计算机网络实验报告

警示

1. 实验报告如有雷同，雷同各方当次实验成绩均以 0 分计。
2. 当次小组成员成绩只计学号、姓名登录在下表中的。
3. 在规定时间内未上交实验报告的，不得以其他方式补交，当次成绩按 0 分计。
4. 实验报告文件以 PDF 格式提交。

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【实验题目】OSPF 路由协议实验

【实验目的】

掌握 OSPF 协议单区域的配置和使用方法。

【实验内容】

(1) 完成路由器配置实验实例 7-3（P252）的“OSPF 单区域配置”，回答步骤 1、步骤 9 问题。

(2) 在（1）的基础上每台路由器上各加入一台电脑，画出新拓扑，然后：

(a) 检查任意两个 PC 之间是否可以 Ping 通，对一台主机 ping 其它主机的结果进行截屏。

(b) 采用#depug ip ospf 显示上面 OSPF 协议的运行情况，观察并保存 R1 发送和接收的 Update 分组(可以改变链路状态来触发)，注意其中 LSA 类型；观察有无 224.0.0.5、224.0.0.6 IP 地址，如有说明这两地址的作用。

(c) 显示并记录路由器 R1 数据库的 Router LSA，Network LSA，LS 数据库信息汇总

 # show ip ospf database router ！ 显示 router LSA

 # show ip ospf database network ！显示 network LSA

 # show ip ospf database database ！显示 OSPF 链路状态数据库信息。

(d) 显示并记录邻居状态。

 # show ip ospf neighbor

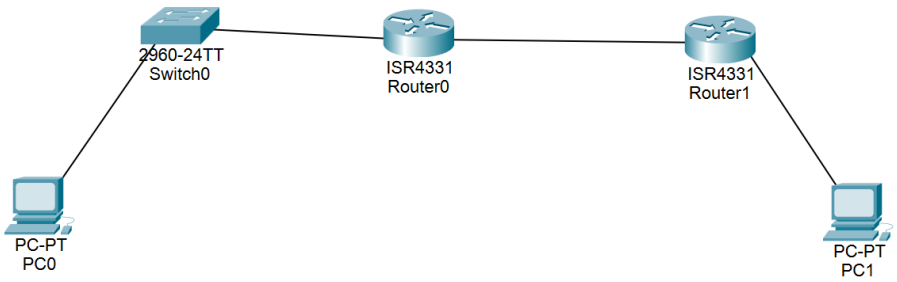
(e) 显示并记录 R1 的所有接口信息

#show ip ospf interface [接口名]

【实验要求】

重要信息信息需给出截图，注意实验步骤的前后对比。

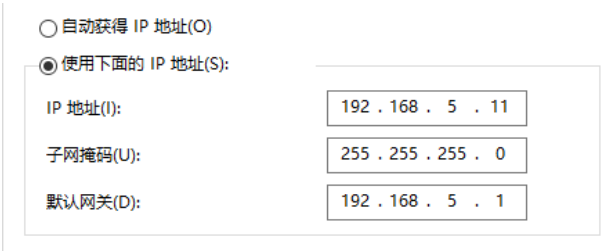
【实验记录】



分析：本实验的预期目标是通过配置动态路由协议 OSPF，自动学习网段的路由信息，在区域内实现网络的互联互通。

步骤 1:

(1) 按照拓扑图配置 PC1 和 PC2 的 IP 地址、子网掩码、网关，并测试它们的连通性。



上图为 PC1 配置 IP 地址、子网掩码和网关的截图。

(2) 在路由器 R2 上执行 show ip route 命令，记录路由表信息。

```
20-RSR20-2>enable 14

Password:
20-RSR20-2#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
        O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
```

上图为 R2 上执行 show ip route 命令的截图，可见此时还没有任何路由条目。

步骤 2: 三层交换机的基本配置。

```
20-S5750-1(config)#vlan 10
20-S5750-1(config-vlan)#vlan 50
20-S5750-1(config-vlan)#interface gi 0/1
20-S5750-1(config-if-GigabitEthernet 0/1)#switchport access vlan 10
20-S5750-1(config-if-GigabitEthernet 0/1)#int gi 0/5
20-S5750-1(config-if-GigabitEthernet 0/5)#switchport access vlan 50
20-S5750-1(config-if-GigabitEthernet 0/5)#int vlan 10
20-S5750-1(config-if-VLAN 10)#ip address 192.168.1.2 255.255.255.0
20-S5750-1(config-if-VLAN 10)#no shut
20-S5750-1(config-if-VLAN 10)#int vlan 50
20-S5750-1(config-if-VLAN 50)#ip address 192.168.5.1 255.255.*Jun  3 08:59:30: %LINK-3-UPDOWN: Interface Gigab
*Jun  3 08:59:30: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet 0/3, changed state to up.
255.0*Jun  3 08:59:35: %LINK-3-UPDOWN: Interface GigabitEthernet 0/3, changed state to down.
*Jun  3 08:59:35: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet 0/3, changed state to down.

20-S5750-1(config-if-VLAN 50)#no shut
```

步骤 3: 路由器 R1 的基本配置。

```
20-RSR20-1>enbable 14

Translating "enbable"...
% Unrecognized host or address, or protocol not running.
20-RSR20-1>enable 14

Password:
20-RSR20-1#con
Enter configuration commands, one per line.  End with CNTL/Z.
20-RSR20-1(config)#int gi 0/1
20-RSR20-1(config-if-GigabitEthernet 0/1)#$2.168.1.1 255.255.255.0
20-RSR20-1(config-if-GigabitEthernet 0/1)#no shut
20-RSR20-1(config-if-GigabitEthernet 0/1)#int serial 2/0
20-RSR20-1(config-if-Serial 2/0)#ip address 192.168.2.1 255.255.255.0
20-RSR20-1(config-if-Serial 2/0)#no shut
```

步骤 4: 路由器 R2 的基本配置。

```
20-RSR20-2#config
Enter configuration commands, one per line.  End with CNTL/Z.
20-RSR20-2(config)#interface gigabitethernet 0/1
20-RSR20-2(config-if-GigabitEthernet 0/1)#ip addr 192.168.3.1 255.255.255.0
20-RSR20-2(config-if-GigabitEthernet 0/1)#no shutdown
20-RSR20-2(config-if-GigabitEthernet 0/1)#exit
20-RSR20-2(config)#interface serial 2/0
20-RSR20-2(config-if-Serial 2/0)#ip addr 192.168.2.2 255.255.255.0
20-RSR20-2(config-if-Serial 2/0)#no shutdown
```

步骤 5：配置 OSPF 路由协议。交换机 S5750 配置 OSPF。

```
20-S5750-1(config-if-VLAN 50)#router ospf 1
20-S5750-1(config-router)#network 192.168.5.0 0.0.0.255 area 0
20-S5750-1(config-router)#metwork 192.168.1.0 0.0.0.255 area 0
% Unknown command.

20-S5750-1(config-router)#network 192.168.1.0 0.0.0.255 area 0
20-S5750-1(config-router)#end
20-S5750-1#*Jun  3 09:04:08: %SYS-5-CONFIG_I: Configured from console by console
```

步骤 6：路由器 R1 配置 OSPF。

```
20-RSR20-1(config-if-Serial 2/0)#router ospf 1
20-RSR20-1(config-router)#network 192.168.1.0 0.0.0.255 area 0
20-RSR20-1(config-router)#network 192.168.2.0 0.0.0.255 area 0
20-RSR20-1(config-router)#*Feb 24 07:18:40: %OSPF-5-ADJCHG: Proces
end
```

步骤 7：路由器 R2 配置 OSPF

```
20-RSR20-2(config-if-Serial 2/0)#router ospf 1
20-RSR20-2(config-router)#network 192.168.2.0 0.0.0.255 area 0
20-RSR20-2(config-router)#*Jun  3 09:00:18: %OSPF-5-ADJCHG: Process 1, Nbr 192.16
*Jun  3 09:00:19: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.2.1-Serial 2/0 from Load
network 192.168.3.0 0.0.0.255 area 0
20-RSR20-2(config-router)#network 192.168.3.0 0.0.0.255 area 0
20-RSR20-2(config-router)#end
```

步骤 8: 查看验证 3 台路由设备的路由表是否自动学习了其他网段的路由信息，请注意路由条目 O 项。

交换机 S5750:

```
20-S5750-1(config)#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
        O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    192.168.1.0/24 is directly connected, VLAN 10
C    192.168.1.2/32 is local host.
O    192.168.2.0/24 [110/51] via 192.168.1.1, 00:04:03, VLAN 10
O    192.168.3.0/24 [110/52] via 192.168.1.1, 00:00:40, VLAN 10
C    192.168.5.0/24 is directly connected, VLAN 50
C    192.168.5.1/32 is local host.
```

路由器 R1:

```
20-RSR20-1(config)#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
        O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
C    192.168.1.0/24 is directly connected, GigabitEthernet 0/1
C    192.168.1.1/32 is local host.
C    192.168.2.0/24 is directly connected, Serial 2/0
C    192.168.2.1/32 is local host.
O    192.168.3.0/24 [110/51] via 192.168.2.2, 00:01:11, Serial 2/0
O    192.168.5.0/24 [110/2] via 192.168.1.2, 00:04:36, GigabitEthernet 0/1
```

路由器 R2:

```
20-RSR20-2#show ip route

Codes:  C - connected, S - static, R - RIP, B - BGP
        O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default

Gateway of last resort is no set
O    192.168.1.0/24 [110/51] via 192.168.2.1, 00:00:21, Serial 2/0
C    192.168.2.0/24 is directly connected, Serial 2/0
C    192.168.2.2/32 is local host.
C    192.168.3.0/24 is directly connected, GigabitEthernet 0/1
C    192.168.3.1/32 is local host.
O    192.168.5.0/24 [110/52] via 192.168.2.1, 00:00:21, Serial 2/0
```

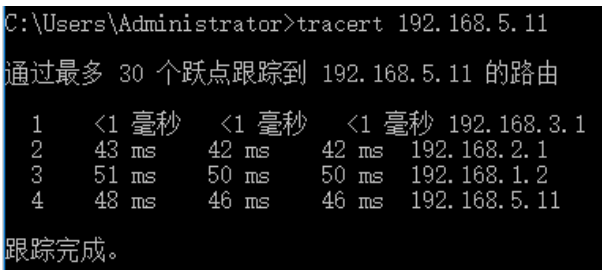
如图所示，可见各路由设备表中均有 O 条目，是通过 OSPF 路由协议学习产生的。

步骤 9：测试网络的连通性。

(1) 将此时的路由表与步骤 0 的路由表进行比较，有什么结论？

比较得出，路由设备根据 OSPF 协议学习了一些路由信息。

(2) 分析 tracert PC1 的执行结果。



如图所示，tracert 根据实验的配置正确输出了结果。

(3) 捕获数据包，分析 OSPF 头部结果。OSPF 包在 PC1 或 PC2 上能捕获到吗？如果希望 2 台主机都能捕获到，请描述方法。

```
Frame 2: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on interface \Device\NPF_{EBC28BE2-6340-4CBB-87CD-F4EB4A236F0F}, id 0
  Interface id: 0 (\Device\NPF_{EBC28BE2-6340-4CBB-87CD-F4EB4A236F0F})
  Encapsulation type: Ethernet (1)
  Arrival Time: Jun  2, 2021 17:01:41.767794000 ■м►►►▣ʰ■■
  [Time shift for this packet: 0.000000000 seconds]
  Epoch Time: 1622624501.767794000 seconds
  [Time delta from previous captured frame: 0.001409000 seconds]
  [Time delta from previous displayed frame: 0.000000000 seconds]
  [Time since reference or first frame: 0.001409000 seconds]
  Frame Number: 2
  Frame Length: 78 bytes (624 bits)
  Capture Length: 78 bytes (624 bits)
  [Frame is marked: False]
  [Frame is ignored: False]
  [Protocols in frame: eth:ethertype:ip:ospf]
  [Coloring Rule Name: Routing]
  [Coloring Rule String: hsrp || eigrp || ospf || bgp || cdp || vrrp || carp || gvrp || igmp || ismp]
Ethernet II, Src: RuijieNe_15:59:e3 (58:69:6c:15:59:e3), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
Internet Protocol Version 4, Src: 192.168.5.1, Dst: 224.0.0.5
Open Shortest Path First

Frame 310: 82 bytes on wire (656 bits), 82 bytes captured (656 bits) on interface \Device\NPF_{F79B1DFF-B47D-45C5-8AFD-605A02562A6C}, id 0
Ethernet II, Src: RuijieNe_27:b5:aa (58:69:6c:27:b5:aa), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
Internet Protocol Version 4, Src: 192.168.3.1, Dst: 224.0.0.5
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
  Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: Not-ECT)
  Total Length: 64
  Identification: 0x0052 (82)
  Flags: 0x00
  Fragment Offset: 0
  Time to Live: 1
  Protocol: OSPF IGP (89)
  Header Checksum: 0x14a5 [validation disabled]
  [Header checksum status: Unverified]
  Source Address: 192.168.3.1
  Destination Address: 224.0.0.5
Open Shortest Path First
  OSPF Header
    Version: 2
    Message Type: Hello Packet (1)
    Packet Length: 44
    Source OSPF Router: 192.168.3.1
    Area ID: 0.0.0.0 (Backbone)
    Checksum: 0x754b [correct]
    Auth Type: Null (0)
    Auth Data (none): 0000000000000000
  OSPF Hello Packet
    Network Mask: 255.255.255.0
    Hello Interval [sec]: 10
    Options: 0x02, (E) External Routing
    Router Priority: 1
    Router Dead Interval [sec]: 40
    Designated Router: 192.168.3.1
    Backup Designated Router: 0.0.0.0
```

如图所示，OSPF 包在 PC1 和 PC2 上都能捕获到。第一张图为 PC1 捕获到的 OSPF 包，第二张图为 PC2 捕获到的 OSPF 包。

(4) 使用#debug ip ospf 命令显示上述 OSPF 协议的运行情况，观察并保存路由器 R1 发送和接收的 Update 分组（可以通过改变链路状态触发），注意其中 LSA 类型，观察有无 224.0.0.5、224.0.0.6 的 IP 地址，如有请说明这两个地址的作用。

```
% Unrecognized host or address.
20-RSR20-1#debug ip ospf
20-RSR20-1#*Feb 24 07:30:07: %7: RECV[Hello]: From 192.168.5.1 via GigabitEthernet 0/1:192.168.1.1 (192.168.1.2 -> 224.0.0.5), len = 48, cksum = 0xf
0f2
*Feb 24 07:30:07: %7: ----------------------------------------------------
*Feb 24 07:30:07: %7: Header
*Feb 24 07:30:07: %7:   Version 2
*Feb 24 07:30:07: %7:   Type 1 (Hello)
*Feb 24 07:30:07: %7:   Packet Len 48
*Feb 24 07:30:07: %7:   Router ID 192.168.5.1
*Feb 24 07:30:07: %7:   Area ID 0.0.0.0
*Feb 24 07:30:07: %7:   Checksum 0xf0f2
*Feb 24 07:30:07: %7:   AuType 0
*Feb 24 07:30:07: %7: Hello
*Feb 24 07:30:07: %7:   NetworkMask 255.255.255.0
*Feb 24 07:30:07: %7:   HelloInterval 10
*Feb 24 07:30:07: %7:   Options 0x2 (-|-|-|-|-|-|E|-)
*Feb 24 07:30:07: %7:   RtrPriority 1
*Feb 24 07:30:07: %7:   RtrDeadInterval 40
*Feb 24 07:30:07: %7:   DRouter 192.168.1.2
*Feb 24 07:30:07: %7:   BDRouter 192.168.1.1
*Feb 24 07:30:07: %7:   # Neighbors 1
*Feb 24 07:30:07: %7:     Neighbor 192.168.2.1
*Feb 24 07:30:07: %7: ----------------------------------------------------
*Feb 24 07:30:07: %7: NFSM[192.168.5.1-GigabitEthernet 0/1]: Full (HelloReceived)
*Feb 24 07:30:07: %7: NFSM[192.168.5.1-GigabitEthernet 0/1]: nfsm_ignore called
*Feb 24 07:30:07: %7: NFSM[192.168.5.1-GigabitEthernet 0/1]: Full (2-WayReceived)
*Feb 24 07:30:08: %7: IFSM[Serial 2/0:192.168.2.1]: Hello timer expire
*Feb 24 07:30:08: %7: SEND[Hello]: To 224.0.0.5 via Serial 2/0:192.168.2.1, length 48
*Feb 24 07:30:08: %7: ----------------------------------------------------
*Feb 24 07:30:08: %7: Header
*Feb 24 07:30:08: %7:   Version 2
*Feb 24 07:30:08: %7:   Type 1 (Hello)
*Feb 24 07:30:08: %7:   Packet Len 48
*Feb 24 07:30:08: %7:   Router ID 192.168.2.1
*Feb 24 07:30:08: %7:   Area ID 0.0.0.0
*Feb 24 07:30:08: %7:   Checksum 0x7647
*Feb 24 07:30:08: %7:   AuType 0
*Feb 24 07:30:08: %7: Hello
*Feb 24 07:30:08: %7:   NetworkMask 255.255.255.0
*Feb 24 07:30:08: %7:   HelloInterval 10
*Feb 24 07:30:08: %7:   Options 0x2 (-|-|-|-|-|-|E|-)
*Feb 24 07:30:08: %7:   RtrPriority 1
*Feb 24 07:30:08: %7:   RtrDeadInterval 40
*Feb 24 07:30:08: %7:   DRouter 0.0.0.0
*Feb 24 07:30:08: %7:   BDRouter 0.0.0.0
*Feb 24 07:30:08: %7:   # Neighbors 1
*Feb 24 07:30:08: %7:     Neighbor 192.168.3.1
*Feb 24 07:30:08: %7: ----------------------------------------------------
```

```
*Feb 24 07:32:17: %7: LSA[0.0.0.0:Type1:192.168.2.1:(self)]: Install router-LSA
*Feb 24 07:32:17: %7: LSA[0.0.0.0:Type1:192.168.2.1:(self)]: LSA refresh scheduled at LS age 1847
*Feb 24 07:32:17: %7: LSA[0.0.0.0:Type1:192.168.2.1:(self)]: Flooding via interface[GigabitEthernet 0/1:192.168.1.1]
*Feb 24 07:32:17: %7: LSA[0.0.0.0:Type1:192.168.2.1:(self)]: Flooding via interface[Serial 2/0:192.168.2.1]
*Feb 24 07:32:17: %7: LSA[0.0.0.0:Type1:192.168.2.1:(self)]: Flooding to neighbor[192.168.3.1]
*Feb 24 07:32:17: %7: LSA[0.0.0.0:Type1:192.168.2.1:(self)]: Added to neighbor[192.168.3.1]'s retransmit-list
*Feb 24 07:32:17: %7: LSA[0.0.0.0:Type1:192.168.2.1:(self)]: Sending update to interface[Serial 2/0:192.168.2.1]
*Feb 24 07:32:17: %7: LSA[0.0.0.0:Type1:192.168.2.1:(self)]: router-LSA refreshed
*Feb 24 07:32:17: %7:   LSA Header
*Feb 24 07:32:17: %7:     LS age 0
*Feb 24 07:32:17: %7:     Options 0x2
*Feb 24 07:32:17: %7:     LS type 1 (router-LSA)
*Feb 24 07:32:17: %7:     Link State ID 192.168.2.1
*Feb 24 07:32:17: %7:     Advertising Router 192.168.2.1
*Feb 24 07:32:17: %7:     LS sequence number 0x80000006
*Feb 24 07:32:17: %7:     LS checksum 0x3786
*Feb 24 07:32:17: %7:     length 48
*Feb 24 07:32:17: %7: ospf[1]: LSA refresh completed [0.000000 sec], count: 1
*Feb 24 07:32:17: %7: SEND[LS-Upd]: 1 LSAs to destination 224.0.0.5
*Feb 24 07:32:17: %7: SEND[LS-Upd]: To 224.0.0.5 via Serial 2/0:192.168.2.1, length 76
```

如图所示，观察到有 224.0.0.5 地址。该地址的作用是用于组播，将路由信息发送到周围的路由设备。

(5) 本实验有没有 BR/BDR（指派路由器/备份指派路由器）？如果有，请指出 BR/BDR 是哪个设备，讨论 BR/BDR 的选举规则和更新方法（通过拔线改变拓扑，观察 BR/BDR 的变化情况）；如没有，请说明原因。

```
20-RSR20-1#show ip ospf neighbor

OSPF process 1, 2 Neighbors, 2 is Full:
Neighbor ID     Pri   State           BFD State  Dead Time   Address         Interface
192.168.5.1       1   Full/DR         -          00:00:34    192.168.1.2     GigabitEthernet 0/1
192.168.3.1       1   Full/ -         -          00:00:36    192.168.2.2     Serial 2/0
```

实验中的 BR 为交换机 S5750。

步骤 10: 在（1）的基础上每台路由器上各加入一台电脑，画出新拓扑，然后:

(a) 检查任意两个 PC 之间是否可以 Ping 通，对一台主机 ping 其它主机的结果进行截屏。

(b) 采用#depug ip ospf 显示上面 OSPF 协议的运行情况，观察并保存 R1 发送和接收的 Update 分组(可以改变链路状态来触发)，注意其中 LSA 类型；观察有无 224.0.0.5、224.0.0.6 IP 地址，如有说明这两地址的作用。

(c) 显示并记录路由器 R1 数据库的 Router LSA，Network LSA，LS 数据库信息汇总

 # show ip ospf database router ！ 显示 router LSA

 # show ip ospf database network ！显示 network LSA

 # show ip ospf database database ！显示 OSPF 链路状态数据库信息。

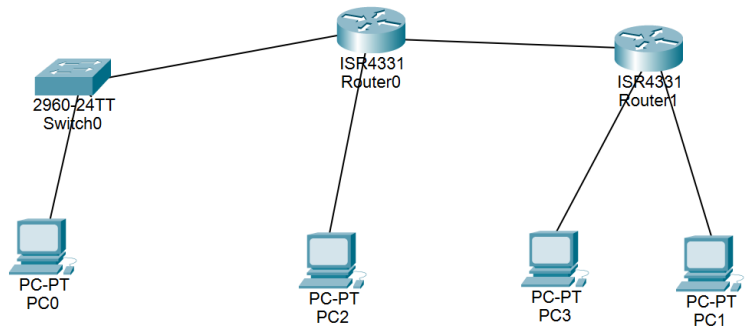
(d) 显示并记录邻居状态。

 # show ip ospf neighbor

(e) 显示并记录 R1 的所有接口信息

#show ip ospf interface [接口名]

新拓扑如下图所示：



(a) 各主机间可以 ping 通，截屏如下：

```
   自动配置已启用. . . . . . . . . . : 是
   本地链接 IPv6 地址. . . . . . . . : fe80::246d:db5f:1e7d:95e3%5(首选)
   IPv4 地址 . . . . . . . . . . . . : 192.168.7.77(首选)
   子网掩码 . . . . . . . . . . . . : 255.255.255.0
   默认网关. . . . . . . . . . . . . : 192.168.7.1
   DHCPv6 IAID . . . . . . . . . . . : 83921049
   DHCPv6 客户端 DUID  . . . . . . . : 00-01-00-01-27-23-EB-78-80-C1-6E-E3-CA-42
   DNS 服务器  . . . . . . . . . . . : fec0:0:0:ffff::1%1
                                       fec0:0:0:ffff::2%1
                                       fec0:0:0:ffff::3%1
   TCPIP 上的 NetBIOS  . . . . . . . : 已启用

无线局域网适配器 WLAN:

   媒体状态  . . . . . . . . . . . . : 媒体已断开连接
   连接特定的 DNS 后缀 . . . . . . . :
   描述. . . . . . . . . . . . . . . : Ralink RT61 Turbo Wireless LAN Card
   物理地址. . . . . . . . . . . . . : 00-0D-0A-4B-0F-A3
   DHCP 已启用 . . . . . . . . . . . : 是
   自动配置已启用. . . . . . . . . . : 是

C:\Users\Administrator>ping 192.168.5.11

正在 Ping 192.168.5.11 具有 32 字节的数据:
请求超时。
请求超时。
请求超时。
请求超时。

192.168.5.11 的 Ping 统计信息:
    数据包: 已发送 = 4, 已接收 = 0, 丢失 = 4 (100% 丢失),

C:\Users\Administrator>ping 192.168.5.11

正在 Ping 192.168.5.11 具有 32 字节的数据:
来自 192.168.5.11 的回复: 字节=32 时间=39ms TTL=61
来自 192.168.5.11 的回复: 字节=32 时间=39ms TTL=61
来自 192.168.5.11 的回复: 字节=32 时间=40ms TTL=61
来自 192.168.5.11 的回复: 字节=32 时间=37ms TTL=61

192.168.5.11 的 Ping 统计信息:
    数据包: 已发送 = 4, 已接收 = 4, 丢失 = 0 (0% 丢失),
往返行程的估计时间(以毫秒为单位):
    最短 = 37ms, 最长 = 40ms, 平均 = 38ms

C:\Users\Administrator>ping 192.168.3.22

正在 Ping 192.168.3.22 具有 32 字节的数据:
来自 192.168.3.22 的回复: 字节=32 时间<1ms TTL=63
来自 192.168.3.22 的回复: 字节=32 时间<1ms TTL=63
来自 192.168.3.22 的回复: 字节=32 时间<1ms TTL=63
来自 192.168.3.22 的回复: 字节=32 时间<1ms TTL=63

192.168.3.22 的 Ping 统计信息:
    数据包: 已发送 = 4, 已接收 = 4, 丢失 = 0 (0% 丢失),
往返行程的估计时间(以毫秒为单位):
    最短 = 0ms, 最长 = 0ms, 平均 = 0ms

C:\Users\Administrator>ping 192.168.6.66

正在 Ping 192.168.6.66 具有 32 字节的数据:
来自 192.168.6.66 的回复: 字节=32 时间=38ms TTL=62
来自 192.168.6.66 的回复: 字节=32 时间=40ms TTL=62
```

(b) #debug ip ospf 的结果如下：

```
20-RSR20-1(config)#exit
20-RSR20-1#*Feb 24 08:09:46: %SYS-5-CONFIG_I: Configured from console by console

20-RSR20-1#debug ip ospf
20-RSR20-1#*Feb 24 08:09:55: %7: RECV[Hello]: From 192.168.3.1 via Serial 2/0:192.168.2.1 (192.168.2.2 -> 224.0.0.5), len = 48, cksum = 0x7647
*Feb 24 08:09:55: %7: ----------------------------------------------------------
*Feb 24 08:09:55: %7: Header
*Feb 24 08:09:55: %7:   Version 2
*Feb 24 08:09:55: %7:   Type 1 (Hello)
*Feb 24 08:09:55: %7:   Packet Len 48
*Feb 24 08:09:55: %7:   Router ID 192.168.3.1
*Feb 24 08:09:55: %7:   Area ID 0.0.0.0
*Feb 24 08:09:55: %7:   Checksum 0x7647
*Feb 24 08:09:55: %7:   AuType 0
*Feb 24 08:09:55: %7: Hello
*Feb 24 08:09:55: %7:   NetworkMask 255.255.255.0
*Feb 24 08:09:55: %7:   HelloInterval 10
*Feb 24 08:09:55: %7:   Options 0x2 (-|-|-|-|-|-|E|-)
*Feb 24 08:09:55: %7:   RtrPriority 1
*Feb 24 08:09:55: %7:   RtrDeadInterval 40
*Feb 24 08:09:55: %7:   DRouter 0.0.0.0
*Feb 24 08:09:55: %7:   BDRouter 0.0.0.0
*Feb 24 08:09:55: %7:   # Neighbors 1
*Feb 24 08:09:55: %7:     Neighbor 192.168.2.1
*Feb 24 08:09:55: %7: ----------------------------------------------------------
*Feb 24 08:09:55: %7: NFSM[192.168.3.1-Serial 2/0]: Full (HelloReceived)
*Feb 24 08:09:55: %7: NFSM[192.168.3.1-Serial 2/0]: nfsm_ignore called
*Feb 24 08:09:55: %7: NFSM[192.168.3.1-Serial 2/0]: Full (2-WayReceived)
*Feb 24 08:09:58: %7: IFSM[GigabitEthernet 0/1:192.168.1.1]: Hello timer expire
*Feb 24 08:09:58: %7: SEND[Hello]: To 224.0.0.5 via GigabitEthernet 0/1:192.168.1.1, length 48
*Feb 24 08:09:58: %7: ----------------------------------------------------------
*Feb 24 08:09:58: %7: Header
*Feb 24 08:09:58: %7:   Version 2
*Feb 24 08:09:58: %7:   Type 1 (Hello)
*Feb 24 08:09:58: %7:   Packet Len 48
*Feb 24 08:09:58: %7:   Router ID 192.168.2.1
*Feb 24 08:09:58: %7:   Area ID 0.0.0.0
*Feb 24 08:09:58: %7:   Checksum 0xf0f2
*Feb 24 08:09:58: %7:   AuType 0
*Feb 24 08:09:58: %7: Hello
*Feb 24 08:09:58: %7:   NetworkMask 255.255.255.0
*Feb 24 08:09:58: %7:   HelloInterval 10
*Feb 24 08:09:58: %7:   Options 0x2 (-|-|-|-|-|-|E|-)
*Feb 24 08:09:58: %7:   RtrPriority 1
*Feb 24 08:09:58: %7:   RtrDeadInterval 40
*Feb 24 08:09:58: %7:   DRouter 192.168.1.2
*Feb 24 08:09:58: %7:   BDRouter 192.168.1.1
*Feb 24 08:09:58: %7:   # Neighbors 1
*Feb 24 08:09:58: %7:     Neighbor 192.168.5.1
*Feb 24 08:09:58: %7: ----------------------------------------------------------
```

如图所示，观察到有 224.0.0.5 地址。该地址的作用是用于组播，将路由信息发送到周围的路由设备。

(c) 结果如下：

```
20-RSR20-1#show ip ospf database router

            OSPF Router with ID (192.168.2.1) (Process ID 1)

                Router Link States (Area 0.0.0.0)

  LS age: 13
  Options: 0x2 (-|-|-|-|-|-|E|-)
  Flags: 0x0
  LS Type: router-LSA
  Link State ID: 192.168.2.1
  Advertising Router: 192.168.2.1
  LS Seq Number: 8000001c
  Checksum: 0xca74
  Length: 72
   Number of Links: 4

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 192.168.1.2
     (Link Data) Router Interface address: 192.168.1.1
      Number of TOS metrics: 0
       TOS 0 Metric: 1

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.3.1
     (Link Data) Router Interface address: 192.168.2.1
      Number of TOS metrics: 0
       TOS 0 Metric: 50

    Link connected to: Stub Network
     (Link ID) Network/subnet number: 192.168.2.0
     (Link Data) Network Mask: 255.255.255.0
      Number of TOS metrics: 0
       TOS 0 Metric: 50

    Link connected to: Stub Network
     (Link ID) Network/subnet number: 192.168.6.0
     (Link Data) Network Mask: 255.255.255.0
      Number of TOS metrics: 0
       TOS 0 Metric: 1

  LS age: 133
```

```
20-RSR20-1#show ip ospf database network

            OSPF Router with ID (192.168.2.1) (Process ID 1)

                Network Link States (Area 0.0.0.0)

  LS age: 50
  Options: 0x2 (-|-|-|-|-|-|E|-)
  LS Type: network-LSA
  Link State ID: 192.168.1.2 (address of Designated Router)
  Advertising Router: 192.168.5.1
  LS Seq Number: 80000005
  Checksum: 0x8d11
  Length: 32
  Network Mask: /24
        Attached Router: 192.168.5.1
        Attached Router: 192.168.2.1


20-RSR20-1#show ip ospf database database

OSPF process 1:

Area 0.0.0.0 database summary:
Router Link States        : 3
Network Link States       : 1
Summary Link States       : 0
ASBR-Summary Link States  : 0
NSSA-external Link States: 0
Link-Local Opaque-LSA     : 0
Area-Local Opaque-LSA     : 0
Total LSA                 : 4

Process 1 database summary:
Router Link States        : 3
Network Link States       : 1
Summary Link States       : 0
ASBR-Summary Link States  : 0
AS External Link States   : 0
NSSA-external Link States: 0
Link-Local Opaque-LSA     : 0
Area-Local Opaque-LSA     : 0
AS-Global Opaque-LSA      : 0
Total LSA                 : 4
```

(d) 结果如下：

```
20-RSR20-1#show ip ospf neighbor

OSPF process 1, 2 Neighbors, 2 is Full:
Neighbor ID     Pri   State           BFD State  Dead Time   Address         Interface
192.168.5.1       1   Full/DR         -          00:00:38    192.168.1.2     GigabitEthernet 0/1
192.168.3.1       1   Full/ -         -          00:00:31    192.168.2.2     Serial 2/0
```

(e) 结果如下：

```
20-RSR20-1#show ip ospf interface
Serial 2/0 is up, line protocol is up
  Internet Address 192.168.2.1/24, Ifindex 2, Area 0.0.0.0, MTU 1500
  Matching network config: 192.168.2.0/24
  Process ID 1, Router ID 192.168.2.1, Network Type POINTOPOINT, Cost: 50
  Transmit Delay is 1 sec, State Point-To-Point
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:09
  Neighbor Count is 1, Adjacent neighbor count is 1
  Crypt Sequence Number is 0
  Hello received 221 sent 245, DD received 3 sent 4
  LS-Req received 1 sent 1, LS-Upd received 5 sent 24
  LS-Ack received 18 sent 5, Discarded 0
GigabitEthernet 0/1 is up, line protocol is up
  Internet Address 192.168.1.1/24, Ifindex 5, Area 0.0.0.0, MTU 1500
  Matching network config: 192.168.1.0/24
  Process ID 1, Router ID 192.168.2.1, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 192.168.5.1, Interface Address 192.168.1.2
  Backup Designated Router (ID) 192.168.2.1, Interface Address 192.168.1.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:08
  Neighbor Count is 1, Adjacent neighbor count is 1
  Crypt Sequence Number is 0
  Hello received 242 sent 245, DD received 19 sent 13
  LS-Req received 3 sent 3, LS-Upd received 13 sent 15
  LS-Ack received 13 sent 6, Discarded 0
```

计算机网络实验报告

【实验总结】

在本次实验中，我们成功地在交换机和路由器之间配置了路由协议 OSPF，其中也遇到了不少困难，锻炼了在小组内与同学合作、分析问题、解决问题与请教他人的能力，将困难一一解决，体会到了团队协作的快乐和完成实验的成就感。

这次的实验也让我感受到了自己在计算机网络方面的知识在慢慢积累，我希望再接再厉，向老师请教，向同学学习，掌握好这门课程。