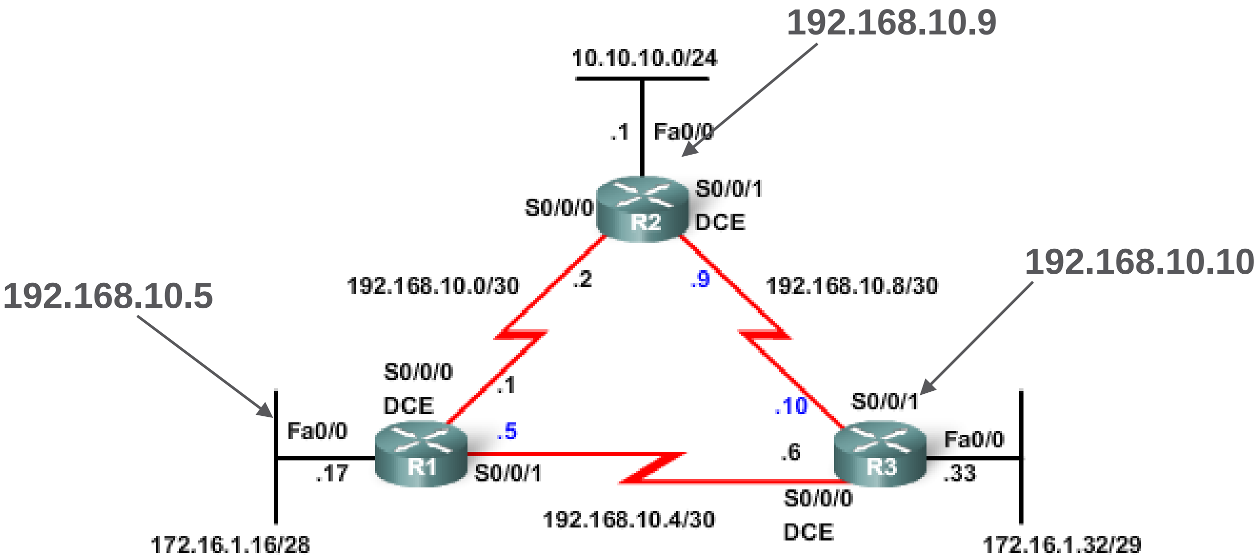
2. If the router-id is not configured, the router chooses highest IP address of any of its loopback interfaces.

3. If no loopback interfaces are configured, the router chooses highest active IP address of any of its physical interfaces.

OSPF Router ID

Router IDs

- Verifying the Router ID



Router IDs

- Loopback Address

    —The advantage of using a loopback interface is that - unlike physical interfaces - it cannot fail.

    —Using a loopback address for the router ID provides stability to the OSPF process.

```
Router(config)#interface loopback number
Router(config-if)#ip address ip-address subnet-mask
```

- The OSPF router-id command

```
Router(config)#router ospf process-id
Router(config-router)#router-id  ip-address
```

Router IDs

- Modifying the Router ID

  —The router ID is selected when OSPF is configured with its first OSPF network command.

  —The router ID can be modified with the IP address from a subsequent OSPF router-id command by reloading the router or by using the following command:

```
Router# clear ip ospf  process-id
```

Router IDs

- OSPF router-id 命令在 IOS 12.0(T) 中引入，且在用于确定路由器 ID 时优先于环回接口和物理接口 IP 地址。
- *重复的 router-ID*

当同一个 OSPF 路由域内的两台路由器具有相同的**router ID** 时，将无法正常路由。如果两台相邻路由器的router ID 相同，则无法建立相邻关系。当出现重复的 OSPF 路由器 ID 时，IOS 将显示一条类似下列的消息：

%OSPF-4-DUP_RTRID1:Detected router with duplicate router ID

Passive Interface

- 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 a Passive Interface on R1

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

Verify OSPF Neighbors

Verify that the router has formed an adjacency with its neighboring routers.

```
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#
```

Verify OSPF Protocol Settings

Verifying R1's OSPF Neighbors

```
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 Process Information

Verifying R1's OSPF Process

```
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
Router is not originating router-LSAs with maximum metric
Initial SPF schedule delay 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Incremental-SPF disabled
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msecs
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msecs
Retransmission pacing timer 66 msecs
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
```

Verify OSPF Interface Settings

Verifying R1's OSPF Interfaces

```
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#
```

Packet Tracer - 点对点单区域 OSPFv2 的配置

在这个Packet Tracer练习中，您会完成以下操作：

- 明确配置路由器ID。
- 使用基于子网掩码的通配符掩码，在R1上配置**network** 命令。
- 使用全零的通配符掩码在R2上配置**network** 命令。
- 在R3上配置接口命令**ip ospf** 。
- 配置被动接口。
- 要想验证OSPF的运行，我们可以使用**show ip protocols**和**show ip route** 命令。

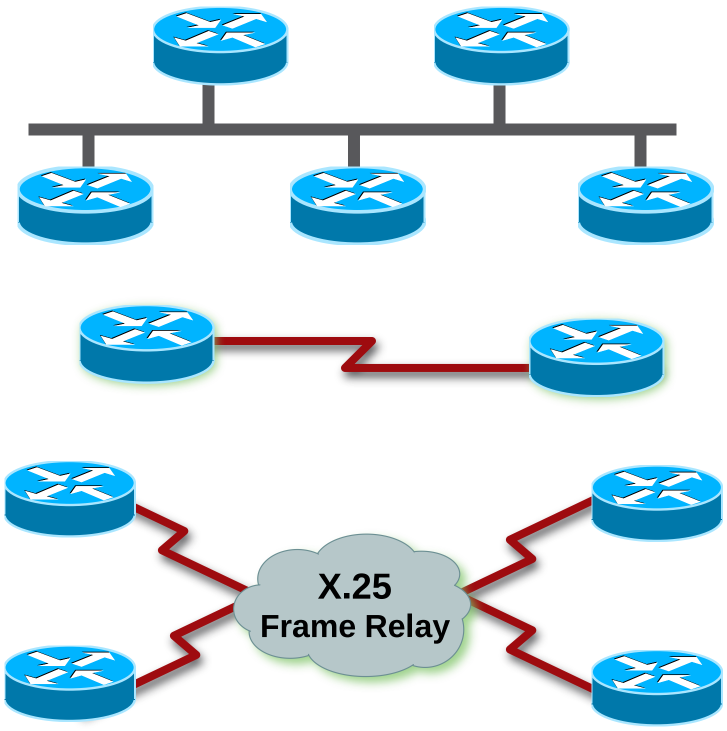
18.5 OSPF和多路访问网络

OSPF Topologies (Network Types)

Broadcast Multiaccess

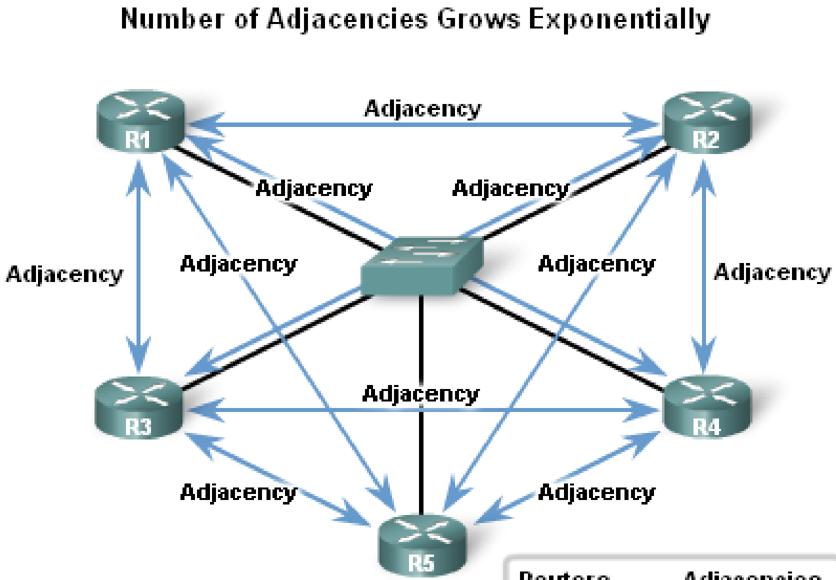
Point-to-Point

NBMA



多路访问网路面临的挑战

- Two challenges presented by multi-access networks
  - 一Multiple adjacencies
  - 一Extensive LSA flooding

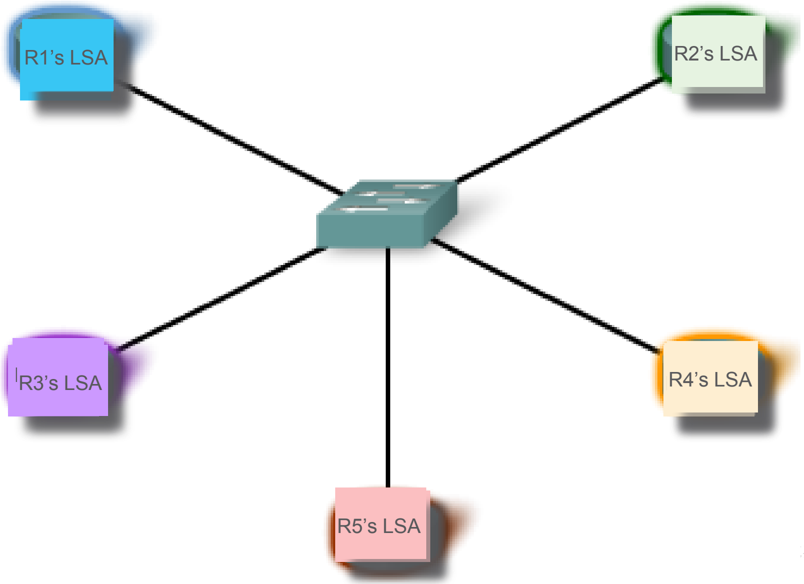


Number of Adjacencies = n(n-1)/2
n = number of routers
Example: 5 routers (5 - 1)/2 = 10 adjacencies

Routers	Adjacencies
n	n(n-1)/2
5	10
10	45
20	190
100	4,950

多路访问网路面临的挑战

- Extensive flooding of LSAs
  - —For every LSA sent out there must be an acknowledgement of receipt sent back to transmitting router.
  - —consequence: lots of bandwidth consumed and chaotic traffic

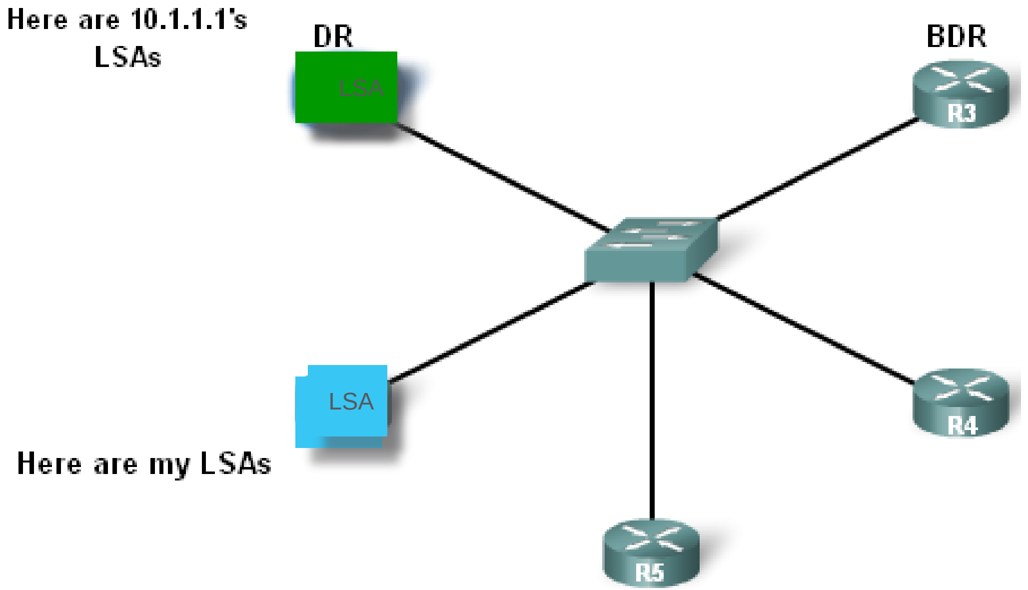


多路访问OSPF 网络
DR和BDR选举

- On multiaccess networks, OSPF elects a Designated Router (DR) for LSAs sent and received.
- A Backup Designated Router (BDR) is also elected in case the Designated Router fails.
- A router that is neither the DR or the BDR become DROthers .
- Adjacencies are formed with DR and BDR only.
- Sending & Receiving LSA
  - 一DRothers send LSAs via multicast 224.0.0.6 to DR & BDR.
  - 一DR forward LSA via multicast address 224.0.0.5 to all other routers.

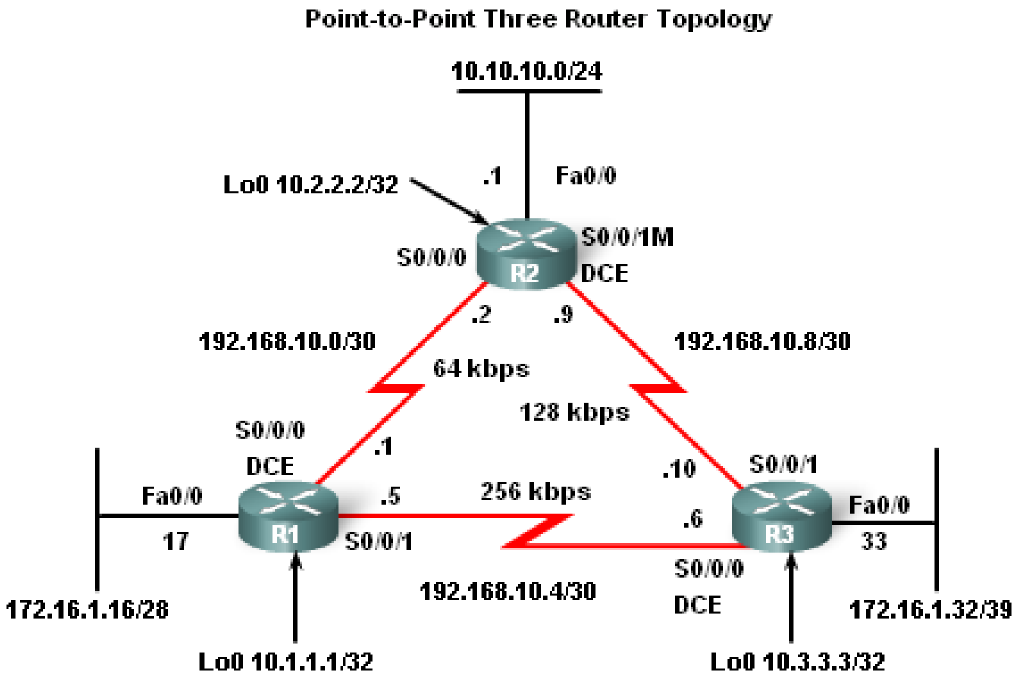
多路访问OSPF 网络
DR和BDR选举

- LSAs are sent to the DR. BDR listens.



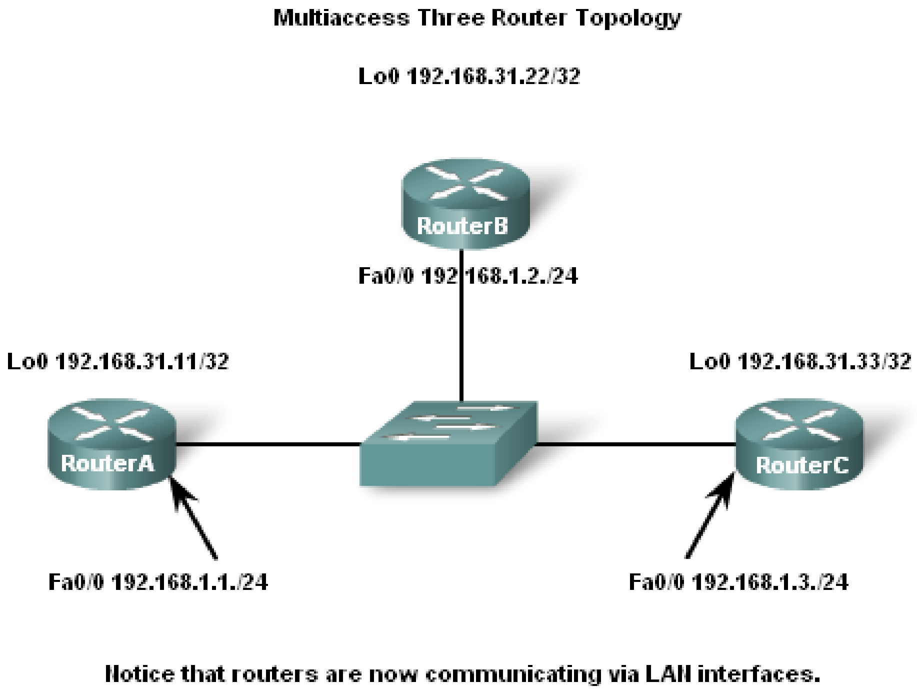
多路访问OSPF 网络
DR和BDR选举

- DR/BDR elections DO NOT occur in point to point networks.



多路访问OSPF 网络
DR和BDR选举

- DR/BDR elections will take place on multi-access networks.



DR和BDR选举

- How do the DR and BDR get elected? The following criteria are applied:

1. DR: Router with the highest OSPF interface priority.
2. BDR: Router with the second highest OSPF interface priority.
3. If OSPF interface priorities are equal, the highest router ID is used to break the tie.

Note: 一 the default OSPF interface priority is 1.

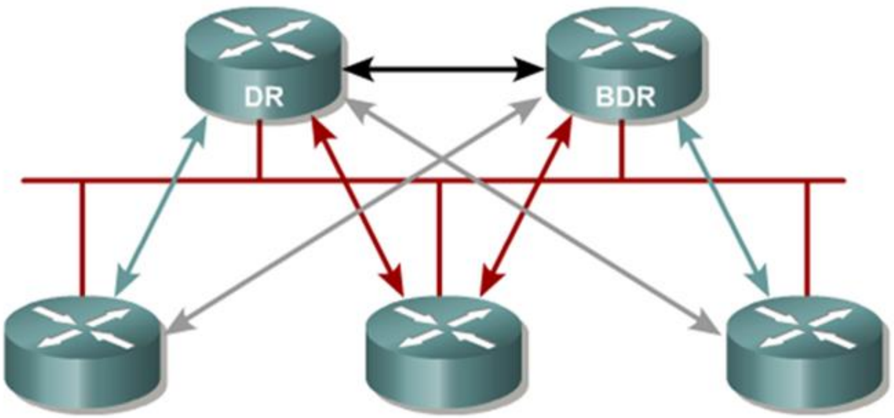
一DROthers only form FULL adjacencies with the DR and BDR.

一All DROther routers in the multiaccess network still receive Hello packets from all other DROther routers.

一Neighbor state of DROther routers is displayed as 2WAY.

多路访问OSPF 网络
DR和BDR选举

- DR /BDR election required since there could be many devices.
  - Neighbor
  - Adjacencies
- Packets to all OSPF routers are forwarded to 224.0.0.5.
- Packets to the DR / BDR are forwarded to 224.0.0.6.



Designated Router (DR)

- The DR is elected and becomes responsible for maintaining the topology table for the segment.
- This DR has two main functions:
  - To become adjacent to all other routers on the network segment.
  - To act as a spokesperson for the network.
- As spokesperson the DR becomes the focal point for collecting and sending routing information (LSAs).

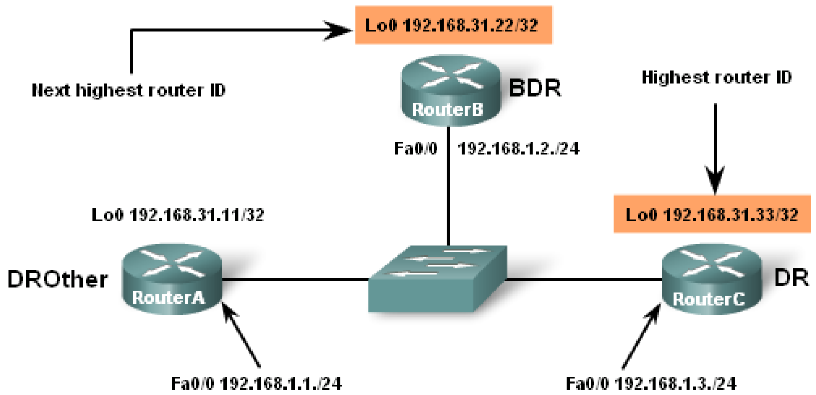
Backup Designated Router (BDR)

- For fault tolerance, a second router is elected as the BDR.
  - The BDR must also become adjacent to all routers on the network and must serve as a second focal point for LSAs.
  - However, the BDR is not responsible for updating the other routers or sending network LSAs.
- The BDR keeps a timer on the DR's update activity to ensure that it is operational.
  - If the BDR does not detect activity from the DR after the timer expires, the BDR immediately becomes the DR and a new BDR is elected.

DR/BDR

- DRs and BDRs are elected on a per-network basis and therefore each network segment has its own DR and BDR.
- The election process is accomplished dynamically using the Hello protocol.
  - However, the election can be manually manipulated the **`ip ospf priority`** *`number`* interface configuration command.
- After a DR and BDR have been selected, any router added to the broadcast network establishes full adjacencies with the DR and BDR only.

多路访问OSPF 网络
DR和BDR选举




```
RouterA#show ip ospf neighbor

Neighbor ID     Pri   State       Dead Time    Address       Interface
192.168.31.33     1   FULL/DR     00:00:39     192.168.1.3   FastEthernet0/0
192.168.31.22     1   FULL/BDR    00:00:36     192.168.1.2   FastEthernet0/0
```

```
RouterB#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time    Address       Interface
192.168.31.33     1   FULL/DR         00:00:34     192.168.1.3   FastEthernet0/0
192.168.31.11     1   FULL/DROTHER    00:00:38     192.168.1.1   FastEthernet0/0
```

```
RouterC#show ip ospf neighbor

Neighbor ID     Pri   State            Dead Time    Address       Interface
192.168.31.22     1   FULL/BDR         00:00:35     192.168.1.2   FastEthernet0
192.168.31.11     1   FULL/DROTHER     00:00:32     192.168.1.1   FastEthernet0
```

Priority is equal at the default value of 1.

多路访问OSPF 网络
DR和BDR选举

```
RouterA#show ip ospf interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Internet Address 192.168.1.1/24, Area 0
  Process ID 1, Router ID 192.168.31.11, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DROTHER, Priority 1
  Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
  Backup Designated router (ID) 192.168.31.22, Interface address 192.168.1.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:06
  Supports Link-local Signaling (LLS)
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 2, Adjacent neighbor count is 2
    Adjacent with neighbor 192.168.31.22  (Backup Designated Router)
    Adjacent with neighbor 192.168.31.33  (Designated Router)
  Suppress hello for 0 neighbor(s)
```

多路访问OSPF 网络
DR和BDR选举

思考：选举的过程是在一瞬间就选完了吗？

- Timing of DR/BDR Election
  - — Election occurs as soon as 1st router has its interface enabled on 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.

多路访问OSPF 网络
DR和BDR选举

- Timing of DR/BDR Election

```
RouterA#show ip ospf interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Internet Address 192.168.1.1/24, Area 0
  Process ID 1, Router ID 192.168.31.11, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DROTHER, Priority 1
  Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
  Backup Designated router (ID) 192.168.31.22, Interface address 192.168.1.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:06
  Supports Link-local Signaling (LLS)
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 2, Adjacent neighbor count is 2
    Adjacent with neighbor 192.168.31.22  (Backup Designated Router)
    Adjacent with neighbor 192.168.31.33  (Designated Router)
  Suppress hello for 0 neighbor(s)
```

All routers currently have the default OSPF Interface Priority of 1

多路访问OSPF 网络
DR和BDR选举

- R2#show ip ospf interface fa 0/0
  - FastEthernet0/0 is up, line protocol is up
  - Internet Address 23.0.0.2/24, Area 0
  - Process ID 1, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 1
  - Transmit Delay is 1 sec, State WAITING, Priority 1
  - No designated router on this network
  - No backup designated router on this network
  - Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  -
  - ……

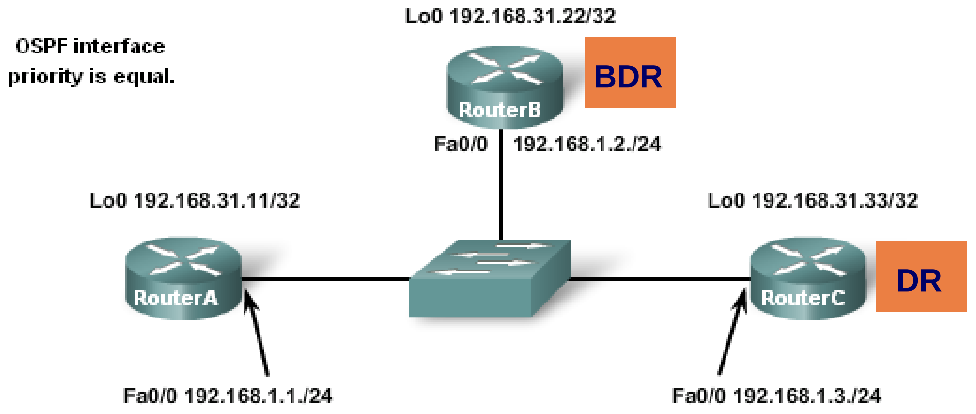
DR和BDR选举

The Election of the DR

1. All neighbors with a priority > 0 are listed.
2. The router with highest priority is elected BDR.
    - If there is a tie, the highest router IDs are used.
3. If there is no DR, the BDR is promoted as DR.
4. The neighbor with the next highest priority is elected BDR.

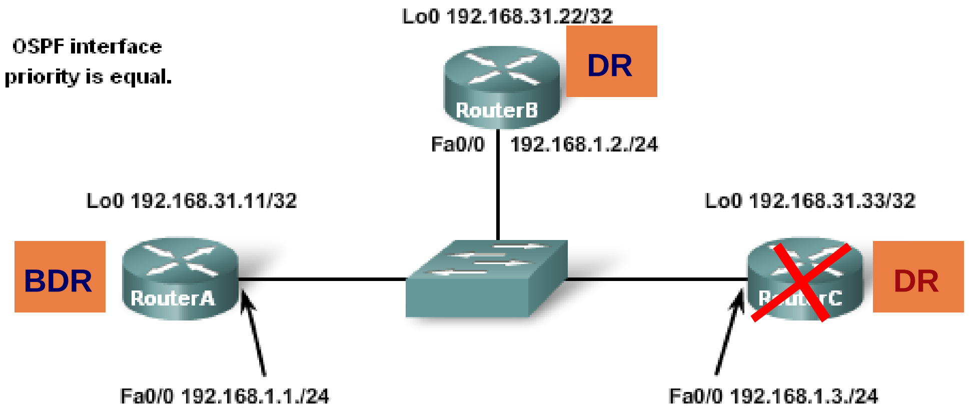
多路访问OSPF 网络
DR和BDR选举

- DR/BDR Election Scenarios



多路访问OSPF 网络
DR和BDR选举

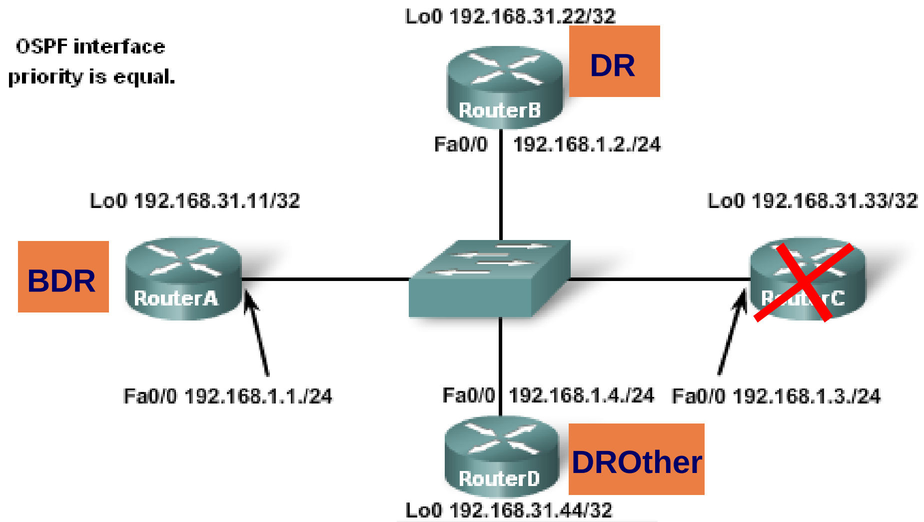
- DR Fails



If the DR fails, the BDR assumes the role of DR and an election is held to choose a new BDR.

多路访问OSPF 网络
DR和BDR选举

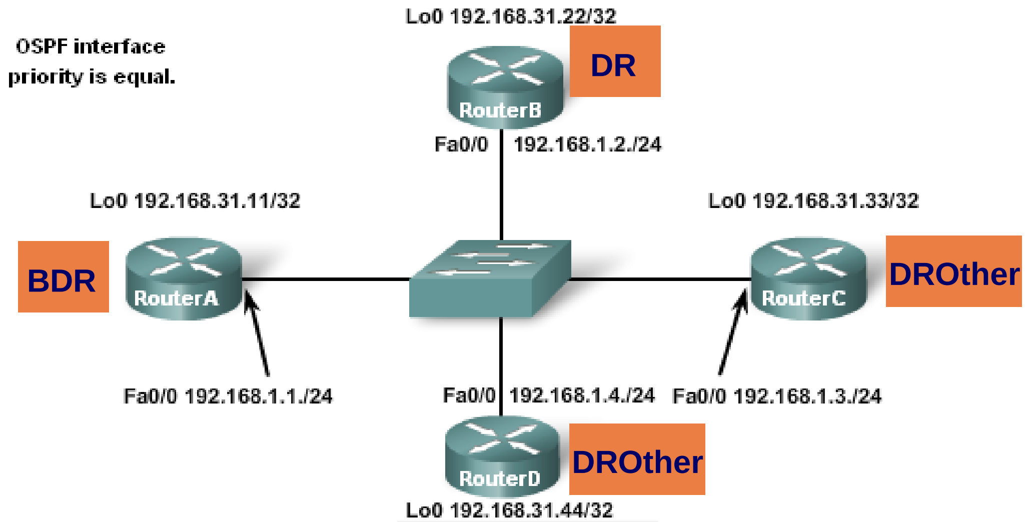
- New Router



If a new router enters the network after the DR and BDR have been elected, it will not become the DR or the BDR even if it has a higher OSPF interface priority or router ID than the current DR or BDR.

多路访问OSPF 网络
DR和BDR选举

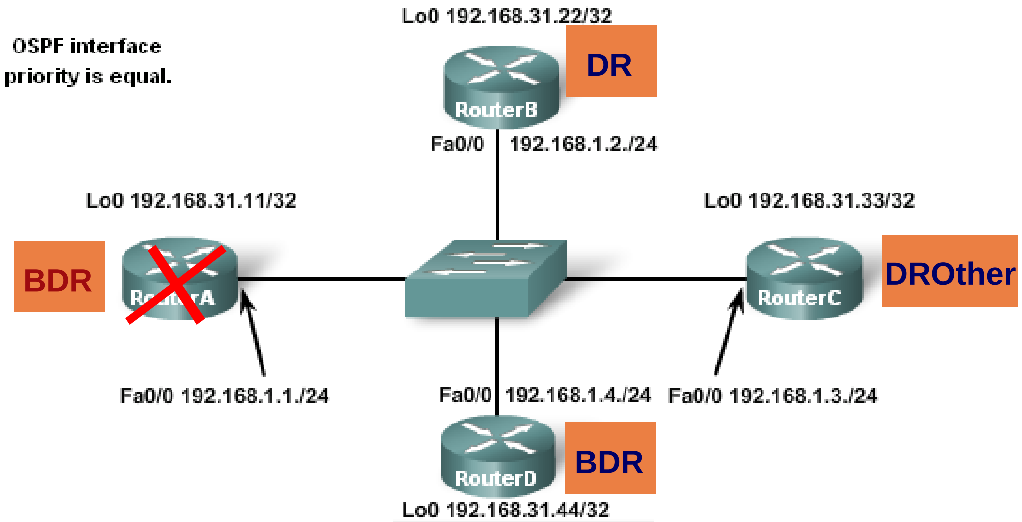
- Old DR Returns



A previous DR does not regain DR status if it returns to the network.

多路访问OSPF 网络
DR和BDR选举

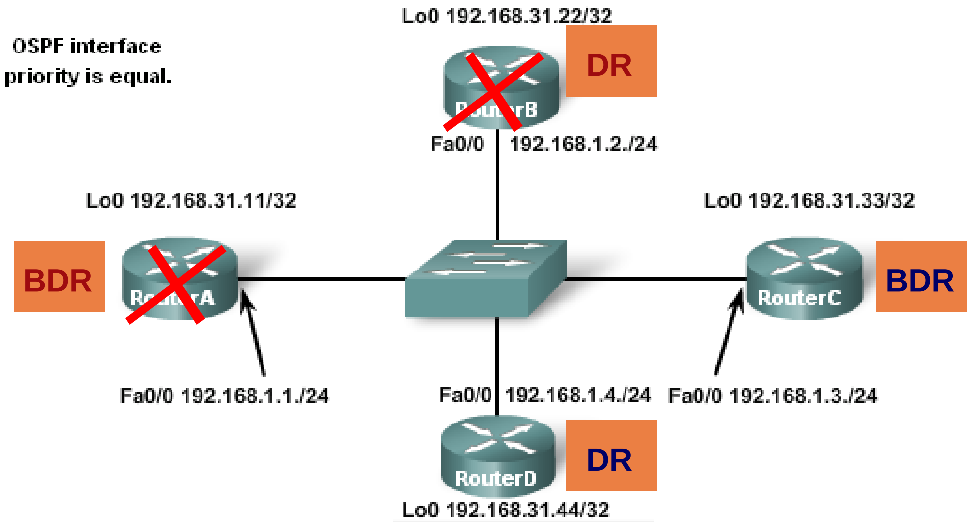
- BDR Fails



If the BDR fails, an election is held among the DRothers to see which router will be the new BDR.

多路访问OSPF 网络
DR和BDR选举

- New DR Fails



Only after both the DR and the BDR fail will the DR and BDR routers change.

OSPF Interface Priority

- Manipulating the election process
  - If you want to influence the election of DR & BDR then do one of the following
    - —Boot up the DR first, followed by the BDR, and then boot all other routers,
    - OR
    - —Shut down the interface on all routers, followed by a **no shutdown** on the DR, then the BDR, and then all other routers.

DR和BDR选举

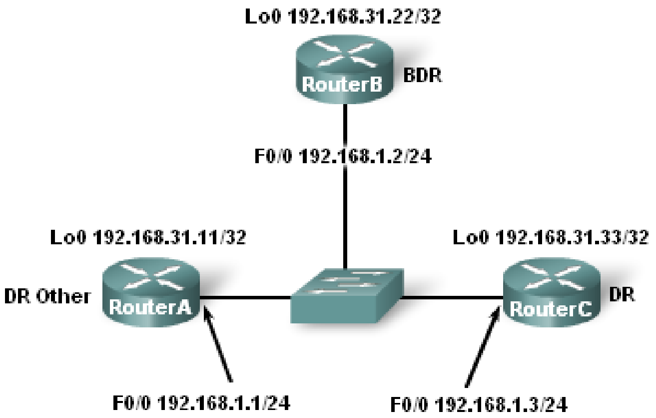
OSPF Interface Priority

- Manipulating the DR/BDR election process continued
  - Use the ip ospf priority interface command.
  - **Example:** Router(config-if)#**ip ospf priority** {**0 - 255**}
    - Priority number range 0 to 255
      - —0 means the router cannot become the DR or BDR
      - —1 is the default priority value

```
Router#sh ip ospf int f0/0
FastEthernet0/0 is up, line protocol is up
  Internet address is 1.1.2.1/24, Area 0
  Process ID 1, Router ID 1.1.1.1, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 1.1.2.2, Interface address 1.1.2.2
```

多路访问OSPF 网络
DR和BDR选举

- Changing OSPF Interface Priority




```
RouterA#show ip ospf interface fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Internet Address 192.168.1.1/24, Area 0
  Process ID 1, Router ID 192.168.31.11, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DROTHER, Priority 1
  Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
  Backup Designated router (ID) 192.168.31.22, Interface address 192.168.1.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:06
  Supports Link-local Signaling (LLS)
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 0, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 2, Adjacent neighbor count is 2
    Adjacent with neighbor 192.168.31.22  (Backup Designated Router)
    Adjacent with neighbor 192.168.31.33  (Designated Router)
  Suppress hello for 0 neighbor(s)
```

All routers currently have the default OSPF Interface Priority of 1

多路访问OSPF 网络
DR和BDR选举

```
RouterA(config)#interface fastethernet 0/0
RouterA(config-if)#ip ospf priority 200
```

```
RouterB(config)#interface fastethernet 0/0
RouterB(config-if)#ip ospf priority 100
```

```
RouterA#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.31.22   100   FULL/BDR        00:00:30    192.168.1.2     FastEthernet0/0
192.168.31.33     1   FULL/DROTHER    00:00:30    192.168.1.3     FastEthernet0/0
```

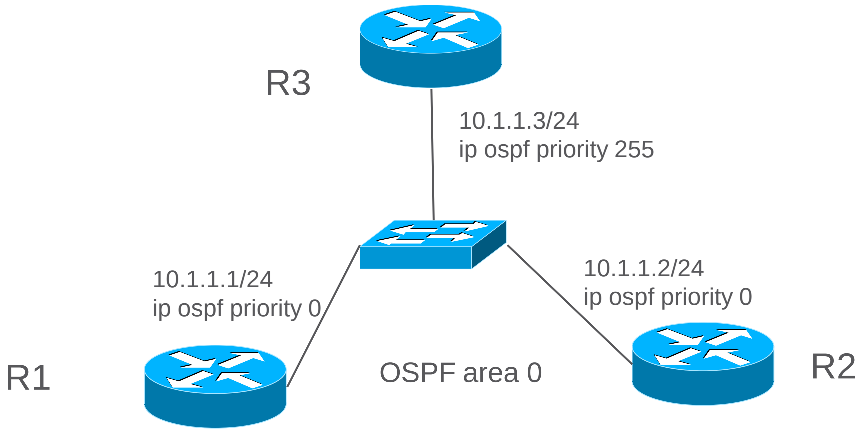
```
RouterB#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.31.11   200   FULL/DR         00:00:37    192.168.1.1     FastEthernet0/0
192.168.31.33     1   FULL/DROTHER    00:00:38    192.168.1.3     FastEthernet0/0
```

```
RouterC#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.31.22   100   FULL/BDR        00:00:32    192.168.1.2     FastEthernet0/0
192.168.31.11   200   FULL/DR         00:00:31    192.168.1.1     FastEthernet0/0
```

DR and BDR roles change

多路访问OSPF 网络
DR和BDR选举

What is the state of OSPF neighbor for R1,R2,R3?

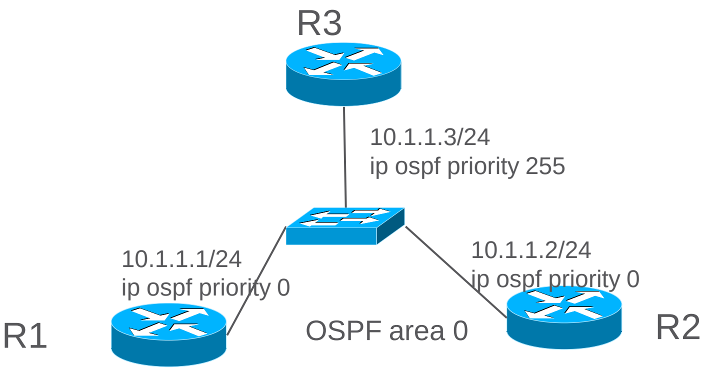


A. R1: Full/Full, R2: Full/Full, R3:Full/Full
B. R1: Full, R2:Full, R3: Full
C. R1: 2Way/2Way, R2:2Way/2Way, R3:2Way/2Way
D. R1: Full/2Way, R2: Full/2Way, R3:Full/2Way

None of above is correct!!!
Correct Answer: R1:Full/2Way, R2: Full/2Way, R3:Full/Full

多路访问OSPF 网络
DR和BDR选举

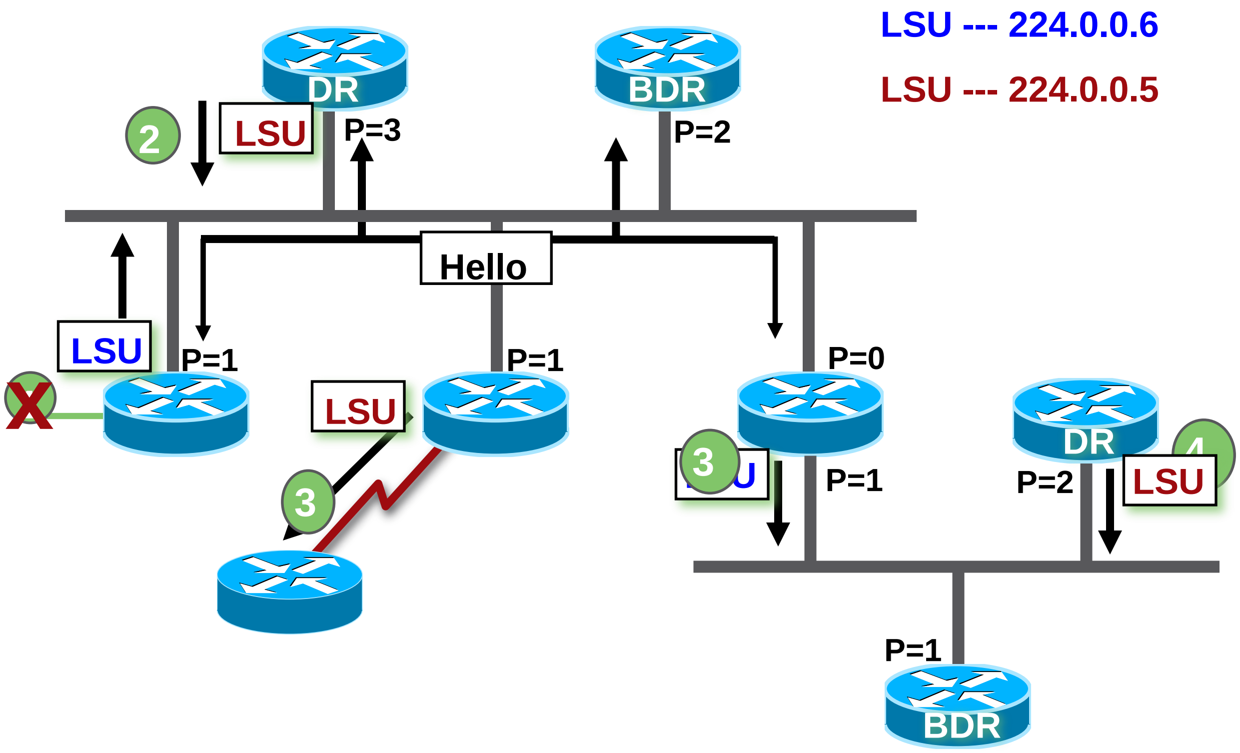
Let’s see the answer on real equipment




```
R1#sh ip ospf nei

Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           0   2WAY/DROTHER    00:00:37    10.1.1.2        FastEthernet0/1
3.3.3.3         255   FULL/DR         00:00:35    10.1.1.3        FastEthernet0/1
R2#sh ip ospf nei

Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           0   2WAY/DROTHER    00:00:33    10.1.1.1        FastEthernet0/C
3.3.3.3         255   FULL/DR         00:00:36    10.1.1.3        FastEthernet0/C
R3#sh ip ospf nei

Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           0   FULL/DROTHER    00:00:31    10.1.1.1        FastEthernet0/C
2.2.2.2           0   FULL/DROTHER    00:00:37    10.1.1.2        FastEthernet0/C
```

多路访问OSPF 网络
DR和BDR选举

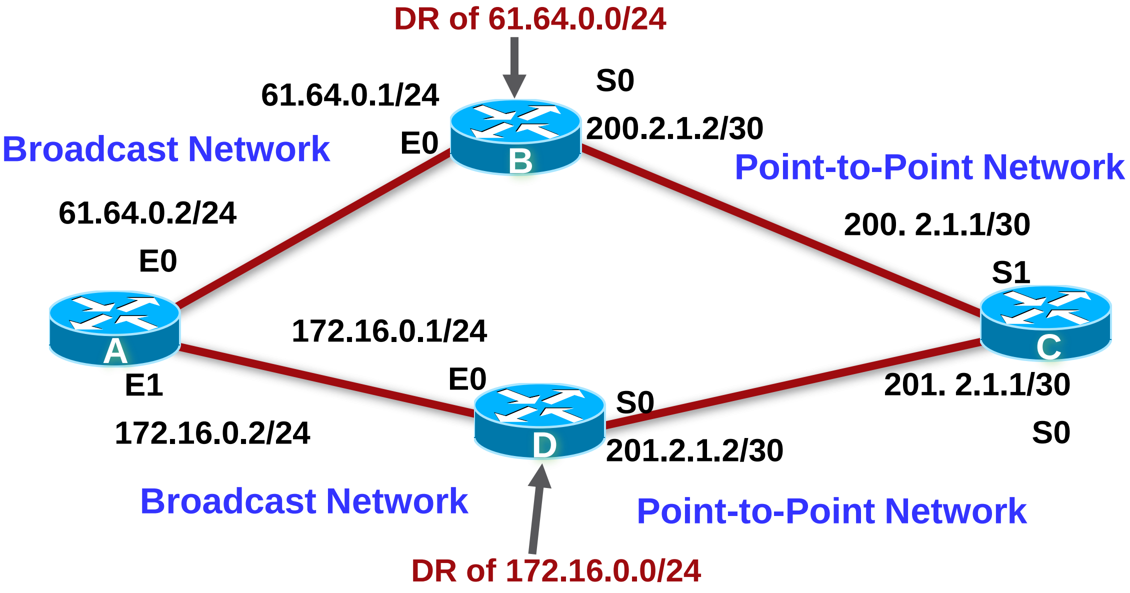
Per Subnet Elect a DR and BDR



多路访问OSPF 网络
DR和BDR选举

Electing the DR and BDR

All router’s priority is equal



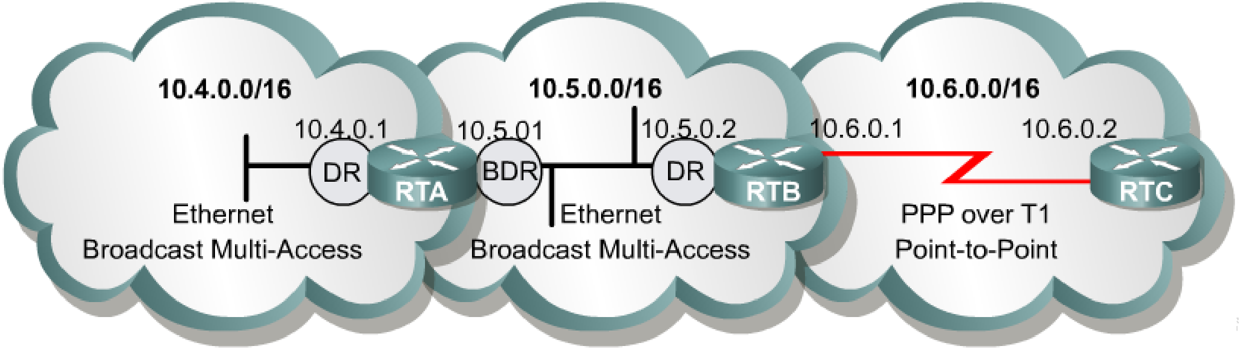
Router with highest OSPF priority elected

If priority is equal , router with highest Router ID elected

多路访问OSPF 网络
DR和BDR选举

Point-to-Point

- Both routers become fully adjacent to each another.
- Usually a serial interface running either PPP or HDLC.
  - May also be a point-to-point subinterface running Frame Relay or ATM.
- No DR /BDR election required since there are only two devices.
- OSPF autodetects this type of network.
- Packets are sent to 224.0.0.5.



OSPF 点对点网络

默认情况下，思科路由器会在以太网接口上选举 DR 和 BDR，即使链路上只连接了一台设备也是如此。我们可以使用**show ip ospf interface**命令来验证这一点。在本例中 DR/BDR 选举其实是不必要的，因为 R1 和 R2 之间的点对点网络上只能有两台路由器。需要注意的是，在命令的输出内容中，路由器的网络类型指定为BROADCAST。

```
R1# show ip ospf interface GigabitEthernet 0/0/0
GigabitEthernet0/0/0 is up, line protocol is up
Internet Address 10.1.1.5/30, Area 0, Attached via Interface Enable
Process ID 10, Router ID 1.1.1.1, Network Type BROADCAST, Cost: 1
Topology-MTID Cost Disabled Shutdown Topology Name
0 1 no no Base
Enabled by interface config, including secondary ip addresses
Transmit Delay is 1 sec, State BDR, Priority 1
Designated Router (ID) 2.2.2.2, Interface address 10.1.1.6
Backup Designated router (ID) 1.1.1.1, Interface address 10.1.1.5
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
oob-resync timeout 40
```

OSPF 点对点网络（续）

要想把它更改为点对点网络，我们可以在所有希望禁用DR/BDR选举进程的接口上，使用接口配置命令**ip ospf network point-to-point**。

```
R1(config)# interface GigabitEthernet 0/0/0
R1(config-if)# ip ospf network point-to-point
*Jun 6 00:44:05.208: %OSPF-5-ADJCHG: Process 10, Nbr 2.2.2.2 on GigabitEthernet0/0/0 from
FULL to DOWN, Neighbor Down: Interface down or detached
*Jun 6 00:44:05.211: %OSPF-5-ADJCHG: Process 10, Nbr 2.2.2.2 on GigabitEthernet0/0/0 from
LOADING to FULL, Loading Done
R1(config-if)# end
R1# show ip ospf interface GigabitEthernet 0/0/0
GigabitEthernet0/0/0 is up, line protocol is up
Internet Address 10.1.1.5/30, Area 0, Attached via Interface Enable
Process ID 10, Router ID 1.1.1.1, Network Type POINT_TO_POINT, Cost: 1
Topology-MTID Cost Disabled Shutdown Topology Name
```

环回和点对点网络

- 我们会出于多种目的，使用环回接口来充当额外的接口。默认情况下，环回接口会被通告为一条掩码为 /32 的主机路由。
- 为了模拟出真实的LAN环境，我们把环回接口配置为点对点网络，这样就可以通告完整网络了。
- R1通告的环回接口在R2看来是这样的：

```
R2# show ip route | include 10.10.1
O 10.10.1.1/32 [110/2] via 10.1.1.5, 00:03:05, GigabitEthernet0/0/0
```

- R1上的配置更改：

```
R1(config-if)# interface Loopback 0
R1(config-if)# ip ospf network point-to-point
```

- R2上的配置结果：

```
R2# show ip route | include 10.10.1
O 10.10.1.0/24 [110/2] via 10.1.1.5, 00:03:05, GigabitEthernet0/0/0
```

Nonbroadcast Multiaccess (NBMA)

- A single interface interconnects multiple sites
- NBMA topologies support multiple routers, but without broadcasting capabilities
- Five modes of OSPF operation are available

DR and BDR Election in NBMA Topology

- OSPF considers NBMA to be like other broadcast media.
- DR and BDR need to have fully meshed connectivity with all other routers, but NBMA networks are not always fully meshed.
- DR and BDR election depends on NBMA topology.

Packet Tracer - 确定DR和BDR

在这个练习中，您会完成以下操作：

- 检查 DR 和 BDR 的角色，并在网络发生变化时观察角色的变化。
- 通过修改优先级来控制角色并强制进行新选举。
- 验证路由器是否充当了相应的角色。

18.6 修改单区域OSPFv2

OSPF Metric = Cost

- OSPF uses **cost** as the metric for determining the best route:
  - The best route will have the lowest cost
  - **Cost** is based on bandwidth of an interface
    - Cost = 10^8 / bandwidth
  - **Reference bandwidth**
    - Defaults= 10^8 (100Mbps)
- Notes:
  - Cisco routers default to T1 (1.544 Mbps) on all serial interfaces and require manual modification with the *bandwidth* command.
  - `auto-cost reference-bandwidth` *reference-bandwidth* can be used to modify the reference-bandwidth for higher speed interfaces

OSPF Metric = Cost

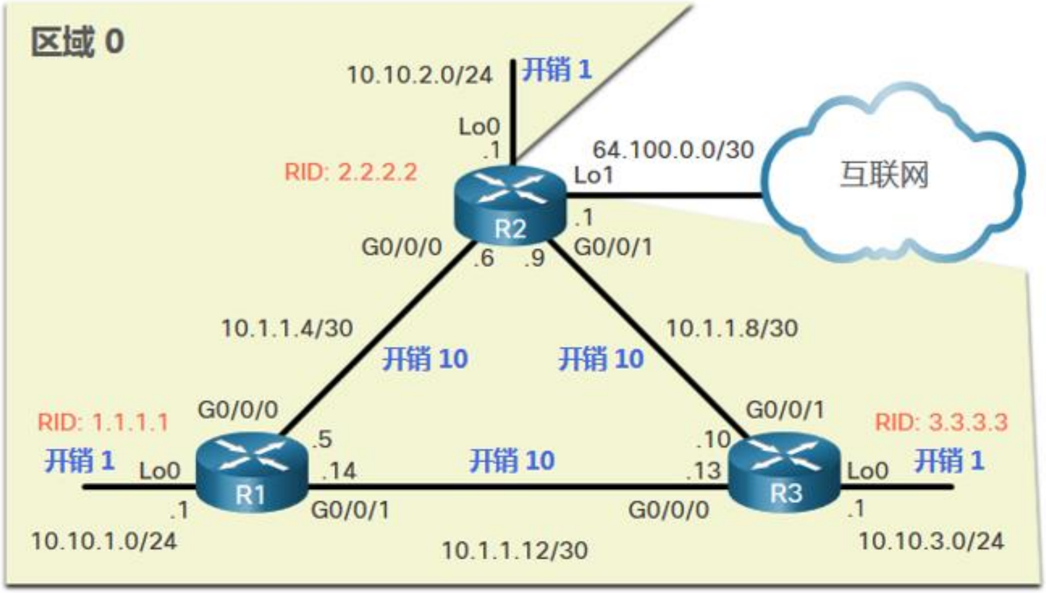
Cisco default interface costs:

- 56-kbps serial link = 1785
- 64-kbps serial link = 1562   128-kbps serial link = 781
- T1 (1.544-Mbps serial link) = 64
- E1 (2.048-Mbps serial link) = 48
- 4-Mbps Token Ring = 25
- Ethernet = 10
- 16-Mbps Token Ring = 6
- Fast Ethernet = 1
- Problem: Gigabit Ethernet and faster = 1

Cost = 100,000,000/Bandwidth

OSPF 累计开销

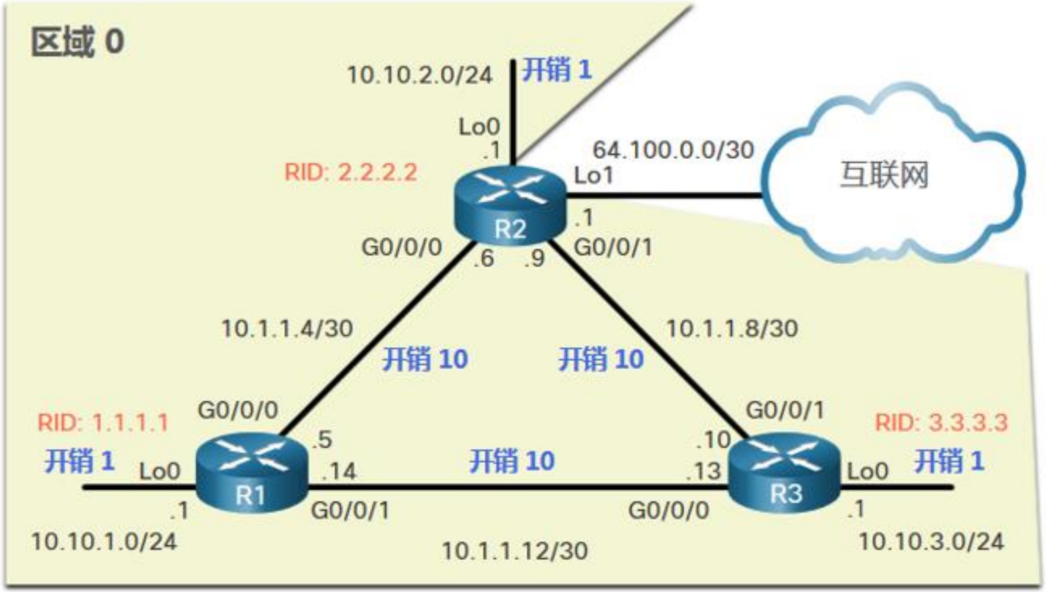
- OSPF 路由的开销为从路由器到目的网络的累计开销值。
- 假设我们已经在所有三台路由器上都配置了**auto-cost reference-bandwidth 10000** 命令，现在每台路由器之间的链路开销都是 10。环回接口的默认开销为 1。



修改单区域 OSPFv2

OSPF 累计开销（续）

- 现在我们可以计算每台路由器去往每个网络的开销了。
- 例如，R1 去往 10.10.2.0/24 网络的总开销为 11。这是因为去往 R2 的链路开销 = 10，环回接口的默认开销 = 1。10 + 1 = 11。
- 我们可以使用 **show ip route** 命令来验证这一点。



OSPF 累计开销(续)

验证去往 10.10.2.0/24 网络的路径累计开销:

```
R1# show ip route | include 10.10.2.0
O 10.10.2.0/24 [110/11] via 10.1.1.6, 01:05:02, GigabitEthernet0/0/0
R1# show ip route 10.10.2.0
Routing entry for 10.10.2.0/24
Known via "ospf 10", distance 110, metric 11, type intra area
Last update from 10.1.1.6 on GigabitEthernet0/0/0, 01:05:13 ago
Routing Descriptor Blocks:
* 10.1.1.6, from 2.2.2.2, 01:05:13 ago, via GigabitEthernet0/0/0
Route metric is 11, traffic share count is 1
R1#
```

Default Interface Bandwidths

On Cisco routers, the default bandwidth on most serial interfaces is set to 1.544 Mb/s.

Verifying the Default Bandwidth Settings of R1 Serial 0/0/0

```
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
```

Adjusting the Interface Bandwidths

- Both sides of a serial link should be configured with the same bandwidth.

  — **Bandwidth** command : 链路cost值还需要计算

  Router(config-if)#**bandwidth** *bandwidth-kbps*

  — **ip ospf cost** command : 用来直接指定接口cost值，无需计算

  Router(config)#interface serial 0/0/0
  Router(config-if)#**ip ospf cost** *cost*

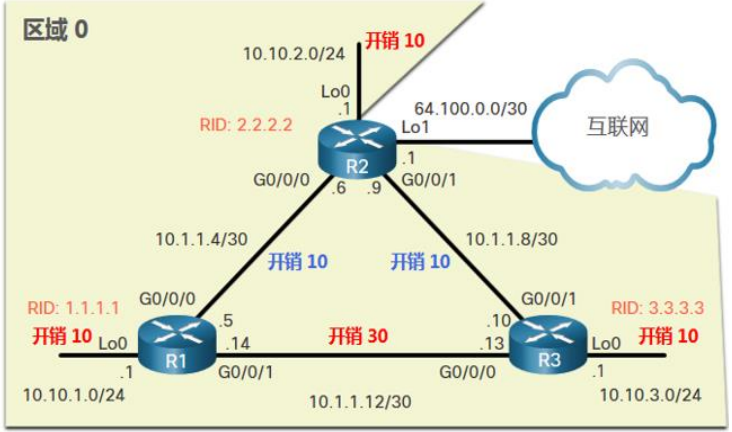
手动设置 OSPF 开销值

我们会出于以下原因手动设置开销值：

- 管理员可能会想要影响OSPF中的路径选择，让OSPF选择不同的路径，而不选择按照默认开销和累计开销计算出的路径。
- 在连接其他厂商的设备时，其他厂商的设备在计算OSPF开销时使用了不同的公式。

要想更改本地OSPF路由器通告的去往其他OSPF路由器的开销值，我们可以使用接口配置命令**ip ospf cost** *value* 。

```
R1(config)# interface g0/0/1
R1(config-if)# ip ospf cost 30
R1(config-if)# interface lo0
R1(config-if)# ip ospf cost 10
R1(config-if)# end
R1#
```



修改单区域 OSPFv2
测试故障切换到备份路由

如果 R2 和 R3 之间的链路出现了故障，会发生什么？我们可以通过关闭GE 0/0/0接口来模拟故障，然后通过查看路由表来验证R3会成为下一跳路由器。首先需要注意，R1当前通过R3去往10.1.1.4/30网络的路由开销值为50。

```
R1# show ip route ospf | begin 10
10.0.0.0/8 is variably subnetted, 8 subnets, 3 masks
O 10.1.1.4/30 [110/50] via 10.1.1.13, 00:00:14, GigabitEthernet0/0/1
O 10.1.1.8/30 [110/40] via 10.1.1.13, 00:00:14, GigabitEthernet0/0/1
O 10.10.2.0/24 [110/50] via 10.1.1.13, 00:00:14, GigabitEthernet0/0/1
O 10.10.3.0/24 [110/40] via 10.1.1.13, 00:00:14, GigabitEthernet0/0/1
R1#
```

修改单区域 OSPFv2

Hello数据包间隔

- OSPFv2路由器会每10秒向组播地址224.0.0.5（代表所有OSPF路由器）发送Hello数据包。这是多接入网络和点对点网络上的默认计时器值。

注意：在使用 **passive-interface**命令设置的被动接口上，不会发送Hello数据包。

- Dead 间隔是路由器在宣告邻居进入 down（不可用）状态之前等待接收 Hello 数据包的时长。如果一个邻居的 Dead 间隔已超时，而路由器尚未收到这个邻居发来的 Hello 数据包，则它会从本地链路状态数据库 (LSDB) 中删除这个邻居。路由器会将该邻居连接断开的 LSDB 信息通过所有启用了 OSPF 的接口以泛洪的方式发送出去。思科设置的Dead间隔默认是Hello间隔的4倍。也就是说在多接入网络和点对点网络上，Dead间隔默认是40秒。

修改单区域 OSPFv2
验证Hello间隔和Dead间隔

- 可以根据每个接口的情况配置 OSPF Hello 间隔和 Dead 间隔。
- OSPF 间隔必须匹配，否则邻接关系不会发生。
- 我们可以使用 **show ip ospf interface** 命令来验证接口上当前配置的OSPFv2开销值。将 GE 0/0/0 的 Hello 间隔和 Dead 间隔分别设置为默认值 10 秒和 40 秒。

```
R1# show ip ospf interface g0/0/0
GigabitEthernet0/0/0 is up, line protocol is up
Internet Address 10.1.1.5/30, Area 0, Attached via Interface Enable
Process ID 10, Router ID 1.1.1.1, Network Type POINT_TO_POINT, Cost: 10
Topology-MTID Cost Disabled Shutdown Topology Name
0 10 no no Base
Enabled by interface config, including secondary ip addresses
Transmit Delay is 1 sec, State POINT_TO_POINT
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
oob-resync timeout 40
（省略部分输出）
```

验证Hello间隔和Dead间隔（续）

使用 **show ip ospf neighbor** 命令来查看Dead时间是从 40 秒开始倒计时的。默认情况下，当 R1 收到邻居每隔 10 秒发来的 Hello 时，此值被重置。

```
R1# show ip ospf neighbor
Neighbor ID Pri State Dead Time  Address Interface
3.3.3.3 0 FULL/ - 00:00:35 10.1.1.13 GigabitEthernet0/0/1
2.2.2.2 0 FULL/ - 00:00:31 10.1.1.6 GigabitEthernet0/0/0
R1#
```

修改 OSPFv2 的间隔

Modifying OSPF timers

- 一Reason to modify timers

  Faster detection of network failures

- 一Manually modifying Hello & Dead intervals

```
Router(config-if)#ip ospf hello-interval  seconds
Router(config-if)#ip ospf dead-interval seconds
```

- 一Point to be made

  Hello & Dead intervals must be the same between neighbors.

- **我们可以使用 no ip ospf hello-interval 和 no ip ospf dead-interval 命令把间隔重置为默认值。**

修改 OSPFv2 间隔（续）

- 在本例中，我们把 R1 和 R2 之间链路上的 Hello 间隔修改为 5 秒。更改 Hello 间隔之后，思科 IOS 会立即自动把 Dead 间隔修改为 Hello 间隔的四倍。但我们也可以在配置中设置新的Dead间隔，如下例所示，手动设置Dead间隔为20秒。
- 当R1上的Dead计时器超时后，R1和R2之间就失去邻接关系了。R1和R2必须配置相同的Hello间隔。要想验证OSPFv1的邻接关系，我们可以使用 **show ip ospf neighbor** 命令。

```
R1(config)# interface g0/0/0
R1(config-if)#  ip  ospf hello-interval 5
R1(confif-if)#  ip  ospf dead-interval  20
R1(config-if)#
*Jun 7 04:56:07.571: %OSPF-5-ADJCHG: Process 10, Nbr 2.2.2.2 on GigabitEthernet0/0/0
from FULL to DOWN, Neighbor Down: Dead timer expired
R1(config-if)# end
R1# show ip ospf neighbor
Neighbor ID Pri State Dead Time Address Interface
3.3.3.3 0 FULL/ - 00:00:37 10.1.1.13 GigabitEthernet0/0/1
R1#
```

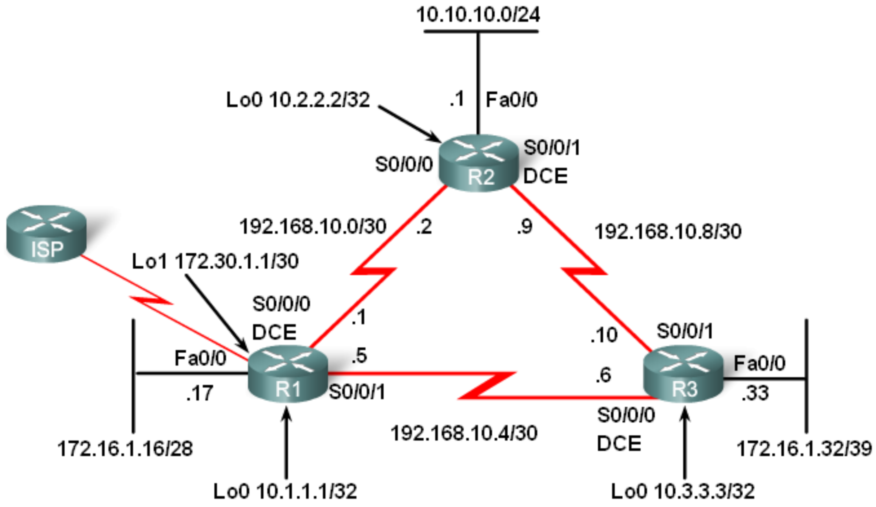
Packet Tracer - 修改单区域 OSPFv2

在这个Packet Tracer练习中，您会完成以下操作：

- 调整参考带宽，以便更好地计算千兆或更快速率接口的开销。
- 修改 OSPF 开销值
- 修改 OSPF Hello 计时器
- 验证修改是否成功。

18.7 默认路由传播

在OSPFv2中传播默认静态路由



两种方法：

– ***default-information originate*** [always]
– ***redistribute static***

在OSPFv2中传播默认静态路由

Topology includes a link to ISP

- Called an autonomous system border router (ASBR)
- Used to propagate a default route

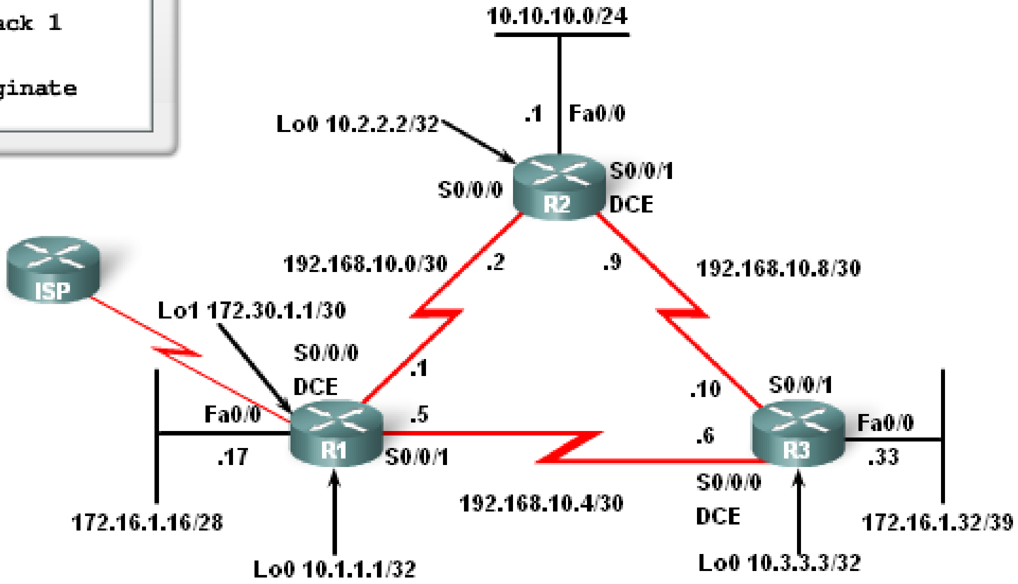
—use **default-information originate** command to advertise the 0.0.0.0/0 static default route to the other routers in the area.

```
R1(config-router)#default-information originate
```

在OSPFv2中传播默认静态路由

Redistributing an OSPF Default Route

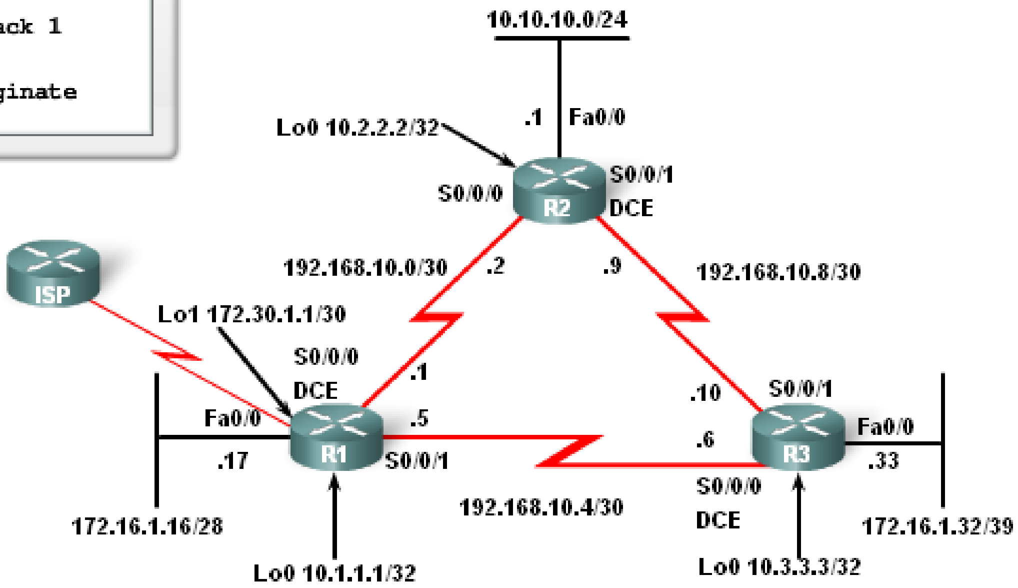
```
R1(config)#interface loopback 1
R1(config-if)#ip add 172.30.1.1 255.255.255.252
R1(config-if)#exit
R1(config)#ip route 0.0.0.0 0.0.0.0 loopback 1
R1(config)#router ospf 1
R1(config-router)#default-information originate
```



在OSPFv2中传播默认静态路由

Redistributing an OSPF Default Route

```
R1(config)#interface loopback 1
R1(config-if)#ip add 172.30.1.1 255.255.255.252
R1(config-if)#exit
R1(config)#ip route 0.0.0.0 0.0.0.0 loopback 1
R1(config)#router ospf 1
R1(config-router)#default-information originate
```



验证已传播的默认路由

- 我们可以在R2上使用 **show ip route** 命令来验证默认路由的设置。还可以验证 R1 和 R3 是否接收到了这条默认路由。
- 请注意R1上的路由来源显示为 **O*E2**，表示这是通过OSPFv2学到的路由。星号标识它为默认路由的优秀候选者。E2 标识确定它是外部路由。E1 和 E2 的含义超出了本模块的知识范围。

```
R2# show ip route | begin Gateway
Gateway of last resort is 0.0.0.0 to network 0.0.0.0
S* 0.0.0.0/0 is directly connected, Loopback1
10.0.0.0/8 is variably subnetted, 9 subnets, 3 masks
（省略部分输出）
```

```
R1# show ip route | begin Gateway
Gateway of last resort is 10.1.1.6 to network 0.0.0.0
O*E2 0.0.0.0/0 [110/1] via 10.1.1.6, 00:11:08, GigabitEthernet0/0/0
10.0.0.0/8 is variably subnetted, 9 subnets, 3 masks
（省略部分输出）
```

Packet Tracer - 在OSPFv2中传播默认静态路由

在这个Packet Tracer练习中，您会完成以下操作：

- 传播默认路由
- 第 2 部分：验证连接

18.8 验证单区域 OSPFv2

验证OSPF邻居

如果您已配置了单区域 OSPFv2，现在需要验证您的配置。以下两条命令特别适合来验证路由：

- **show ip interface brief** - 这条命令可以用来验证接口的状态是否正常，并且是否配置了正确的IP地址。
- **show ip route**- 这条命令可以用来验证路由表中是否包含了所有预期的路由。

还有其他命令可以用来确定OSPF的工作状态是否正常，如下所示：

- **show ip ospf neighbor**
- **show ip protocols**
- **show ip ospf**
- **show ip ospf interface**

验证OSPF邻居（续）

- 我们可以使用 **show ip ospf neighbor** 命令验证该路由器是否已与其相邻路由器建立邻接关系。如果未显示相邻路由器的路由器 ID，或未显示 FULL 状态，则表明两台路由器未建立 OSPFv2 邻接关系。

注意：非DR或BDR的路由器在与另一台非DR或BDR的路由器之间建立邻居关系时，邻居关系会稳定在Two-Way状态，不会进入Full状态。

- 以下命令的输出内容中显示了 R1 的邻居表。

```
R1# show ip ospf neighbor
Neighbor ID Pri State Dead Time  Address Interface
3.3.3.3 0 FULL/ - 00:00:35 10.1.1.13 GigabitEthernet0/0/1
2.2.2.2 0 FULL/ - 00:00:31 10.1.1.6 GigabitEthernet0/0/0
R1#
```

验证OSPF邻居（续）

在下列情况中，两台路由器之间不会形成OSPFv2邻接关系：

- 子网掩码不匹配，导致该两台路由器分处于不同的网络中。
- OSPFv2 Hello 计时器或 Dead 计时器不匹配。
- OSPFv2 网络类型不匹配。
- 存在信息缺失或不正确的 OSPFv2 network 命令。

验证OSPF协议设置

我们可以使用 **show ip protocols** 命令来快速验证重要的OSPF配置信息，如下例命令输出所示。这些重要信息包括 OSPFv2 进程 ID、路由器 ID、明确配置为通告OSPF路由的接口、路由器从哪个邻居那里接收了更新、默认的管理距离（OSPF 为 110）。

```
R1# show ip protocols
*** IP Routing is NSF aware ***
（省略部分输出）
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:
Routing on Interfaces Configured Explicitly (Area 0):
Loopback 0
GigabitEthernet0/0/1
GigabitEthernet0/0/0
Routing Information Sources:
Gateway Distance Last Update
3.3.3.3 110 00:09:30
2.2.2.2 110 00:09:58
Distance: (default is 110)
R1#
```

验证 OSPF 进程信息

我们也可以使用 **show ip ospf** 命令来查看OSPFv2的进程ID和路由器ID，如下列命令输出所示。这条命令会显示出OSPFv2的区域信息，以及上次执行SPF计算的时间。

```
R1# show ip ospf
Routing Process "ospf 10" with ID 1.1.1.1
Start time: 00:01:47.390, Time elapsed: 00:12:32.320
（省略部分输出）
Cisco NSF helper support enabled
Reference bandwidth unit is 10000 mbps
Area BACKBONE(0)
Number of interfaces in this area is 3
Area has no authentication
SPF algorithm last executed 00:11:31.231 ago
SPF algorithm executed 4 times
Area ranges are
Number of LSA 3. Checksum Sum 0x00E77E
Number of opaque link LSA 0. Checksum Sum 0x000000
Number of DCbitless LSA 0 Number of indication LSA 0
Number of DoNotAge LSA 0 Flood list length 0
R1#
```

验证OSPF接口设置

我们可以使用 **show ip ospf interface** 命令来查看每个启用了OSPFv2的接口详情。指定一个接口只显示这个接口的设置。这条命令的输出内容中包含进程 ID、本地路由器 ID、网络类型、OSPF 开销、多接入链路上的 DR 和 BDR 信息（未显示），以及相邻的邻居。

```
R1# show ip ospf interface GigabitEthernet 0/0/0
GigabitEthernet0/0/0 is up, line protocol is up
Internet Address 10.1.1.5/30, Area 0, Attached via Interface Enable
Process ID 10, Router ID 1.1.1.1, Network Type POINT_TO_POINT, Cost: 10

<省略部分输出>

Neighbor Count is 1, Adjacent neighbor count is 1
Adjacent with neighbor 2.2.2.2
Suppress hello for 0 neighbor(s)
R1#
```

验证OSPF接口设置（续）

要想快速查看启用了OSPFv2的接口汇总，我们可以使用 **show ip ospf interface brief** 命令，如以下命令输出所示。这条命令非常适合查看以下重要信息：

- 参与了OSPF的接口
- 宣告出去的网络（IP 地址/掩码）
- 每条链路的开销
- 网络状态
- 每条链路上的邻居数量

```
R1# show ip ospf interface brief
Interface PID Area IP Address/Mask Cost State Nbrs F/C
Lo0 10 0 10.10.1.1/24 10 P2P 0/0
Gi0/0/1 10 0 10.1.1.14/30 30 P2P 1/1
Gi0/0/0 10 0 10.1.1.5/30 10 P2P 1/1
R1#
```

Packet Tracer - 验证单区域 OSPFv2

在这个Packet Tracer练习中，您会完成以下操作：

- 确认和验证OSPF邻居的状态。
- 确定如何学习网络中的路由。
- 解释如何确定邻居状态。
- 检查OSPF进程ID的设置。
- 在现有OSPF网络中添加新的LAN并验证连通性。

18.9 单元练习与测验

Packet Tracer - 单区域OSPFv2的配置

在这个Packet Tracer练习中，您会完成以下操作：

- 在点对点和广播多接入网络中实施单区域 OSPFv2。

Packet Tracer - 单区域OSPFv2的配置

在本实验中，您将完成以下目标：

- 构建网络并完成设备的基本配置
- 配置和验证单区域 OSPF 的基本设置
- 优化和验证单区域 OSPFV2 的配置

在这个模块中我学到了什么？

- 我们可以使用全局配置命令 **router ospf process-id** 来启用OSPFv2。process-id值代表一个介于 1 和 65,535 之间的数字，由网络管理员选定。
- OSPF 路由器 ID 是一个 32 位的值，与 IPv4 地址的格式相同。启用了OSPF的路由器会使用路由器ID来同步OSPF数据库，并用它来参与DR和BDR的选举。
- 思科路由器会按顺序并根据以下条件来选择路由器ID：1) 使用 OSPF 路由器配置模式的命令**router id** *rid* 命令明确配置的路由器ID，2) 选择已配置的环回接口中最高的 IPv4 地址，或者 3) 选择物理接口的最高活动 IPv4 地址。
- 命令的基本语法是**network** command is **network** *network-address wildcard-mask* **area** *area-id*. 路由器上任何匹配 **network** 命令中的网络地址的接口上都会启用OSPF，都会发送和接收 OSPF 数据包。
- 在配置单区域 OSPFv2 时，我们必须在所有路由器的 **network** 命令中配置相同的area-id值。通配符掩码通常与接口上配置的子网掩码相反，但也可以使用全零的通配符掩码来指定具体的接口。

在这个模块中我学到了什么？(续)

- 要想直接在接口上配置OSPF，可以使用接口配置命令 **ip ospf interface** 。命令的语法是 **ip ospf** *process-id* **area** *area-id*。
- 我们可以使用路由器配置命令 **passive-interface interface**阻止路由器通过某个接口传输路由消息，但仍然会把这个网络通告给其他路由器。
- 在本例中 DR/BDR 选举其实是不必要的，因为 R1 和 R2 之间的点对点网络上只能有两台路由器。我们可以在所有希望禁用DR/BDR选举进程的接口上，使用接口配置命令 **ip ospf network point-to-point** 。
- 默认情况下，环回接口会被通告为一条掩码为 /32 的主机路由。为了模拟出真实的LAN环境，我们把环回接口0配置为点对点网络。
- OSPF 网络类型
- DR负责收集和分发LSA。DR 会使用组播IPv4地址 224.0.0.5，这个地址代表所有 OSPF 路由器。如果 DR 停止生成 hello 数据包，那么 BDR 将提升自己并担任 DR 的角色。所有其他路由器都会成为 DROTHER。
- DROTHER 会使用组播地址 224.0.0.6(这个地址代表所有指定路由器)向 DR 和 BDR 发送OSPF数据包。只有DR和BDR会监听发往 224.0.0.6 的流量。
- 要想验证OSPFv2路由器的角色，我们可以使用 **show ip ospf interface** 命令。

在这个模块中我学到了什么？（续）

- 要想验证OSPFv2的邻接关系，我们可以使用 **show ip ospf neighbor** 命令。多接入网络中的邻居状态可以是以下状态之一：FULL/DROTHER、FULL/DR。FULL/BDR，或2-WAY/DROTHER。
- 在选举DR和BDR时，OSPF会选择最高接口优先级的路由器为DR。具有第二高接口优先级的路由器被选为 BDR。如果路由器的接口优先级相等，则选择路由器 ID 最高的路由器作为 DR。路由器 ID 第二高的路由器被选为 BDR。
- 优先级可配置为 0 - 255 之间的任意数字。如果管理员把接口优先级值设置为 0，则该接口不会被选为 DR 或 BDR。多接入广播接口的默认优先级为 1。
- OSPF 中 DR 和 BDR 选择并不会主动发生。如果 DR 发生故障，那么 BDR 将自动提升为 DR。
- 要想设置接口优先级，我们可以使用命令 **ip ospf priority** *value*，其中值的取值范围为 0 到 255。如果接口优先级值为 0，这台路由器就不会成为 DR 或 BDR。对于介于 1–255 的值，值越高，路由器越有可能成为这个接口上的 DR 或 BDR。
- OSPF 使用开销作为度量。开销越低，表示路径越好。
- 计算 OSPF 开销的公式是：开销 = 参考带宽/接口带宽

在这个模块中我学到了什么？(续)

- 由于 OSPF 的开销值必须是一个整数，因此FE(快速以太网)接口、GE(千兆以太网)接口和 10GE(万兆以太网)接口的开销值相同。要想进行优化，我们可以在每台OSPF路由器上使用 **auto-cost reference-bandwidth** 命令来调整参考带宽，或者使用 **ip ospf cost** 命令手动设置 OSPF 开销值。
- OSPF 路由的开销为从路由器到目的网络的累计开销值。管理员可以通过修改OSPF的开销值，来影响OSPF的路由选择。要想更改本地OSPF路由器通告的去往其他OSPF路由器的开销值，我们可以使用接口配置命令 **ip ospf cost** *value*。
- 如果一个邻居的 Dead 间隔已超时，而路由器尚未收到这个邻居发来的 Hello 数据包，则它会从本地链路状态数据库 (LSDB) 中删除这个邻居。路由器会将该邻居连接断开的 LSDB 信息通过所有启用了 OSPF 的接口以泛洪的方式发送出去。
- 在多接入网络和点对点网络上，思科默认使用 4 倍的 Hello 间隔，即 40 秒。我们可以使用 **show ip ospf interface** 命令来验证接口上当前配置的OSPFv2开销值。
- 我们可以使用以下命令来手动修改OSPFv2的Hello间隔和Dead间隔：**ip ospf hello-interval** 和 **ip ospf dead-interval**.

在这个模块中我学到了什么？(续)

- 在 OSPF 术语中，位于 OSPF 路由域和非 OSPF 网络之间的路由器称为ASBR。要想传播默认路由，我们必须在ASBR上配置一条默认静态路由，使用命令 **ip route 0.0.0.0 0.0.0.0** [*next-hop-address* | *exit-intf*]，然后再使用路由器配置命令 **default-information originate router** 。
- 我们可以在ASBR上使用 **show ip route** 命令来验证默认路由的设置。
- 用于确定 OSPF 是否按预期运行的其他命令包括：**show ip ospf neighbor**，**show ip protocols**，**show ip ospf**，和 **show ip ospf interface**。
- 我们可以使用 **show ip ospf neighbor** 命令验证该路由器是否已与其相邻路由器建立邻接关系。

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