实验 5 - 路由技术

一．实验目的

1. 学习路由器的路由表，转发表等基本概念；
2. 学习路由选择协议相关内容；
3. 学习 OSPF 协议的相关内容；

二．实验环境

1. eNSP 网络环境仿真平台
2. wireShark 抓包工具

三．实验基本原理

1．路由器的基本概念

路由表

路由表是路由器用来决定如何转发数据包的核心数据结构。它包含了网络的目标地址、下一跳地址、以及接口信息。每一个条目定义了从路由器到达目标网络的路径。路由表的条目通常包括以下信息：

- 目标网络 (Destination Network)
- 子网掩码 (Subnet Mask)
- 下一跳 (Next Hop)
- 出接口 (Outgoing Interface)
- 距离值 (Metric)

转发表

转发表是路由器实际用来转发数据包的表格，它是从路由表中选取最优路径并生成的。转发表的条目直接影响数据包的转发过程，确保数据包能够通过最优路径送达目的地。

2．路由选择协议

路由选择协议的功能

路由选择协议的主要功能是通过动态更新路由器之间的路由信息，自动构建和维护路由表。这些协议通过交换路由信息，找到到达各个目标网络的最佳路径。常见的路由选择协

议包括 RIP（Routing Information Protocol）、OSPF（Open Shortest Path First）、EIGRP（Enhanced Interior Gateway Routing Protocol）等。

路由选择协议的分类

- **距离矢量路由协议**（如 RIP）：通过周期性地交换包含距离矢量的路由更新包，逐跳传播网络信息。
- **链路状态路由协议**（如 OSPF）：通过链路状态广播的方式，将整个网络拓扑信息发送到所有路由器，使每个路由器可以构建完整的网络拓扑图，并计算最优路径。

3．OSPF 协议

OSPF 的基本概念

OSPF（开放最短路径优先）是一种链路状态路由协议，主要用于大型和复杂的 IP 网络。OSPF 通过 SPF（Shortest Path First）算法计算路径，确保数据包通过最短路径传输。OSPF 支持无类域间路由（CIDR），并能够快速响应网络拓扑变化。

OSPF 的关键特性

- **区域（Area）**：OSPF 网络可以被划分为多个区域，每个区域内的路由器维护自己的链路状态数据库（LSDB），减少了路由信息的规模和复杂性。
- **路由器类型**：OSPF 路由器分为不同类型，如内部路由器（Internal Router）、区域边界路由器（ABR，Area Border Router）、自治系统边界路由器（ASBR，Autonomous System Boundary Router）等。
- **LSA（Link State Advertisement）**：OSPF 使用 LSA 来通告路由信息，不同类型的 LSA 负责通告不同类型的路由信息，如 Router LSA、Network LSA、Summary LSA 等。
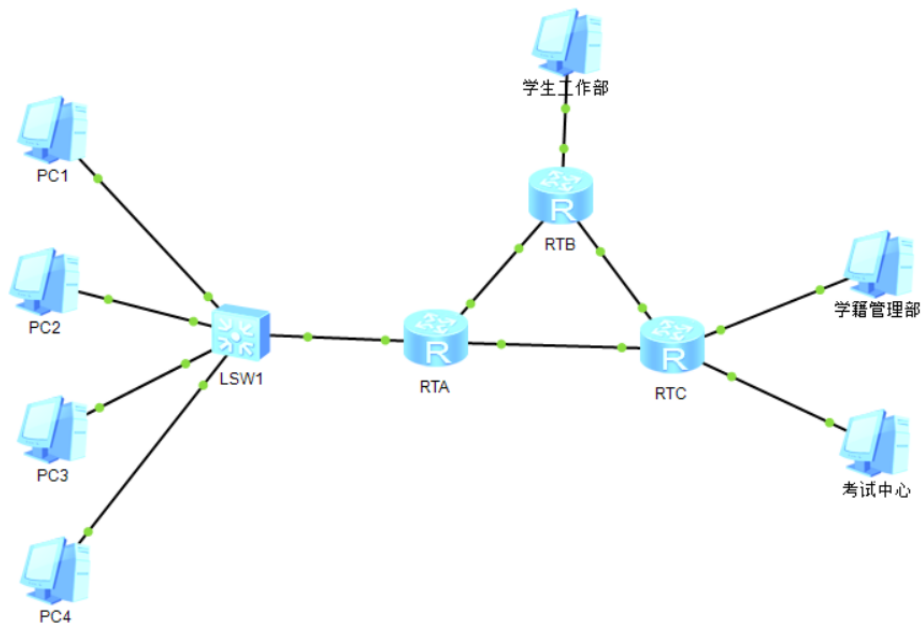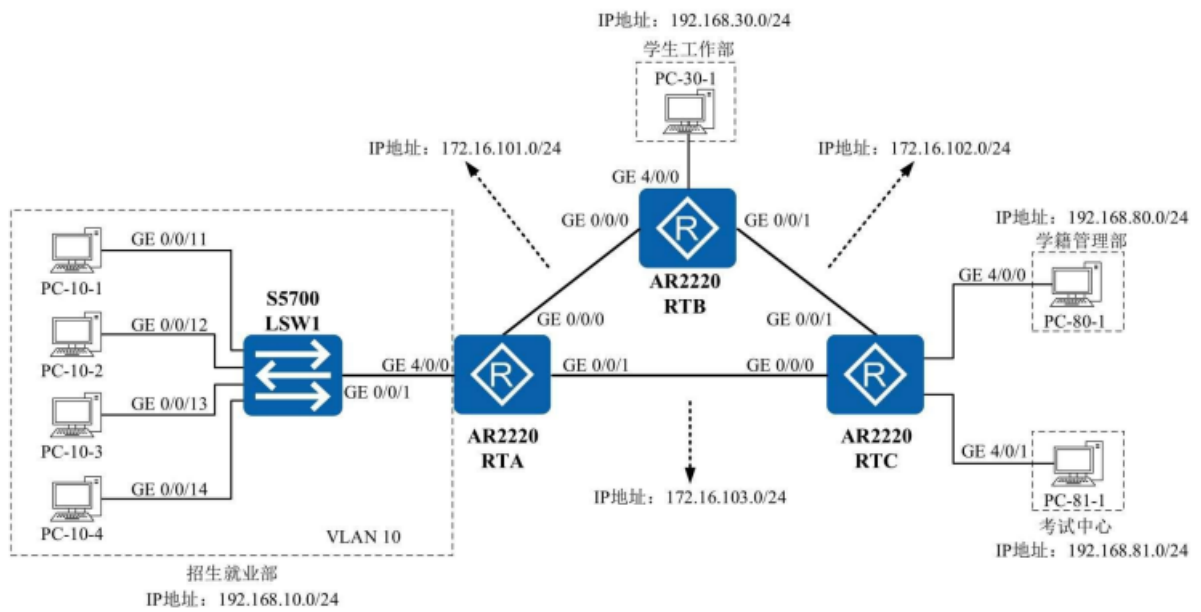
OSPF 工作过程

1. **邻居发现与建立**：路由器通过 Hello 包发现和建立邻居关系。
2. **状态同步**：邻居之间同步链路状态数据库。
3. **SPF 计算**：每个路由器使用 SPF 算法计算到达所有网络的最短路径，并更新路由表。

四．实验案例及结果分析

5.1 路由器配置静态和默认路由 实现 IP 子网之间的通信

网络拓扑

IP地址：192.168.30.0/24
学生工作部
PC-30-1

IP地址：172.16.101.0/24

GE 4/0/0

GE 0/0/0   GE 0/0/1

AR2220
RTB

IP地址：172.16.102.0/24

IP地址：192.168.80.0/24
学籍管理部
PC-80-1

GE 4/0/0

GE 0/0/11
PC-10-1

S5700
LSW1

GE 0/0/0

GE 0/0/12
PC-10-2

GE 4/0/0   GE 0/0/1   GE 0/0/0

GE 0/0/1

GE 0/0/13
PC-10-3

AR2220
RTA

AR2220
RTC

GE 4/0/1
PC-81-1

GE 0/0/14
PC-10-4   VLAN 10

IP地址：172.16.103.0/24

考试中心
IP地址：192.168.81.0/24

招生就业部
IP地址：192.168.10.0/24

学生工作部

PC1

RTB

PC2

学籍管理部

LSW1   RTA   RTC

PC3

考试中心

PC4

参数配置

	IPv4 地址	子网掩码	默认网关
招生就业部网段	**192.168.10.0**	**255.255.255.0**	
PC-10-1	192.168.10.11	255.255.255.0	192.168.10.1
PC-10-2	192.168.10.12	255.255.255.0	192.168.10.1
PC-10-3	192.168.10.13	255.255.255.0	192.168.10.1
PC-10-4	192.168.10.14	255.255.255.0	192.168.10.1
学生工作部网段	**192.168.30.0**	**255.255.255.0**	
PC-30-1	192.168.30.11	255.255.255.0	192.168.30.1
学籍管理部网段	**192.168.80.0**	**255.255.255.0**	
PC-80-1	192.168.80.11	255.255.255.0	192.168.80.1
考试中心网段	**192.168.81.0**	**255.255.255.0**	
PC-70-1	192.168.81.11	255.255.255.0	192.168.81.1

	IPv4 地址	子网掩码	默认网关
路由器 RTA			
GE 0/0/0	172.16.101.1	255.255.255.0	
GE 0/0/1	172.16.103.1	255.255.255.0	
GE 4/0/0	192.168.10.1	255.255.255.0	
路由器 RTB			
GE 0/0/0	172.16.101.2	255.255.255.0	
GE 0/0/1	172.16.102.2	255.255.255.0	
GE 4/0/0	192.168.30.1	255.255.255.0	
路由器 RTC			
GE 0/0/0	172.16.103.2	255.255.255.0	
GE 0/0/1	172.16.102.1	255.255.255.0	
GE 4/0/0	192.168.80.1	255.255.255.0	
GE 4/0/1	192.168.81.1	255.255.255.0	

实验步骤及结果

1. 修改路由器接口 IP

```
interface g 0/0/1 # 选择接口 0/0/1
ip address 192.168.1.1 24 # 设置 ip 及掩码
dis this # 查看当前接口配置
```

2. 查看路由器配置

```
display ip interface brief
```

3. 招生就业部局域网 vlan 设置

最初 vlan 均为 1

```
[Huawei]display mac-address
MAC address table of slot 0:
--------------------------------------------------------------------------------
MAC Address      VLAN/           PEVLAN CEVLAN Port            Type      LSP/LSR-ID
                 VSI/SI                                                  MAC-Tunnel
--------------------------------------------------------------------------------
5489-9884-5892 1                 -      -      GE0/0/11        dynamic   0/-
5489-986f-5cab 1                 -      -      GE0/0/12        dynamic   0/-
5489-985b-15c7 1                 -      -      GE0/0/13        dynamic   0/-
5489-98d9-4f54 1                 -      -      GE0/0/14        dynamic   0/-
--------------------------------------------------------------------------------
Total matching items on slot 0 displayed = 4
```

将各接口 vlan 设置为 10

```
[Huawei]interface g 0/0/14
[Huawei-GigabitEthernet0/0/14]port link-type access
[Huawei-GigabitEthernet0/0/14]port default vlan 10
```

```
[Huawei]display vlan
The total number of vlans is : 2
--------------------------------------------------------------------------------
U: Up;          D: Down;         TG: Tagged;          UT: Untagged;
MP: Vlan-mapping;                ST: Vlan-stacking;
#: ProtocolTransparent-vlan;     *: Management-vlan;
--------------------------------------------------------------------------------

VID  Type    Ports
--------------------------------------------------------------------------------
1    common  UT:GE0/0/2(D)      GE0/0/3(D)       GE0/0/4(D)       GE0/0/5(D)
                GE0/0/6(D)       GE0/0/7(D)       GE0/0/8(D)       GE0/0/9(D)
                GE0/0/10(D)      GE0/0/15(D)      GE0/0/16(D)      GE0/0/17(D)
                GE0/0/18(D)      GE0/0/19(D)      GE0/0/20(D)      GE0/0/21(D)
                GE0/0/22(D)      GE0/0/23(D)      GE0/0/24(D)

10   common  UT:GE0/0/1(U)      GE0/0/11(U)      GE0/0/12(U)      GE0/0/13(U)
                GE0/0/14(U)


VID  Status  Property     MAC-LRN Statistics Description
--------------------------------------------------------------------------------
1    enable  default      enable  disable    VLAN 0001
10   enable  default      enable  disable    VLAN 0010
```

```
[Huawei]display mac-address
MAC address table of slot 0:
--------------------------------------------------------------------------------
MAC Address      VLAN/           PEVLAN CEVLAN Port            Type      LSP/LSR-ID
                 VSI/SI                                                  MAC-Tunnel
--------------------------------------------------------------------------------
5489-9884-5892 10                -      -      GE0/0/11        dynamic   0/-
5489-985b-15c7 10                -      -      GE0/0/13        dynamic   0/-
5489-986f-5cab 10                -      -      GE0/0/12        dynamic   0/-
5489-9847-1046 10                -      -      GE0/0/1         dynamic   0/-
5489-98d9-4f54 10                -      -      GE0/0/14        dynamic   0/-
--------------------------------------------------------------------------------
Total matching items on slot 0 displayed = 5
```

3. 招生就业部局域网 vlan 设置

最初 vlan 均为 1

4. 各路由器接口 IP

```
RTA                                                                    _ □ X
*down: administratively down
!down: FIB overload down
^down: standby
(l): loopback
(s): spoofing
(d): Dampening Suppressed
The number of interface that is UP in Physical is 4
The number of interface that is DOWN in Physical is 7
The number of interface that is UP in Protocol is 4
The number of interface that is DOWN in Protocol is 7

Interface                        IP Address/Mask        Physical    Protocol
Ethernet0/0/0                    unassigned             down        down
Ethernet0/0/1                    unassigned             down        down
GigabitEthernet0/0/0             172.16.101.1/24        up          up
GigabitEthernet0/0/1             172.16.103.1/24        up          up
GigabitEthernet0/0/2             192.168.10.1/24        up          up
```

```
RTB                                                                    _ □ X
!down: FIB overload down
^down: standby
(l): loopback
(s): spoofing
(d): Dampening Suppressed
The number of interface that is UP in Physical is 4
The number of interface that is DOWN in Physical is 8
The number of interface that is UP in Protocol is 4
The number of interface that is DOWN in Protocol is 8

Interface                        IP Address/Mask        Physical    Protocol
Ethernet0/0/0                    unassigned             down        down
Ethernet0/0/1                    unassigned             down        down
GigabitEthernet0/0/0             172.16.101.2/24        up          up
GigabitEthernet0/0/1             172.16.102.2/24        up          up
GigabitEthernet0/0/2             192.168.30.1/24        up          up
```

```
RTC                                                                    _ □ X
*down: administratively down
!down: FIB overload down
^down: standby
(l): loopback
(s): spoofing
(d): Dampening Suppressed
The number of interface that is UP in Physical is 5
The number of interface that is DOWN in Physical is 6
The number of interface that is UP in Protocol is 5
The number of interface that is DOWN in Protocol is 6

Interface                        IP Address/Mask        Physical    Protocol
Ethernet0/0/0                    unassigned             down        down
Ethernet0/0/1                    unassigned             down        down
GigabitEthernet0/0/0             172.16.103.2/24        up          up
GigabitEthernet0/0/1             172.16.102.1/24        up          up
GigabitEthernet0/0/2             192.168.80.1/24        up          up
GigabitEthernet0/0/3             192.168.81.1/24        up          up
```

5. 设置表项

```
[Huawei]ip route-static 192.168.30.0 24 172.16.102.2
[Huawei]ip route-static 192.168.10.0 24 172.16.103.1
```

6. 各局域网之间 PC 的通信

```
PC>ping 192.168.10.12  ❶

Ping 192.168.10.12: 32 data bytes, Press Ctrl_C to break
From 192.168.10.12: bytes=32 seq=1 ttl=126 time=125 ms
From 192.168.10.12: bytes=32 seq=2 ttl=126 time=94 ms

--- 192.168.10.12 ping statistics ---
  2 packet(s) transmitted
  2 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 94/109/125 ms

PC>ping 192.168.80.11  ❷

Ping 192.168.80.11: 32 data bytes, Press Ctrl_C to break
From 192.168.80.11: bytes=32 seq=1 ttl=127 time=47 ms
From 192.168.80.11: bytes=32 seq=2 ttl=127 time=31 ms

--- 192.168.80.11 ping statistics ---
  2 packet(s) transmitted
  2 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 31/39/47 ms

PC>ping 192.168.81.11  ❸

Ping 192.168.81.11: 32 data bytes, Press Ctrl_C to break
From 192.168.81.11: bytes=32 seq=1 ttl=128 time<1 ms
From 192.168.81.11: bytes=32 seq=2 ttl=128 time<1 ms
From 192.168.81.11: bytes=32 seq=3 ttl=128 time<1 ms

--- 192.168.81.11 ping statistics ---
  3 packet(s) transmitted
  3 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 0/0/0 ms

PC>ping 192.168.30.11  ❹

Ping 192.168.30.11: 32 data bytes, Press Ctrl_C to break
From 192.168.30.11: bytes=32 seq=1 ttl=126 time=94 ms
```

7. 查看路由表及转发表

RTC 转发表

```
[Huawei]display fib
Route Flags: G - Gateway Route, H - Host Route,    U - Up Route
             S - Static Route,  D - Dynamic Route, B - Black Hole Route
-------------------------------------------------------------------------
 FIB Table:
 Total number of Routes : 12

Destination/Mask    Nexthop        Flag  TimeStamp    Interface     TunnelID
192.168.81.1/32     127.0.0.1      HU    t[7]         InLoop0       0x0
192.168.80.1/32     127.0.0.1      HU    t[7]         InLoop0       0x0
172.16.102.1/32     127.0.0.1      HU    t[6]         InLoop0       0x0
172.16.103.2/32     127.0.0.1      HU    t[6]         InLoop0       0x0
127.0.0.1/32        127.0.0.1      HU    t[6]         InLoop0       0x0
127.0.0.0/8         127.0.0.1      U     t[6]         InLoop0       0x0
172.16.103.0/24     172.16.103.2   U     t[6]         GE0/0/0       0x0
172.16.102.0/24     172.16.102.1   U     t[6]         GE0/0/1       0x0
192.168.80.0/24     192.168.80.1   U     t[7]         GE0/0/2       0x0
192.168.81.0/24     192.168.81.1   U     t[7]         GE0/0/3       0x0
192.168.30.0/24     172.16.102.2   GSU   t[405]       GE0/0/1       0x0
192.168.10.0/24     172.16.103.1   GSU   t[408]       GE0/0/0       0x0
```

RTC 路由表

```
[Huawei]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 12      Routes : 12

Destination/Mask      Proto   Pre  Cost       Flags NextHop         Interface

       127.0.0.0/8    Direct  0    0          D     127.0.0.1       InLoopBack0
       127.0.0.1/32   Direct  0    0          D     127.0.0.1       InLoopBack0
   172.16.102.0/24    Direct  0    0          D     172.16.102.1    GigabitEthernet
0/0/1
    172.16.102.1/32   Direct  0    0          D     127.0.0.1       GigabitEthernet
0/0/1
    172.16.103.0/24   Direct  0    0          D     172.16.103.2    GigabitEthernet
0/0/0
    172.16.103.2/32   Direct  0    0          D     127.0.0.1       GigabitEthernet
0/0/0
    192.168.10.0/24   Static  60   0          RD    172.16.103.1    GigabitEthernet
0/0/0
    192.168.30.0/24   Static  60   0          RD    172.16.102.2    GigabitEthernet
0/0/1
    192.168.80.0/24   Direct  0    0          D     192.168.80.1    GigabitEthernet
0/0/2
    192.168.80.1/32   Direct  0    0          D     127.0.0.1       GigabitEthernet
0/0/2
    192.168.81.0/24   Direct  0    0          D     192.168.81.1    GigabitEthernet
0/0/3
    192.168.81.1/32   Direct  0    0          D     127.0.0.1       GigabitEthernet
0/0/3
```

5.2 路由器配置单区域 OSPF 基本功能

网络拓扑
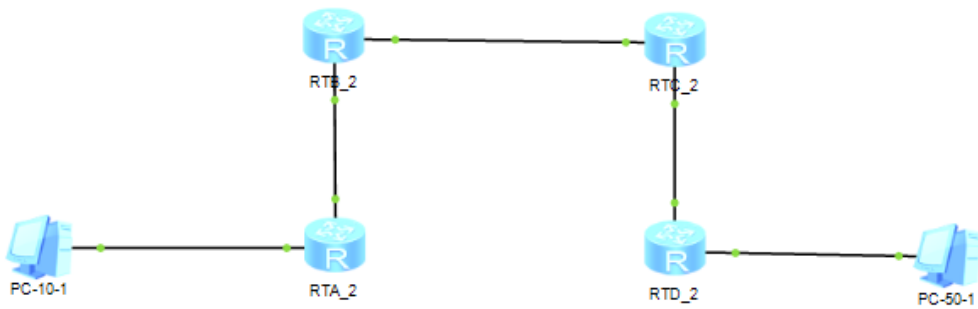
参数配置

实验步骤及结果

1. 各主机及路由器接口 IP 设置
   - RTA

```
GigabitEthernet0/0/0          172.16.101.1/24     up        up
GigabitEthernet0/0/1          unassigned          down      down
GigabitEthernet0/0/2          10.1.10.1/24        up        up
```

- RTB

```
GigabitEthernet0/0/0          172.16.101.2/24      up      up
GigabitEthernet0/0/1          172.16.102.1/24      up      up
```

- RTC

```
GigabitEthernet0/0/0          172.16.103.2/24      up      up
GigabitEthernet0/0/1          172.16.102.2/24      up      up
```

- RTD

```
GigabitEthernet0/0/0          172.16.103.1/24      up      up
GigabitEthernet0/0/1          unassigned           down    down
GigabitEthernet0/0/2          11.1.50.1/24         up      up
```

- PC-10-1

IPv4 配置

● 静态	○ DHCP		☐ 自动获取 DNS 服务器地址
IP 地址:	10 . 1 . 10 . 11	DNS1:	0 . 0 . 0 . 0
子网掩码:	255 . 255 . 255 . 0	DNS2:	0 . 0 . 0 . 0
网关:	10 . 1 . 10 . 1		

- PC-50-1

IPv4 配置

● 静态	○ DHCP		☐ 自动获取 DNS 服务器地址
IP 地址:	11 . 1 . 50 . 11	DNS1:	0 . 0 . 0 . 0
子网掩码:	255 . 255 . 255 . 0	DNS2:	0 . 0 . 0 . 0
网关:	11 . 1 . 50 . 1		

2. ospf 配置

```
router id 1.1.1.1
ospf 1
area 0
network 172.16.101.0 0.0.0.255
```

3. 连通性测试

```
PC-10-1                                                              _  □  X

 基础配置    命令行    组播   UDP发包工具    串口

From 10.1.10.11: bytes=32 seq=3 ttl=128 time<1 ms
From 10.1.10.11: bytes=32 seq=4 ttl=128 time<1 ms
From 10.1.10.11: bytes=32 seq=5 ttl=128 time<1 ms

--- 10.1.10.11 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 0/0/0 ms

PC>ping 11.1.50.11

Ping 11.1.50.11: 32 data bytes, Press Ctrl_C to break
From 11.1.50.11: bytes=32 seq=1 ttl=124 time=125 ms
From 11.1.50.11: bytes=32 seq=2 ttl=124 time=125 ms
From 11.1.50.11: bytes=32 seq=3 ttl=124 time=109 ms
From 11.1.50.11: bytes=32 seq=4 ttl=124 time=109 ms
From 11.1.50.11: bytes=32 seq=5 ttl=124 time=110 ms

--- 11.1.50.11 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 109/115/125 ms

PC>
```

```
PC-50-1                                                              _  □  X

 基础配置    命令行    组播   UDP发包工具    串口

From 11.1.50.11: bytes=32 seq=3 ttl=128 time<1 ms
From 11.1.50.11: bytes=32 seq=4 ttl=128 time<1 ms
From 11.1.50.11: bytes=32 seq=5 ttl=128 time<1 ms

--- 11.1.50.11 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 0/0/0 ms

PC>ping 10.1.10.11

Ping 10.1.10.11: 32 data bytes, Press Ctrl_C to break
From 10.1.10.11: bytes=32 seq=1 ttl=124 time=109 ms
From 10.1.10.11: bytes=32 seq=2 ttl=124 time=109 ms
From 10.1.10.11: bytes=32 seq=3 ttl=124 time=125 ms
From 10.1.10.11: bytes=32 seq=4 ttl=124 time=141 ms
From 10.1.10.11: bytes=32 seq=5 ttl=124 time=94 ms

--- 10.1.10.11 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 94/115/141 ms

PC>
```

4. ospf 邻居信息
   RTA

```
[Huawei]display ospf peer brief

       OSPF Process 1 with Router ID 1.1.1.1
            Peer Statistic Information
-------------------------------------------------------------------------
Area Id          Interface                    Neighbor id       State
0.0.0.0          GigabitEthernet0/0/0         2.2.2.2           Full
-------------------------------------------------------------------------
[Huawei]
```

```
[Huawei]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
         Destinations : 3        Routes : 3

OSPF routing table status : <Active>
         Destinations : 3        Routes : 3

Destination/Mask     Proto     Pre   Cost       Flags NextHop          Interface

     11.1.50.0/24    OSPF      10    4            D   172.16.101.2     GigabitEthernet
0/0/0
   172.16.102.0/24   OSPF      10    2            D   172.16.101.2     GigabitEthernet
0/0/0
   172.16.103.0/24   OSPF      10    3            D   172.16.101.2     GigabitEthernet
0/0/0

OSPF routing table status : <Inactive>
         Destinations : 0        Routes : 0

[Huawei]
```

```
[Huawei]dis ospf lsdb

        OSPF Process 1 with Router ID 1.1.1.1
            Link State Database

                 Area: 0.0.0.0
 Type       LinkState ID      AdvRouter        Age   Len   Sequence     Metric
 Router     4.4.4.4           4.4.4.4          133   48    80000006       1
 Router     2.2.2.2           2.2.2.2          318   48    80000009       1
 Router     1.1.1.1           1.1.1.1          112   48    8000000B       1
 Router     3.3.3.3           3.3.3.3          183   48    80000009       1
 Network    172.16.102.1      2.2.2.2          318   32    80000003       0
 Network    172.16.101.1      1.1.1.1          445   32    80000003       0
 Network    172.16.103.2      3.3.3.3          183   32    80000003       0
```

RTB

```
[Huawei]display ospf peer brief

        OSPF Process 1 with Router ID 2.2.2.2
            Peer Statistic Information
------------------------------------------------------------------------------
 Area Id          Interface              Neighbor id       State
 0.0.0.0          GigabitEthernet0/0/0   1.1.1.1           Full
 0.0.0.0          GigabitEthernet0/0/1   3.3.3.3           Full
------------------------------------------------------------------------------
[Huawei]
```

```
[Huawei]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
         Destinations : 3        Routes : 3

OSPF routing table status : <Active>
         Destinations : 3        Routes : 3

Destination/Mask     Proto     Pre   Cost       Flags NextHop          Interface

     10.1.10.0/24    OSPF      10    2            D   172.16.101.1     GigabitEthernet
0/0/0
     11.1.50.0/24    OSPF      10    3            D   172.16.102.2     GigabitEthernet
0/0/1
   172.16.103.0/24   OSPF      10    2            D   172.16.102.2     GigabitEthernet
0/0/1

OSPF routing table status : <Inactive>
         Destinations : 0        Routes : 0

[Huawei]
```
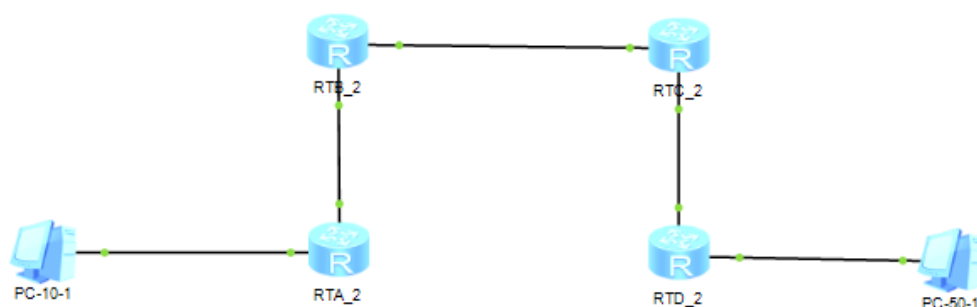
```
<Huawei>dis ospf lsdb

        OSPF Process 1 with Router ID 2.2.2.2
            Link State Database

                    Area: 0.0.0.0
    Type        LinkState ID      AdvRouter          Age   Len   Sequence     Metric
    Router      4.4.4.4           4.4.4.4            395   48    80000006     1
    Router      2.2.2.2           2.2.2.2            580   48    80000009     1
    Router      1.1.1.1           1.1.1.1            376   48    8000000B     1
    Router      3.3.3.3           3.3.3.3            445   48    80000009     1
    Network     172.16.102.1      2.2.2.2            580   32    80000003     0
    Network     172.16.101.1      1.1.1.1            709   32    80000003     0
    Network     172.16.103.2      3.3.3.3            445   32    80000003     0
```
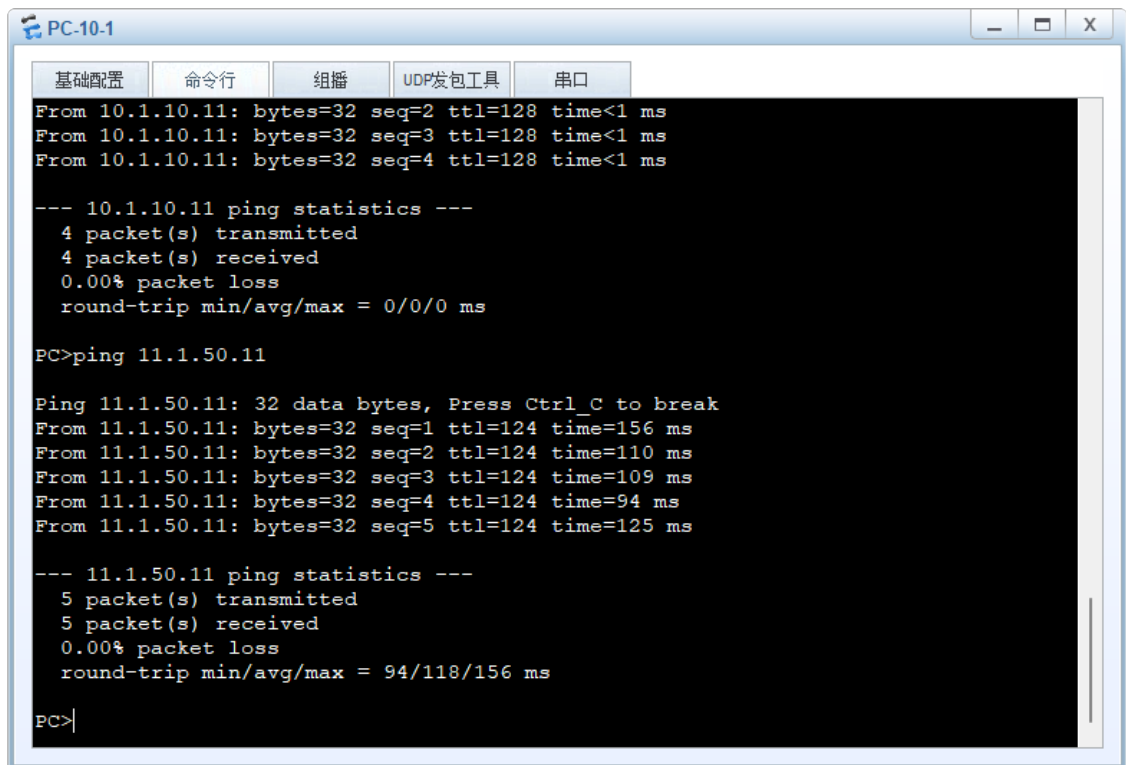
RTC

```
[Huawei]display ospf peer brief

        OSPF Process 1 with Router ID 3.3.3.3
            Peer Statistic Information
    ----------------------------------------------------------------------
    Area Id          Interface                       Neighbor id       State
    0.0.0.0          GigabitEthernet0/0/0            4.4.4.4           Full
    0.0.0.0          GigabitEthernet0/0/1            2.2.2.2           Full

    ----------------------------------------------------------------------
[Huawei]
```

```
[Huawei]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------
Public routing table : OSPF
        Destinations : 3        Routes : 3

OSPF routing table status : <Active>
        Destinations : 3        Routes : 3

Destination/Mask    Proto   Pre  Cost      Flags NextHop          Interface

    10.1.10.0/24    OSPF    10   3         D     172.16.102.1     GigabitEthernet
0/0/1
    11.1.50.0/24    OSPF    10   2         D     172.16.103.1     GigabitEthernet
0/0/0
  172.16.101.0/24   OSPF    10   2         D     172.16.102.1     GigabitEthernet
0/0/1

OSPF routing table status : <Inactive>
        Destinations : 0        Routes : 0

[Huawei]
```

```
[Huawei]dis ospf lsdb

        OSPF Process 1 with Router ID 3.3.3.3
            Link State Database

                    Area: 0.0.0.0
    Type        LinkState ID      AdvRouter          Age   Len   Sequence     Metric
    Router      4.4.4.4           4.4.4.4            176   48    80000006     1
    Router      2.2.2.2           2.2.2.2            363   48    80000009     1
    Router      1.1.1.1           1.1.1.1            158   48    8000000B     1
    Router      3.3.3.3           3.3.3.3            226   48    80000009     1
    Network     172.16.102.1      2.2.2.2            363   32    80000003     0
    Network     172.16.101.1      1.1.1.1            492   32    80000003     0
    Network     172.16.103.2      3.3.3.3            226   32    80000003     0
```

RTD

```
[Huawei]display ospf peer brief

        OSPF Process 1 with Router ID 4.4.4.4
             Peer Statistic Information
 -------------------------------------------------------------------------------
 Area Id          Interface                          Neighbor id       State
 0.0.0.0          GigabitEthernet0/0/0               3.3.3.3           Full
 -------------------------------------------------------------------------------
[Huawei]
```

```
[Huawei]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
         Destinations : 3        Routes : 3

OSPF routing table status : <Active>
         Destinations : 3        Routes : 3

Destination/Mask     Proto    Pre   Cost       Flags NextHop         Interface

     10.1.10.0/24    OSPF     10    4          D     172.16.103.2    GigabitEthernet
0/0/0
   172.16.101.0/24   OSPF     10    3          D     172.16.103.2    GigabitEthernet
0/0/0
   172.16.102.0/24   OSPF     10    2          D     172.16.103.2    GigabitEthernet
0/0/0

OSPF routing table status : <Inactive>
         Destinations : 0        Routes : 0

[Huawei]
```

```
<Huawei>display ospf lsdb

        OSPF Process 1 with Router ID 4.4.4.4
             Link State Database

                       Area: 0.0.0.0
 Type        LinkState ID    AdvRouter         Age   Len  Sequence    Metric
 Router      4.4.4.4         4.4.4.4           429   48   80000006    1
 Router      2.2.2.2         2.2.2.2           618   48   80000009    1
 Router      1.1.1.1         1.1.1.1           414   48   8000000B    1
 Router      3.3.3.3         3.3.3.3           481   48   80000009    1
 Network     172.16.102.1    2.2.2.2           618   32   80000003    0
 Network     172.16.101.1    1.1.1.1           747   32   80000003    0
 Network     172.16.103.2    3.3.3.3           481   32   80000003    0
```
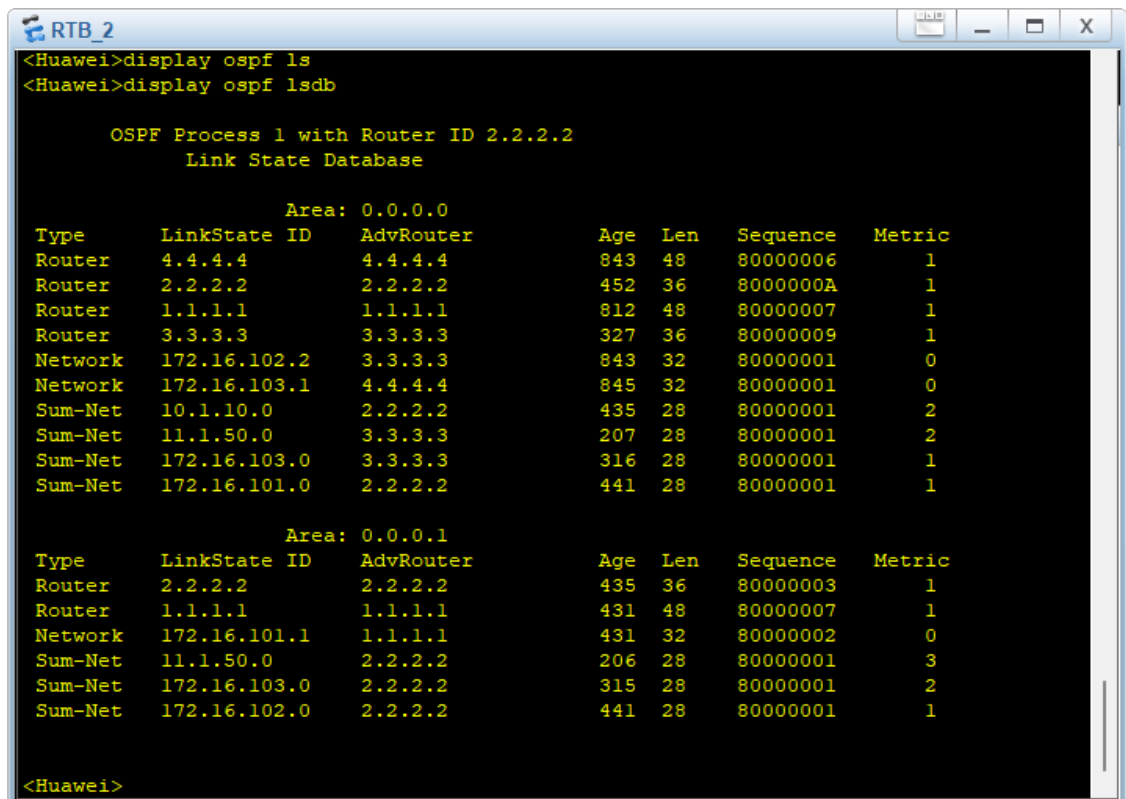
5.3 多区域 OSPF

网络拓扑

实验过程记录

1. 连通性测试

- ## PC-10-1

- ## PC-50-1

2. OSPF 配置信息

- RTA

```
[Huawei]display ospf lsdb

        OSPF Process 1 with Router ID 1.1.1.1
              Link State Database

                    Area: 0.0.0.0
Type        LinkState ID    AdvRouter           Age   Len    Sequence     Metric
Router      4.4.4.4         4.4.4.4             705   48     80000006     1
Router      2.2.2.2         2.2.2.2             698   48     80000007     1
Router      3.3.3.3         3.3.3.3             705   48     80000007     1
Network     172.16.102.2    3.3.3.3             705   32     80000001     0
Network     172.16.101.2    2.2.2.2             698   32     80000002     0
Network     172.16.103.1    4.4.4.4             707   32     80000001     0

                    Area: 0.0.0.1
Type        LinkState ID    AdvRouter           Age   Len    Sequence     Metric
Router      2.2.2.2         2.2.2.2             297   36     80000003     1
Router      1.1.1.1         1.1.1.1             291   48     80000007     1
Network     172.16.101.1    1.1.1.1             291   32     80000002     0
Sum-Net     11.1.50.0       2.2.2.2              68   28     80000001     3
Sum-Net     172.16.103.0    2.2.2.2             177   28     80000001     2
Sum-Net     172.16.102.0    2.2.2.2             303   28     80000001     1


[Huawei]
```

- RTB

```
RTB_2
<Huawei>display ospf ls
<Huawei>display ospf lsdb

        OSPF Process 1 with Router ID 2.2.2.2
              Link State Database

                    Area: 0.0.0.0
Type        LinkState ID    AdvRouter           Age   Len    Sequence     Metric
Router      4.4.4.4         4.4.4.4             843   48     80000006     1
Router      2.2.2.2         2.2.2.2             452   36     8000000A     1
Router      1.1.1.1         1.1.1.1             812   48     80000007     1
Router      3.3.3.3         3.3.3.3             327   36     80000009     1
Network     172.16.102.2    3.3.3.3             843   32     80000001     0
Network     172.16.103.1    4.4.4.4             845   32     80000001     0
Sum-Net     10.1.10.0       2.2.2.2             435   28     80000001     2
Sum-Net     11.1.50.0       3.3.3.3             207   28     80000001     2
Sum-Net     172.16.103.0    3.3.3.3             316   28     80000001     1
Sum-Net     172.16.101.0    2.2.2.2             441   28     80000001     1

                    Area: 0.0.0.1
Type        LinkState ID    AdvRouter           Age   Len    Sequence     Metric
Router      2.2.2.2         2.2.2.2             435   36     80000003     1
Router      1.1.1.1         1.1.1.1             431   48     80000007     1
Network     172.16.101.1    1.1.1.1             431   32     80000002     0
Sum-Net     11.1.50.0       2.2.2.2             206   28     80000001     3
Sum-Net     172.16.103.0    2.2.2.2             315   28     80000001     2
Sum-Net     172.16.102.0    2.2.2.2             441   28     80000001     1


<Huawei>
```

- RTC

```
      OSPF Process 1 with Router ID 3.3.3.3
            Link State Database

                  Area: 0.0.0.0
Type          LinkState ID    AdvRouter        Age   Len   Sequence     Metric
Router        4.4.4.4         4.4.4.4          892   48    80000006     1
Router        2.2.2.2         2.2.2.2          503   36    8000000A     1
Router        1.1.1.1         1.1.1.1          862   48    80000007     1
Router        3.3.3.3         3.3.3.3          376   36    80000009     1
Network       172.16.102.2    3.3.3.3          891   32    80000001     0
Network       172.16.103.1    4.4.4.4          893   32    80000001     0
Sum-Net       10.1.10.0       2.2.2.2          485   28    80000001     2
Sum-Net       11.1.50.0       3.3.3.3          256   28    80000001     2
Sum-Net       172.16.103.0    3.3.3.3          365   28    80000001     1
Sum-Net       172.16.101.0    2.2.2.2          491   28    80000001     1

                  Area: 0.0.0.2
Type          LinkState ID    AdvRouter        Age   Len   Sequence     Metric
Router        4.4.4.4         4.4.4.4          231   48    80000005     1
Router        3.3.3.3         3.3.3.3          250   36    80000005     1
Network       172.16.103.2    3.3.3.3          250   32    80000002     0
Sum-Net       10.1.10.0       3.3.3.3          365   28    80000001     3
Sum-Net       172.16.102.0    3.3.3.3          365   28    80000001     1
Sum-Net       172.16.101.0    3.3.3.3          365   28    80000001     2

[Huawei]
```

- RTD

```
      OSPF Process 1 with Router ID 4.4.4.4
            Link State Database

                  Area: 0.0.0.0
Type          LinkState ID    AdvRouter        Age   Len   Sequence     Metric
Router        2.2.2.2         2.2.2.2          537   36    8000000A     1
Router        1.1.1.1         1.1.1.1          897   48    80000007     1
Router        3.3.3.3         3.3.3.3          926   48    80000007     1
Network       172.16.102.2    3.3.3.3          926   32    80000001     0
Sum-Net       10.1.10.0       2.2.2.2          520   28    80000001     2
Sum-Net       172.16.101.0    2.2.2.2          526   28    80000001     1

                  Area: 0.0.0.2
Type          LinkState ID    AdvRouter        Age   Len   Sequence     Metric
Router        4.4.4.4         4.4.4.4          264   48    80000005     1
Router        3.3.3.3         3.3.3.3          285   36    80000005     1
Network       172.16.103.2    3.3.3.3          285   32    80000002     0
Sum-Net       10.1.10.0       3.3.3.3          400   28    80000001     3
Sum-Net       172.16.102.0    3.3.3.3          400   28    80000001     1
Sum-Net       172.16.101.0    3.3.3.3          400   28    80000001     2


[Huawei]
```
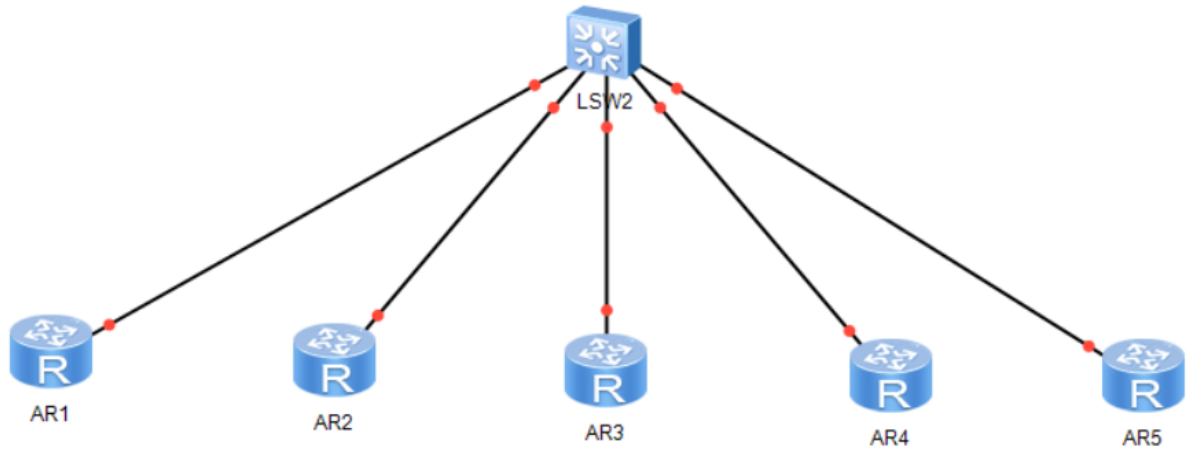
5.4 DR 选举

策略

在 DR/BDR 的选举过程中，首先比较路由接口的 DR 优先级，优先就最高的路由器将被选为 DR，次之为 BDR，其余为 DRother。DR 优先级默认值为 1，如果为 0 则代表不参与选举。如果接口的 DR 优先级相同，则比较路由器的 router-id，数值最大的为 DR，次之为 BDR，其余为 DRother。
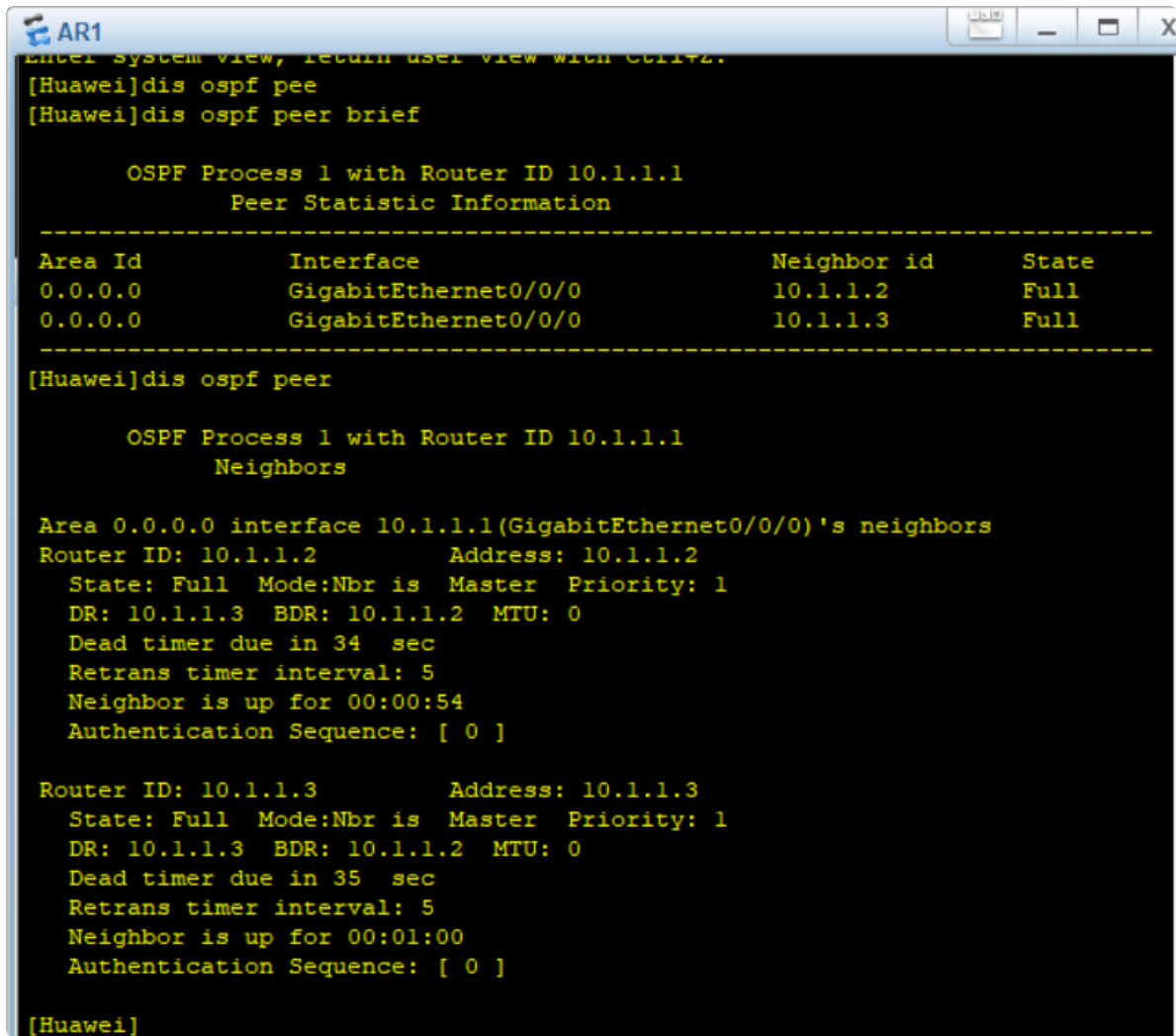
在路由器上查看 DR/BDR 的选举情况：

```
display ospf interface
```

网络拓扑

实验过程记录

1. 开启 LSW1，AR1，AR2，AR3

```
AR1                                                                    ▢▢ _ ☐ X

Enter system view, return user view with Ctrl+Z.
[Huawei]dis ospf pee
[Huawei]dis ospf peer brief

        OSPF Process 1 with Router ID 10.1.1.1
              Peer Statistic Information
-------------------------------------------------------------------------------
Area Id           Interface                        Neighbor id        State
0.0.0.0           GigabitEthernet0/0/0             10.1.1.2           Full
0.0.0.0           GigabitEthernet0/0/0             10.1.1.3           Full
-------------------------------------------------------------------------------
[Huawei]dis ospf peer

        OSPF Process 1 with Router ID 10.1.1.1
            Neighbors

 Area 0.0.0.0 interface 10.1.1.1(GigabitEthernet0/0/0)'s neighbors
 Router ID: 10.1.1.2          Address: 10.1.1.2
   State: Full  Mode:Nbr is  Master  Priority: 1
   DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
   Dead timer due in 34  sec
   Retrans timer interval: 5
   Neighbor is up for 00:00:54
   Authentication Sequence: [ 0 ]

 Router ID: 10.1.1.3          Address: 10.1.1.3
   State: Full  Mode:Nbr is  Master  Priority: 1
   DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
   Dead timer due in 35  sec
   Retrans timer interval: 5
   Neighbor is up for 00:01:00
   Authentication Sequence: [ 0 ]

[Huawei]
```

```
AR2

[Huawei]dis ospf peer brief

       OSPF Process 1 with Router ID 10.1.1.2
            Peer Statistic Information
--------------------------------------------------------------------
Area Id            Interface                    Neighbor id      State
0.0.0.0            GigabitEthernet0/0/0         10.1.1.1         Full
0.0.0.0            GigabitEthernet0/0/0         10.1.1.3         Full
--------------------------------------------------------------------
[Huawei]dis ospf peer

       OSPF Process 1 with Router ID 10.1.1.2
            Neighbors

 Area 0.0.0.0 interface 10.1.1.2(GigabitEthernet0/0/0)'s neighbors
 Router ID: 10.1.1.1          Address: 10.1.1.1
   State: Full  Mode:Nbr is  Slave  Priority: 1
   DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
   Dead timer due in 37  sec
   Retrans timer interval: 5
   Neighbor is up for 00:03:47
   Authentication Sequence: [ 0 ]

 Router ID: 10.1.1.3          Address: 10.1.1.3
   State: Full  Mode:Nbr is  Master  Priority: 1
   DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
   Dead timer due in 32  sec
   Retrans timer interval: 5
   Neighbor is up for 00:03:53
   Authentication Sequence: [ 0 ]

[Huawei]
```

```
AR3

       OSPF Process 1 with Router ID 10.1.1.3
            Peer Statistic Information
--------------------------------------------------------------------
Area Id            Interface                    Neighbor id      State
0.0.0.0            GigabitEthernet0/0/0         10.1.1.1         Full
0.0.0.0            GigabitEthernet0/0/0         10.1.1.2         Full
--------------------------------------------------------------------
[Huawei]dis ospf peer

       OSPF Process 1 with Router ID 10.1.1.3
            Neighbors

 Area 0.0.0.0 interface 10.1.1.3(GigabitEthernet0/0/0)'s neighbors
 Router ID: 10.1.1.1          Address: 10.1.1.1
   State: Full  Mode:Nbr is  Slave  Priority: 1
   DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
   Dead timer due in 39  sec
   Retrans timer interval: 5
   Neighbor is up for 00:03:41
   Authentication Sequence: [ 0 ]

 Router ID: 10.1.1.2          Address: 10.1.1.2
   State: Full  Mode:Nbr is  Slave  Priority: 1
   DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
   Dead timer due in 34  sec
   Retrans timer interval: 3
   Neighbor is up for 00:03:41
   Authentication Sequence: [ 0 ]

[Huawei]
```

2. 开启 AR4，AR5

AR 4，5 的加入并未影响 DR 选举的结果

- AR 4

- AR 5


```
       OSPF Process 1 with Router ID 10.1.1.5
             Peer Statistic Information
--------------------------------------------------------------------
Area Id          Interface                     Neighbor id      State
0.0.0.0          GigabitEthernet0/0/0          10.1.1.1         2-Way
0.0.0.0          GigabitEthernet0/0/0          10.1.1.2         Full
0.0.0.0          GigabitEthernet0/0/0          10.1.1.3         Full
0.0.0.0          GigabitEthernet0/0/0          10.1.1.4         2-Way
--------------------------------------------------------------------
<Huawei>dis ospf peer

       OSPF Process 1 with Router ID 10.1.1.5
             Neighbors

 Area 0.0.0.0 interface 10.1.1.5(GigabitEthernet0/0/0)'s neighbors
 Router ID: 10.1.1.1        Address: 10.1.1.1
   State: 2-Way  Mode:Nbr is  Master  Priority: 1
   DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
   Dead timer due in 34  sec
   Retrans timer interval: 0
   Neighbor is up for 00:00:00
   Authentication Sequence: [ 0 ]

 Router ID: 10.1.1.2        Address: 10.1.1.2
   State: Full  Mode:Nbr is  Slave  Priority: 1
   DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
   Dead timer due in 34  sec
   Retrans timer interval: 5
   Neighbor is up for 00:07:25
   Authentication Sequence: [ 0 ]

 Router ID: 10.1.1.3        Address: 10.1.1.3
   State: Full  Mode:Nbr is  Slave  Priority: 1
   DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
   Dead timer due in 28  sec
   Retrans timer interval: 0
   Neighbor is up for 00:07:25
   Authentication Sequence: [ 0 ]

 Router ID: 10.1.1.4        Address: 10.1.1.4
   State: 2-Way  Mode:Nbr is  Master  Priority: 1
   DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
   Dead timer due in 31  sec
   Retrans timer interval: 0
   Neighbor is up for 00:00:00
   Authentication Sequence: [ 0 ]

<Huawei>
```
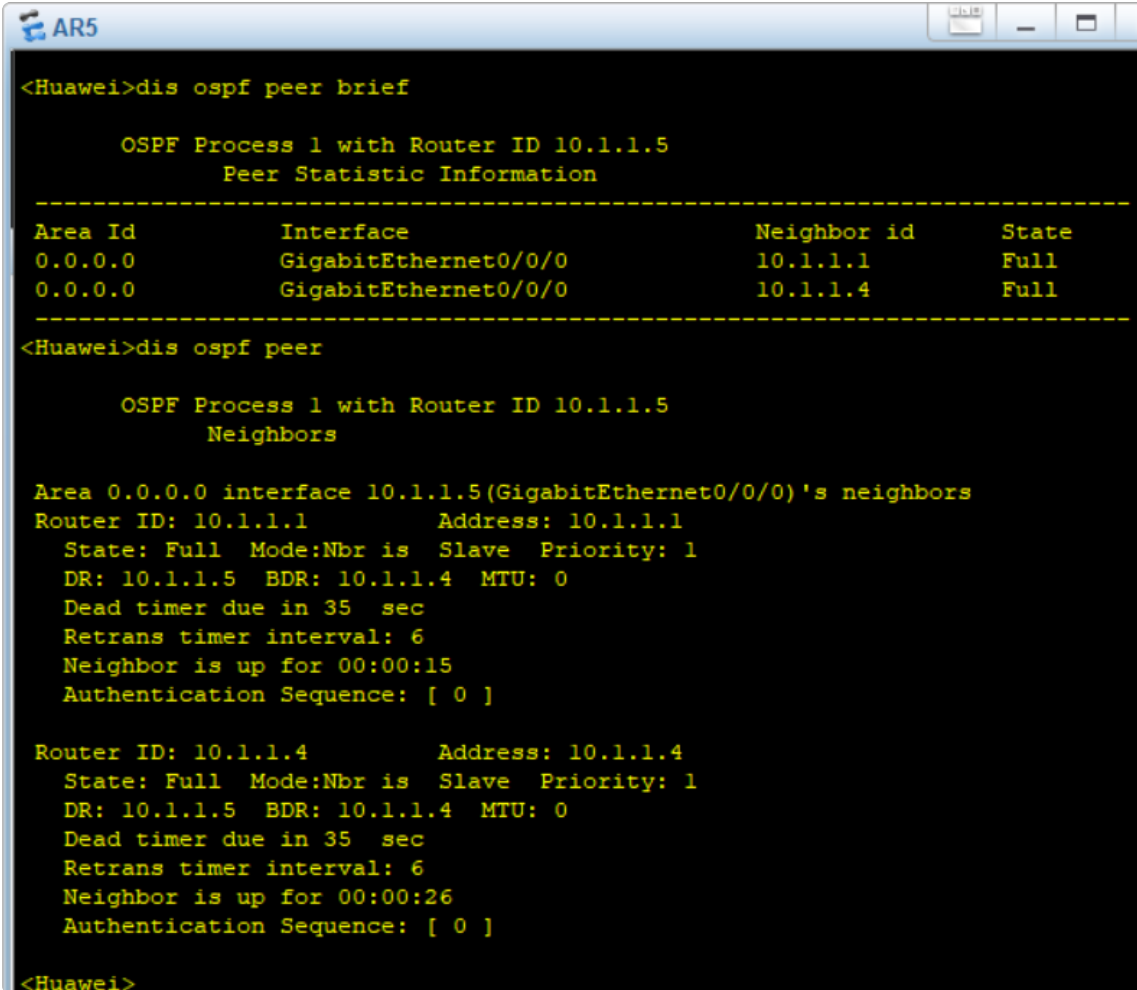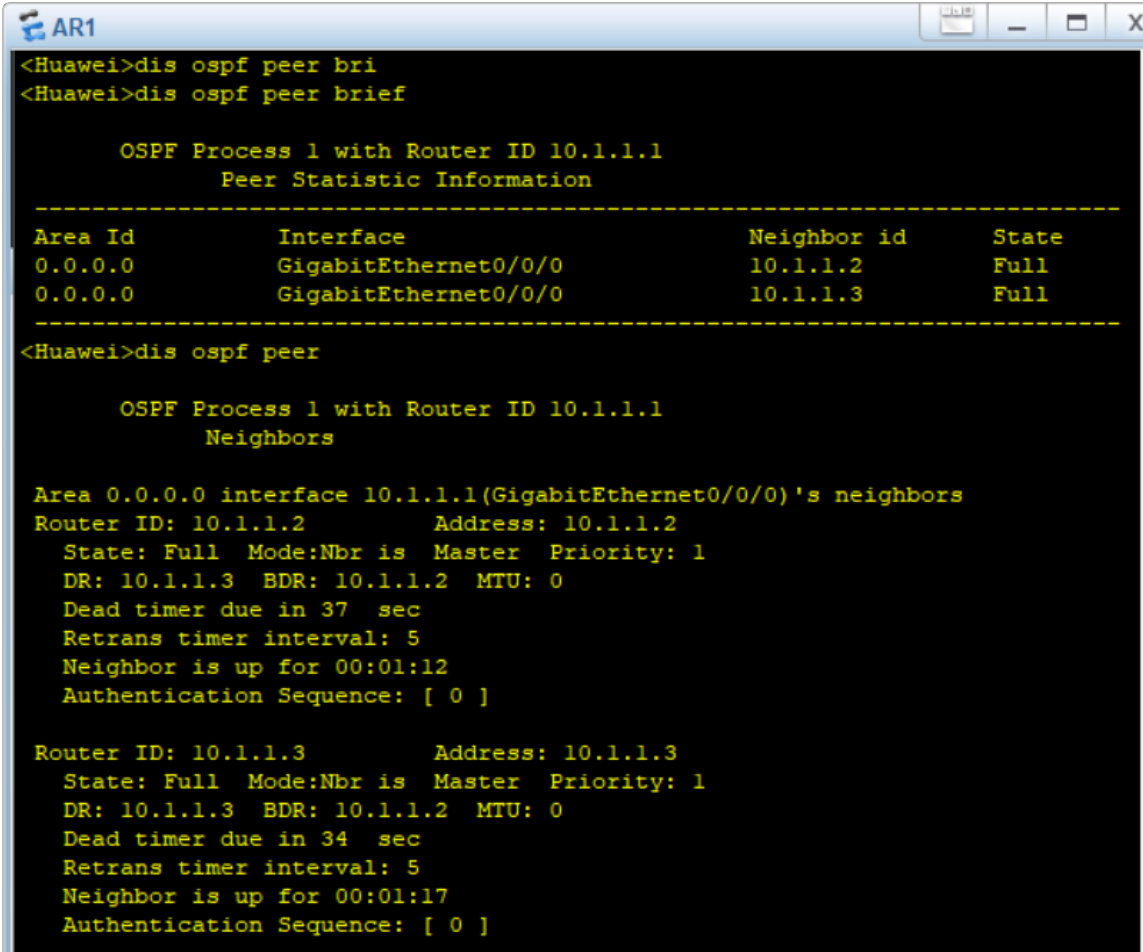
3. 关闭 AR2，AR3，查看选举情况

ↆ DR，BDR 切换为 AR5，AR4

4. 只有当前 DR 或 BDR 失效时，才会进行重新选举，优先级相同时，选择 router id 大的作为 DR，BDR

关闭 AR4，AR5，启动 AR2，AR3

```
<Huawei>dis ospf peer bri
<Huawei>dis ospf peer brief

        OSPF Process 1 with Router ID 10.1.1.1
              Peer Statistic Information
  ------------------------------------------------------------------------
  Area Id          Interface                       Neighbor id      State
  0.0.0.0          GigabitEthernet0/0/0            10.1.1.2         Full
  0.0.0.0          GigabitEthernet0/0/0            10.1.1.3         Full
  ------------------------------------------------------------------------
<Huawei>dis ospf peer

        OSPF Process 1 with Router ID 10.1.1.1
              Neighbors

Area 0.0.0.0 interface 10.1.1.1(GigabitEthernet0/0/0)'s neighbors
Router ID: 10.1.1.2          Address: 10.1.1.2
  State: Full  Mode:Nbr is  Master  Priority: 1
  DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
  Dead timer due in 37  sec
  Retrans timer interval: 5
  Neighbor is up for 00:01:12
  Authentication Sequence: [ 0 ]

Router ID: 10.1.1.3          Address: 10.1.1.3
  State: Full  Mode:Nbr is  Master  Priority: 1
  DR: 10.1.1.3  BDR: 10.1.1.2  MTU: 0
  Dead timer due in 34  sec
  Retrans timer interval: 5
  Neighbor is up for 00:01:17
  Authentication Sequence: [ 0 ]
```
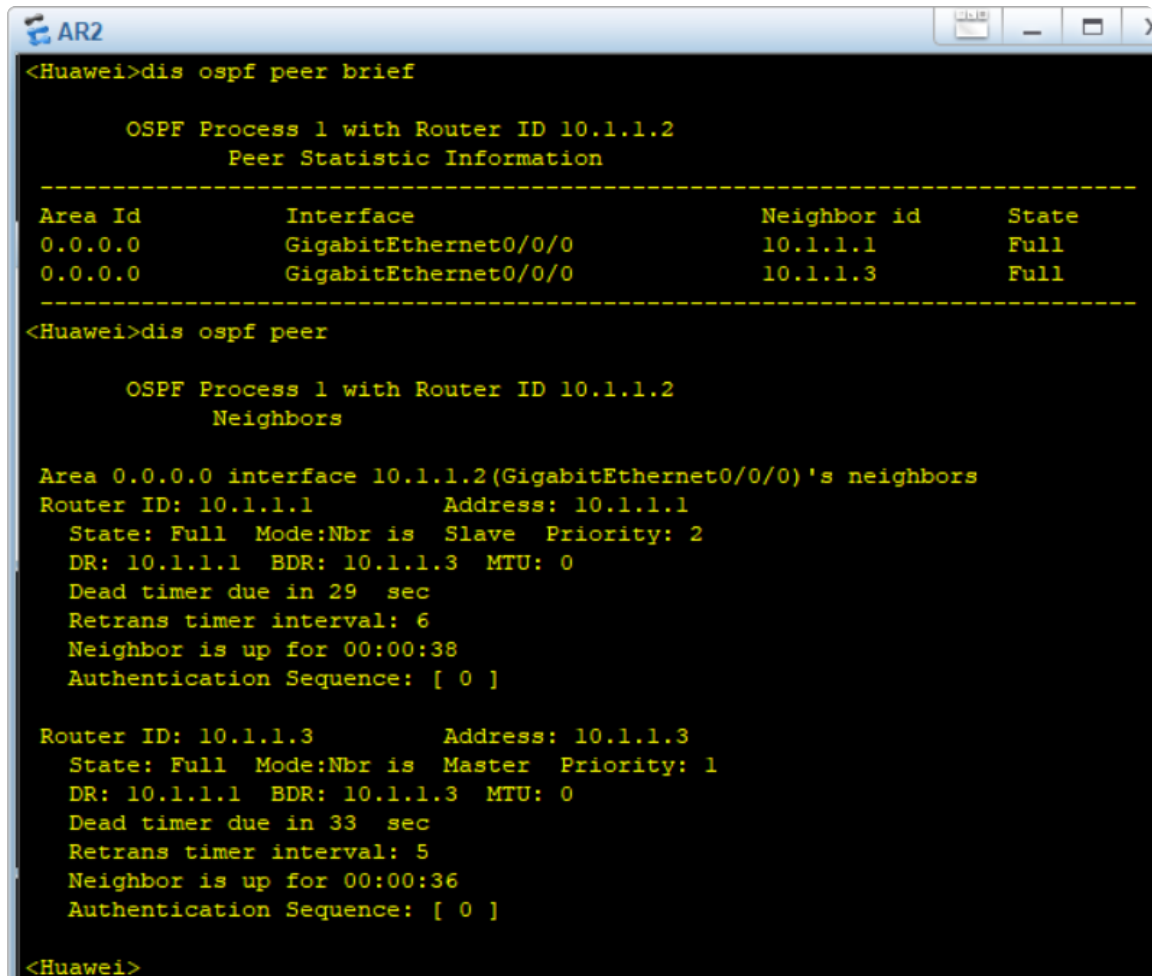
5. 重启全部设备

6. 设置 AR1 优先级为 2

7. 停止 AR4，AR5，触发重选举

关闭 AR4，AR5，启动 AR2，AR3

DR 切换为优先级更高的 AR 1

```
AR2                                                              ＿  □  ×

<Huawei>dis ospf peer brief

      OSPF Process 1 with Router ID 10.1.1.2
            Peer Statistic Information
------------------------------------------------------------------------------
Area Id           Interface                    Neighbor id      State
0.0.0.0           GigabitEthernet0/0/0         10.1.1.1         Full
0.0.0.0           GigabitEthernet0/0/0         10.1.1.3         Full
------------------------------------------------------------------------------
<Huawei>dis ospf peer

      OSPF Process 1 with Router ID 10.1.1.2
            Neighbors

Area 0.0.0.0 interface 10.1.1.2(GigabitEthernet0/0/0)'s neighbors
Router ID: 10.1.1.1          Address: 10.1.1.1
  State: Full  Mode:Nbr is  Slave  Priority: 2
  DR: 10.1.1.1  BDR: 10.1.1.3  MTU: 0
  Dead timer due in 29  sec
  Retrans timer interval: 6
  Neighbor is up for 00:00:38
  Authentication Sequence: [ 0 ]

Router ID: 10.1.1.3          Address: 10.1.1.3
  State: Full  Mode:Nbr is  Master  Priority: 1
  DR: 10.1.1.1  BDR: 10.1.1.3  MTU: 0
  Dead timer due in 33  sec
  Retrans timer interval: 5
  Neighbor is up for 00:00:36
  Authentication Sequence: [ 0 ]

<Huawei>
```

五．问题回答

1. eNSP 路由器无法启动
   解决方案:
   使用 Router 代替 AR 2220
2. 对 DR 选举策略的认识
   - 选举机制
     在 DR/BDR 的选举过程中，首先比较路由接口的 DR 优先级，优先就最高的
     路由器将被选为 DR，次之为 BDR，其余为 DRother。DR 优先级默认值为
     1，如果为 0 则代表不参与选举。如果接口的 DR 优先级相同，则比较路由器
     的 router-id，数值最大的为 DR，次之为 BDR，其余为 DRother。
   - 重选举的触发机制
     新路由器的加入不会影响现有 DR 选举结果，原因如下:
     - 如果 DR 和 BDR 仍然在线并工作正常，网络不会进行重新选举。
     - OSPF 协议设计了稳定的选举机制，避免频繁的 DR/BDR 更换。
       此种设计确保网络的稳定性，只有在特定条件下（如 DR 或 BDR 失效）
       才会触发重新选举过程。