BGP路由协议

Dr. Xiqun Lu
College of Computer Science,
Zhejiang University

实验目的

- 理解距离向量路由协议的工作原理。
- 理解BGP协议的工作机制。
- 掌握配置和调试BGP协议的方法。

实验内容

- 创建多种类型的网络，各自成为一个独立的AS
- AS内部路由器配置成启用OSPF路由协议
- 在同一个AS边界上的路由器启用BGP协议，形成邻居关系
- 在不同AS边界路由器上启用BGP协议，直连路由器之间建立邻居关系
- 观察各路由器上的路由表和BGP运行数据，并验证各PC能够相互Ping通
- 断开某些链路，观察BGP事件和路由表变化
- 在AS边界路由器上配置路由聚合（选做）
- 在AS间进行多径负载均衡（选做）

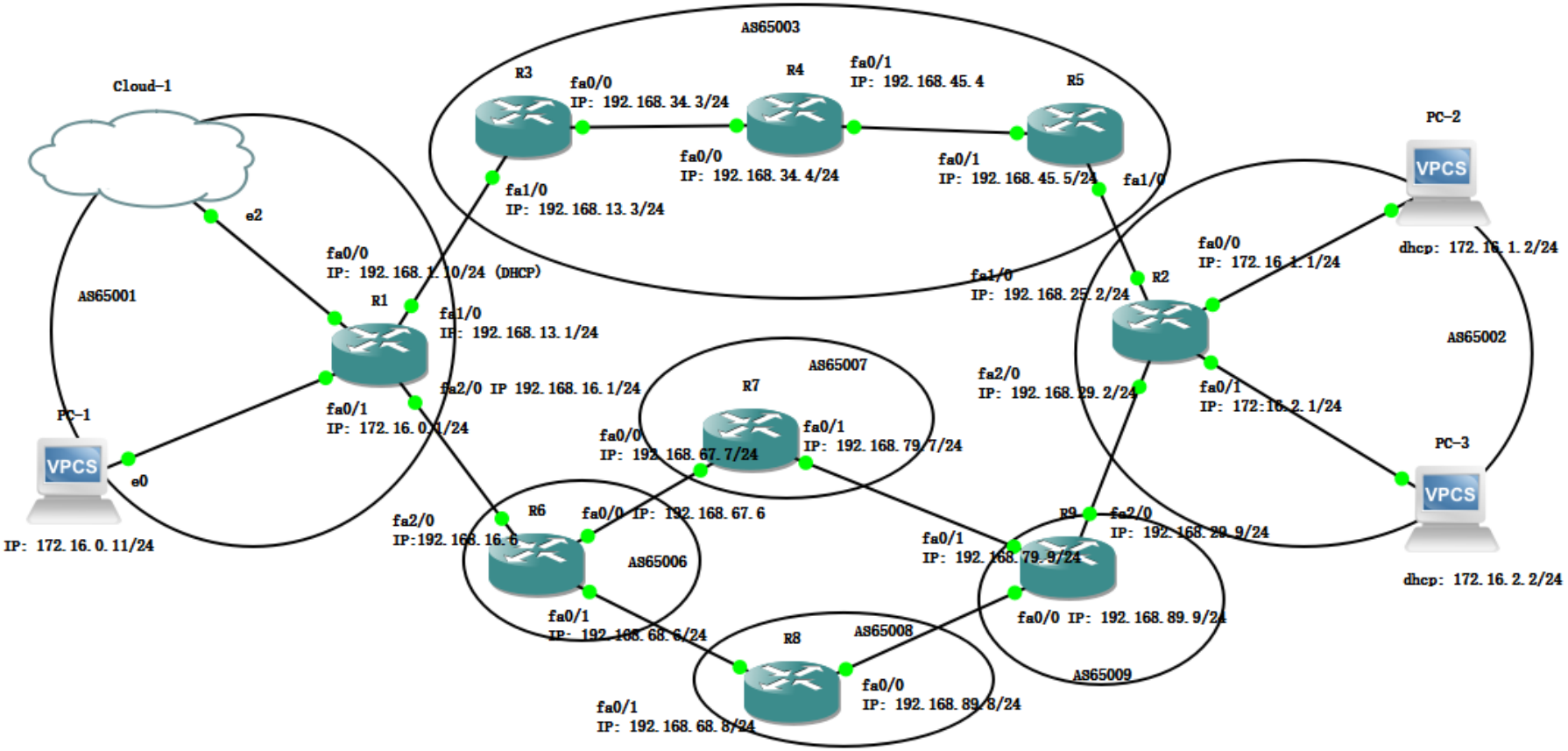
OSPF路由协议

- 配置OSPF协议命令：
  - Router(config)# router ospf *process-id* (*process-id*是指本地路由器的一个进程号)
  - 这个进程号区分同一台路由器上的多个OSPF进程。其进程id号的取值范围是1~65535。一个路由器上可以运行多个OSPF进程，它们的进程号必须不同。进程号只有局部意义，与其他路由器的进程可以相同也可以不同。
  - Router(config-router)#network *address wildcard-mask* area *area-id* (其中*address*是主机号为0的网络地址，下面的*wildcard-mask*的值为1的那些比特位对应该字段的主机号部分，而的值为0的那些比特对应该*address*字段的网络号和子网号部分。*wildcard-mask*为通配符，是子网掩码的反码。)

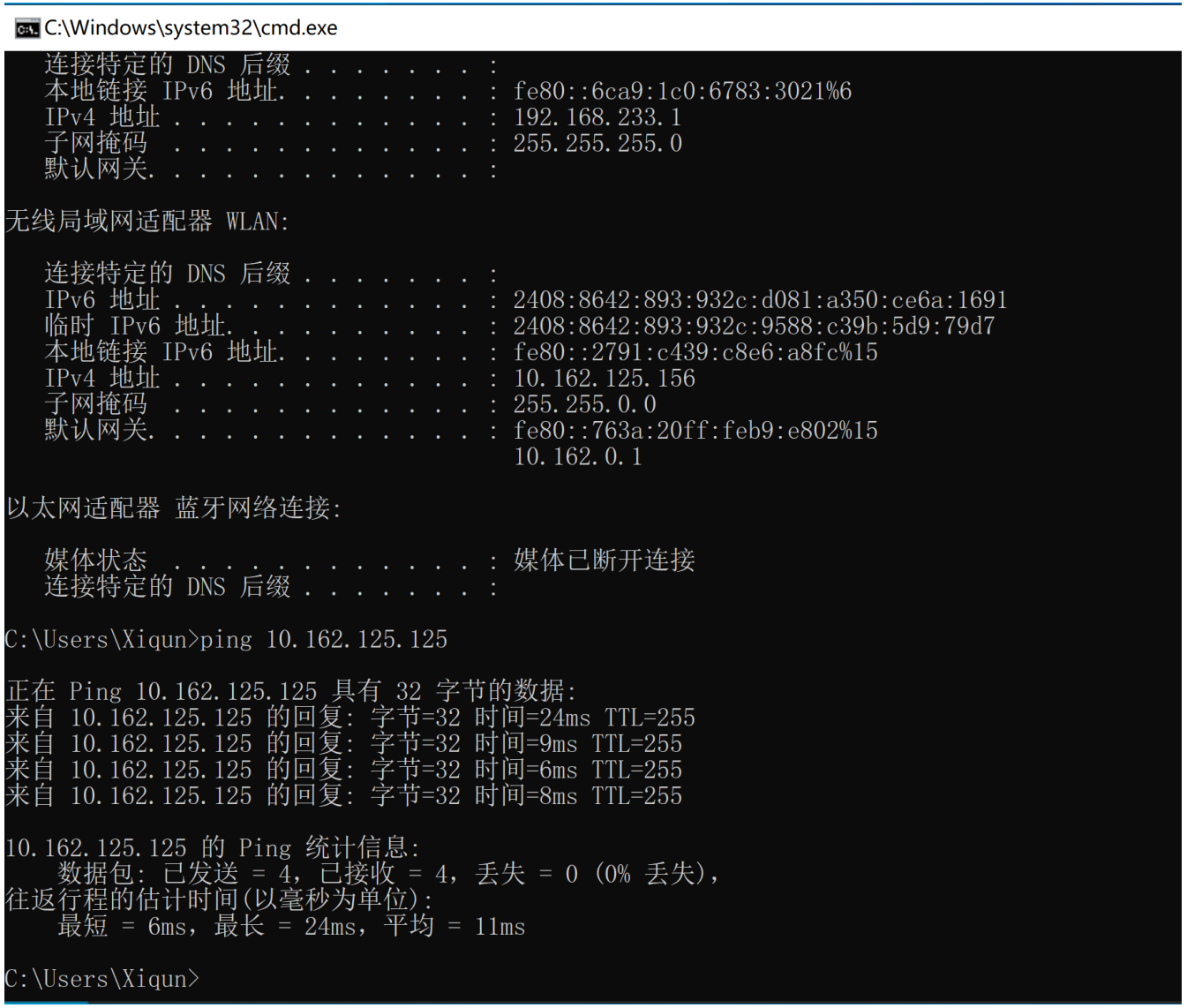
BGP路由协议

- BGP属于外部网关协议。
- BGP 可以在不同的自治系统之间传递路由信息。如果在同一个自治系统之内使用 BGP，就叫做 iBGP (内部 BGP)。如果在不同自治系统之间使用 BGP，就叫做 eBGP (外部 BGP)。
- 64512-65534之间的AS号属于私有AS号，不在互联网出现。

Lab 6 Topology

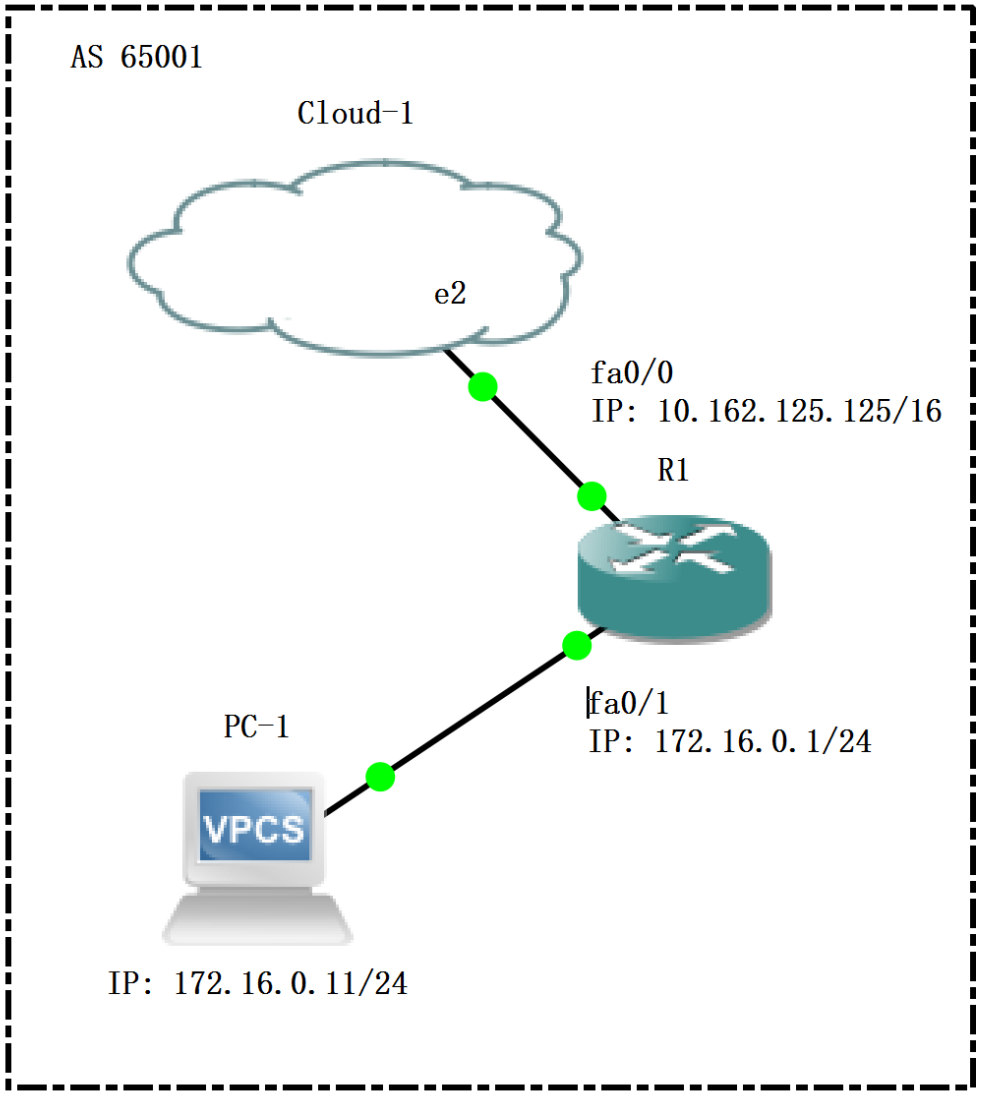


真实网络配置情况 (ipconfig)



Part 1

- 路由器R1的接口fa0/0与Cloud 1的接口e2相连，如果直接对路由器R1的fa0/0接口采用“ip address dhcp”命令动态配置IP地址，配置完采用“show interface fa0/0”，如果看不到动态分配的IP地址，可以改采用手动方式对路由器R1的fa0/0接口进行IP地址设置:

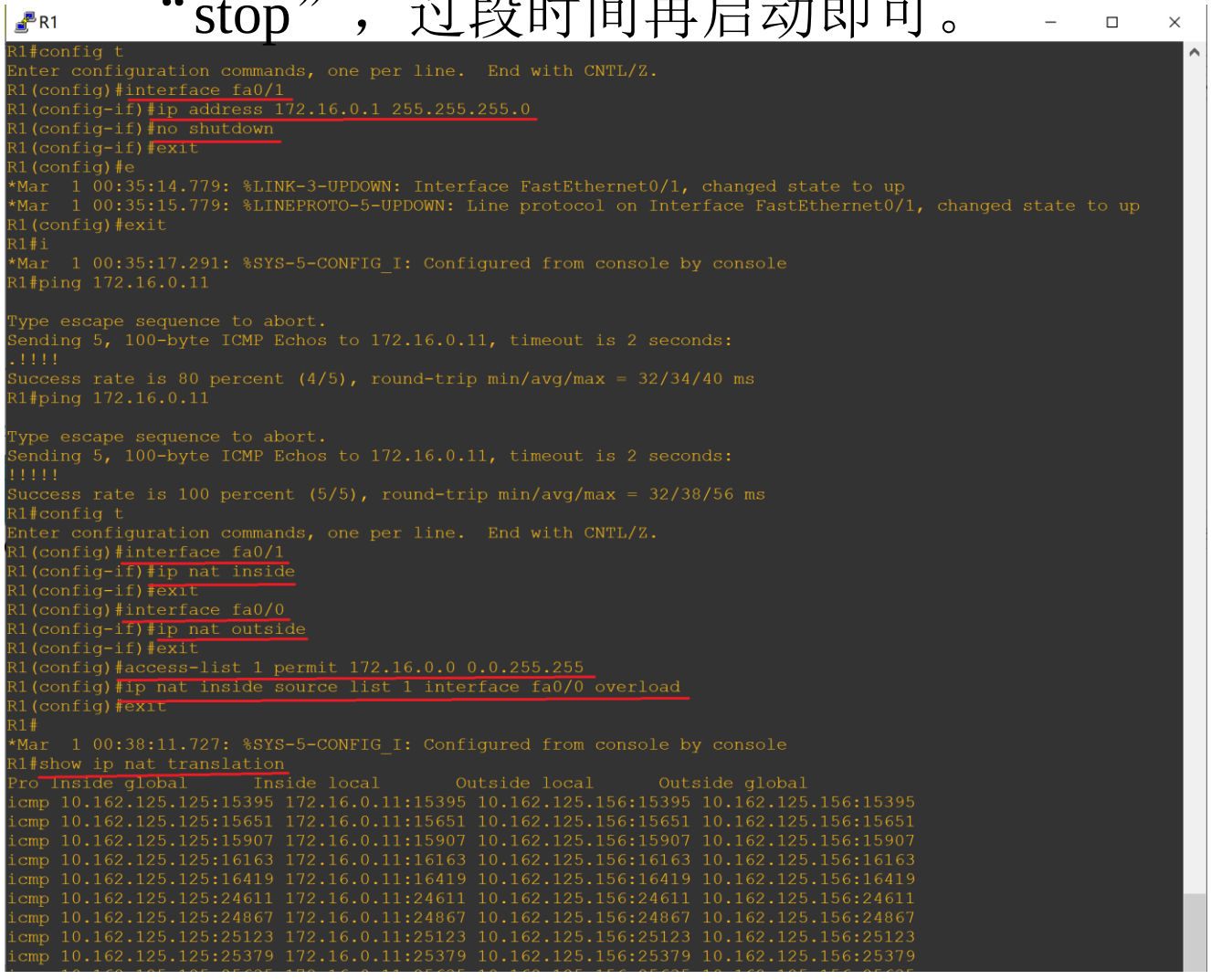



```
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface fa0/0
R1(config-if)#ip address 10.162.125.125 255.255.0.0
R1(config-if)#no shutdown
R1(config-if)#exit
R1(config)#exit
R1#
*Mar  1 00:03:47.239: %SYS-5-CONFIG_I: Configured from console by console
R1#show interface fa0/0
FastEthernet0/0 is up, line protocol is up
  Hardware is Gt96k FE, address is c401.0771.0000 (bia c401.0771.0000)
  Internet address is 10.162.125.125/16
  MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Half-duplex, 10Mb/s, 100BaseTX/FX
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:26, output 00:00:02, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     1 packets input, 243 bytes
     Received 1 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 watchdog
     0 input packets with dribble condition detected
     40 packets output, 8214 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
```

- 配置完了，在本机上能ping通R1的fa0/0接口的IP地址10.162.125.125。把本机防火墙都关掉，则在路由器R1上能ping通本机的IP地址10.162.125.156。
- 使用与真实网络不同的私网地址（如172.16.0.x/24）；并给PC1配置默认网关；具体命令如下：
- PC1机上：
  - 1) ip 172.16.0.11/24 172.16.0.1
  - 2) save
- 路由器R1上：
  - 1) config t
  - 2) interface fa0/1
  - 3) ip address 172.16.0.1 255.255.255.0
  - 4) no shutdown

- 要让PC1能否访问Cloud 1上的真实网络，需要在路由器R1上配置NAT，步骤如下：
- 1) config t
- 2) interface fa0/0
- 3) ip nat outside
- 4) exit
- 5) interface fa0/1
- 6) ip nat inside
- 7) exit
- 8) access-list 1 permit 172.16.0.0 0.0.255.255 (注意还在配置模式中)
- 9) ip nat inside source list 1 interface fa0/0 overload
- 10) exit (返回到命令行模式)

- 如果PC1持续“ping”本机IP地址10.162.125.156：ping 10.162.125.156 –t，然后在路由器R1上采用“show ip nat translation”命令就能显示如下地址转换信息。关闭PC1持续“ping”，可以在网络拓扑图中对PC1点击右键，选择“stop”，过段时间再启动即可。



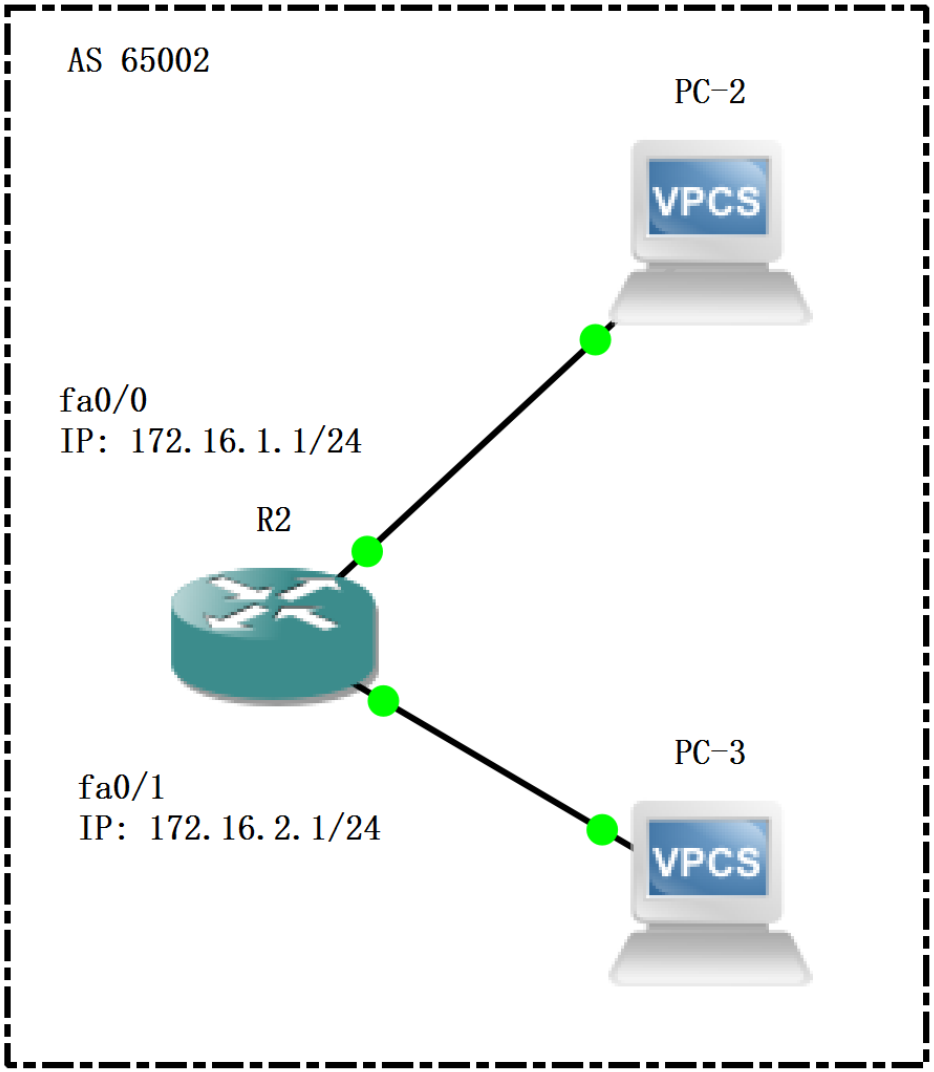
- 在路由器R1上启用BGP协议, 设置AS号（例如65001）（命令：router bgp *AS-Number*），并宣告2个直连网络（命令：network x.x.x.x mask x.x.x.x）。

R1

```
Sending 5, 100-byte ICMP Echos to 10.162.125.156, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/35/36 ms
R1#ping 10.162.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.162.0.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
R1#write
Building configuration...
[OK]
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router bgp 65001
R1(config-router)#network 172.16.0.0 mask 255.255.255.0
R1(config-router)#network 10.162.0.0 mask 255.255.0.0
R1(config-router)#exit
R1(config)#exit
R1#
*Mar  1 01:22:06.111: %SYS-5-CONFIG_I: Configured from console by console
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 10.162.0.1 to network 0.0.0.0

     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.0.0 is directly connected, FastEthernet0/1
     10.0.0.0/16 is subnetted, 1 subnets
C       10.162.0.0 is directly connected, FastEthernet0/0
S*   0.0.0.0/0 [1/0] via 10.162.0.1
R1#
```

Part 2

- 增加一个路由器、2台虚拟PC，用网线将他们连接起来并启动它们；
- 使用私网地址（如172.16.1.x/24、172.16.2.x/24）给三个设备配置IP地址，使用DHCP方式，需把R2配置为DHCP服务器。



- 给路由器R2连接PC2和PC3的接口配置IP地址

R2

```
*Mar  1 00:00:07.303: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet4/11, changed state to down
*Mar  1 00:00:07.303: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet4/10, changed state to down
*Mar  1 00:00:07.307: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet4/9, changed state to down
*Mar  1 00:00:07.311: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet4/8, changed state to down
*Mar  1 00:00:07.311: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet4/7, changed state to down
*Mar  1 00:00:07.315: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet4/6, changed state to down
R2#
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#interface fa0/0
R2(config-if)#ip address 172.16.1.1 255.255.255.0
R2(config-if)#no shutdown
R2(config-if)#exit
R2(config)#int
*Mar  1 00:00:51.123: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar  1 00:00:52.123: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R2(config)#interface fa0/1
R2(config-if)#ip address 172.16.2.1 255.255.255.0
R2(config-if)#no shutdown
R2(config-if)#exit
R2(config)#
*Mar  1 00:01:12.727: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Mar  1 00:01:13.727: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R2(config)#ext
          ^
% Invalid input detected at '^' marker.

R2(config)#
```

- 有关DHCP配置的一些命令

R2

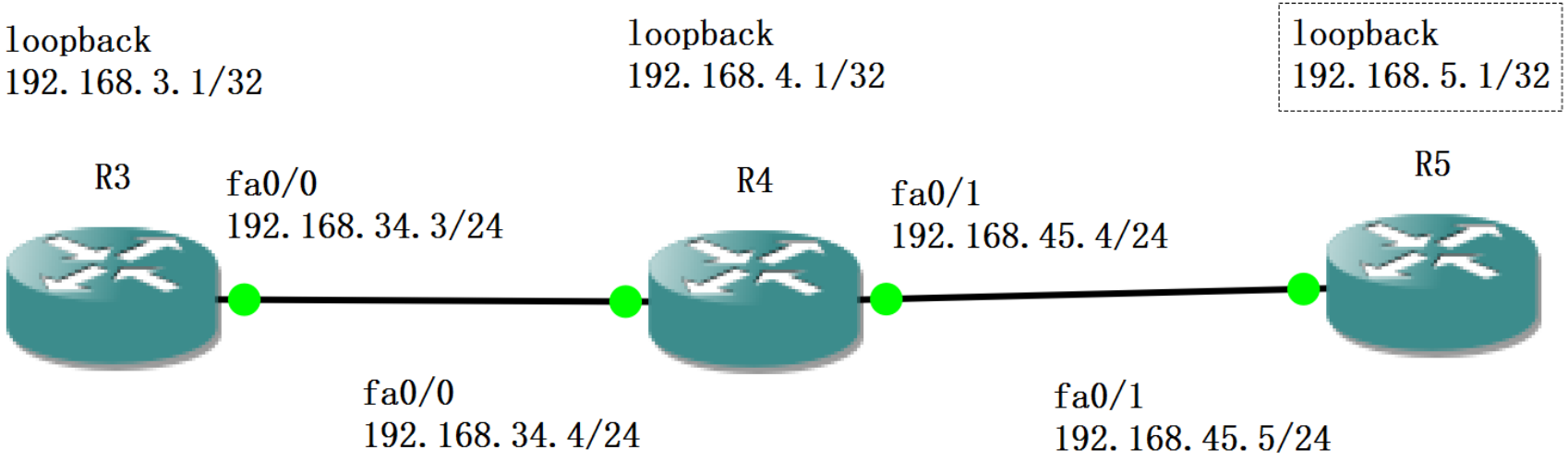
```
R2#s
*Mar  1 00:03:36.247: %SYS-5-CONFIG_I: Configured from console by console
R2#write
Building configuration...
[OK]
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#ip dhcp pool 1
R2(dhcp-config)#network 172.16.1.0/24
                                    ^
% Invalid input detected at '^' marker.

R2(dhcp-config)#network 172.16.1.0 /24
R2(dhcp-config)#default-router 172.16.1.1
R2(dhcp-config)#exit
R2(config)#ip dhcp pool 2
R2(dhcp-config)#network 172.16.2.0 /24
R2(dhcp-config)#default-router 172.16.2.1
R2(dhcp-config)#ext
                  ^
% Invalid input detected at '^' marker.

R2(dhcp-config)#exit
R2(config)#service dhcp
R2(config)#exit
R2#
*Mar  1 00:05:54.959: %SYS-5-CONFIG_I: Configured from console by console
R2#
```

- 在路由器R2上启用BGP协议，设置AS号（例如65002）（命令：router bgp AS-Number），并宣告2个直连网络（命令：network x.x.x.x mask x.x.x.x）。

```
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#router bgp 65002
R2(config-router)#network 172.16.1.0 mask 255.255.255.0
R2(config-router)#network 172.16.2.0 mask 255.255.255.0
R2(config-router)#exit
R2(config)#exit
R2#
*Mar  1 00:15:15.931: %SYS-5-CONFIG_I: Configured from console by console
R2#write
Building configuration...
[OK]
```

Part 3

- 增加三个路由器，用网线将他们连接起来并启动它们；
- 使用私网地址（如192.168.34.x/24、192.168.45.x/24）给三个设备的互联接口配置IP地址；



路由器R3上的一些配置命令 (I)

- 配置回环IP地址，查看回环IP地址的命令
  - 1) config t (进入配置模式)
  - 2) interface loopback 0 (回环)
  - 3) ip address 192.168.3.1 255.255.255.255 (子网掩码32位)
  - 4) no shutdown
  - 5) exit (推出回环配置)
  - 6) interface fa0/0
  - 7) ip address 192.168.34.3 255.255.255.0 (子网掩码24位)
  - 8) no shutdown
  - 9) …

  - show interface loopback 0

路由器R3上的一些配置命令 (II)

- 启用OSPF路由协议，并宣告直连和回环网络
  - 1) config t
  - 2) router ospf 1212 (1212是设置的进程号，进程号只有局部意义，与其他路由器的进程可以相同也可以不同。注意router bgp 后面跟的是AS-number，而router ospf 后面跟的是进程号)
  - 3) network 192.168.34.0 0.0.0.255 area 0 (红色部分是*wildcard-mask*通配符，是网络掩码的反码。)
  - 4) network 192.168.3.1 0.0.0.0 area 0 (宣告回环网络)
  - …
  - show ip route (查看路由表)

路由器R3上的路由表

R3

```
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/0 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
R3#write
Building configuration...
[OK]
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

O    192.168.45.0/24 [110/20] via 192.168.34.4, 00:03:27, FastEthernet0/0
     192.168.4.0/32 is subnetted, 1 subnets
O       192.168.4.1 [110/11] via 192.168.34.4, 00:03:27, FastEthernet0/0
     192.168.5.0/32 is subnetted, 1 subnets
O       192.168.5.1 [110/21] via 192.168.34.4, 00:03:27, FastEthernet0/0
C    192.168.34.0/24 is directly connected, FastEthernet0/0
     192.168.3.0/32 is subnetted, 1 subnets
C       192.168.3.1 is directly connected, Loopback0
R3#
```

路由器R3上的一些配置命令 (III)

- 在路由器R3、R5上启用BGP协议，设置同样的AS号（例如65003），并宣告直连网络，然后把对方增加为AS内部的邻居（命令：neighbor *IP*-Address remote-as *AS-Number*），IP-Address为对方回环接口的IP，AS-Number设置为相同的AS号；
- 由于路由器R3和R5是也属于AS Boundary Router，它们各自运行两个路由协议，一个是OSPF，另一个是BGP。
- 命令照着实验报告中配置吧，这里不再重复了。

References

- [1] https://zhuanlan.zhihu.com/p/126754314
- [2] https://zhuanlan.zhihu.com/p/376420342
- [3] https://www.cisco.com/c/en/us/support/docs/ip/border-gateway-protocol-bgp/22166-bgp-trouble-main.html