计算机网络 Lab6

一、实验任务

Part1

实现思路：

1. **rtinit( )**
   通过初始化`dt0`距离表，将节点0与其邻接节点的直接连接成本设为1、3、7，并将其余节点的成本设为一个高值（999）。然后，通过构造一个`rtpkt`包，将节点0的最短路径开销信息发送给直接相连的节点1、2、3。接收到信息的邻居节点将更新各自的路由表，并如果有变化，继续广播给它们的邻居。这实现了异步更新机制，并且通过调用`tolayer2()`确保信息传递无误。然后调用clocktime打印当前时间和当前节点的距离表。

2. **rtupdate()**

   该函数实现节点的路由更新机制。当节点0接收到来自邻居节点的路由选择更新分组时，首先根据分组中的最短路径信息更新自己的距离表。如果通过邻居的路径开销更低，节点0更新其到其他节点的最短路径开销，并将更新信息通过路由分组发送给直接相连的邻居。更新的过程会打印相关信息，包括时间戳、当前距离表以及是否进行了更新。如果没有发生更新，输出相应的提示信息。

运行命令：

```
gcc prog3.c node0.c node1.c node2.c node3.c
./a.exe
```

部分输出截图

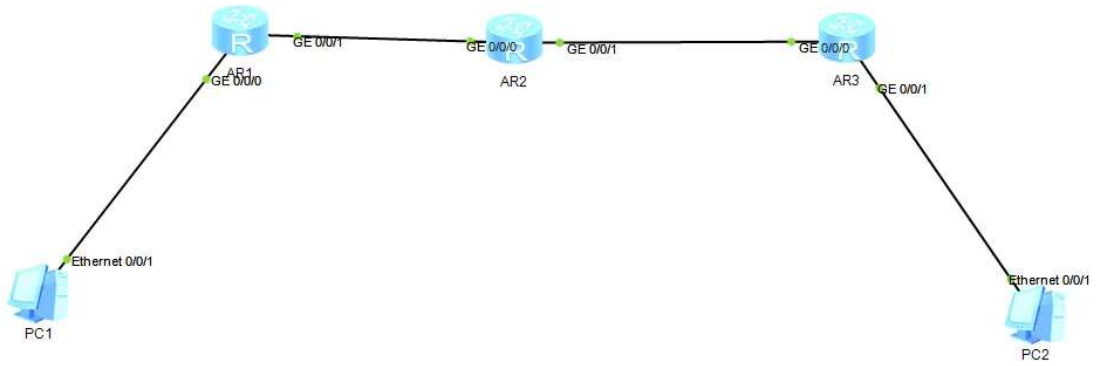
```
MAIN: rcv event, t=5.760, at 2 src: 1, dest: 2, contents:   1   0   1   3
No Update in node 2
MAIN: rcv event, t=6.212, at 1 src: 0, dest: 1, contents:   0   1   2   4
No Update in node 1
MAIN: rcv event, t=6.315, at 3 src: 2, dest: 3, contents:   2   1   0   2
update table 3
             via
   D3 |    0     2
  ----|-----------
     0|    7     4
dest 1|    8     3
     2|    9     2
MAIN: rcv event, t=6.435, at 0 src: 2, dest: 0, contents:   2   1   0   2
No Update in node 0
MAIN: rcv event, t=6.771, at 2 src: 0, dest: 2, contents:   0   1   2   7
No Update in node 2
MAIN: rcv event, t=7.003, at 3 src: 0, dest: 3, contents:   0   1   2   4
No Update in node 3
MAIN: rcv event, t=7.406, at 0 src: 3, dest: 0, contents:   4   3   2   0
No Update in node 0
MAIN: rcv event, t=7.650, at 2 src: 3, dest: 2, contents:   7   8   2   0
No Update in node 2
MAIN: rcv event, t=8.069, at 2 src: 0, dest: 2, contents:   0   1   2   5
No Update in node 2
MAIN: rcv event, t=9.377, at 2 src: 3, dest: 2, contents:   5   3   2   0
No Update in node 2
MAIN: rcv event, t=10.016, at 2 src: 0, dest: 2, contents:   0   1   2   4
No Update in node 2
MAIN: rcv event, t=11.030, at 2 src: 3, dest: 2, contents:   4   3   2   0
No Update in node 2
MAIN: rcv event, t=10000.000, at -1MAIN: rcv event, t=20000.000, at 6750544
Simulator terminated at t=20000.000000, no packets in medium
```

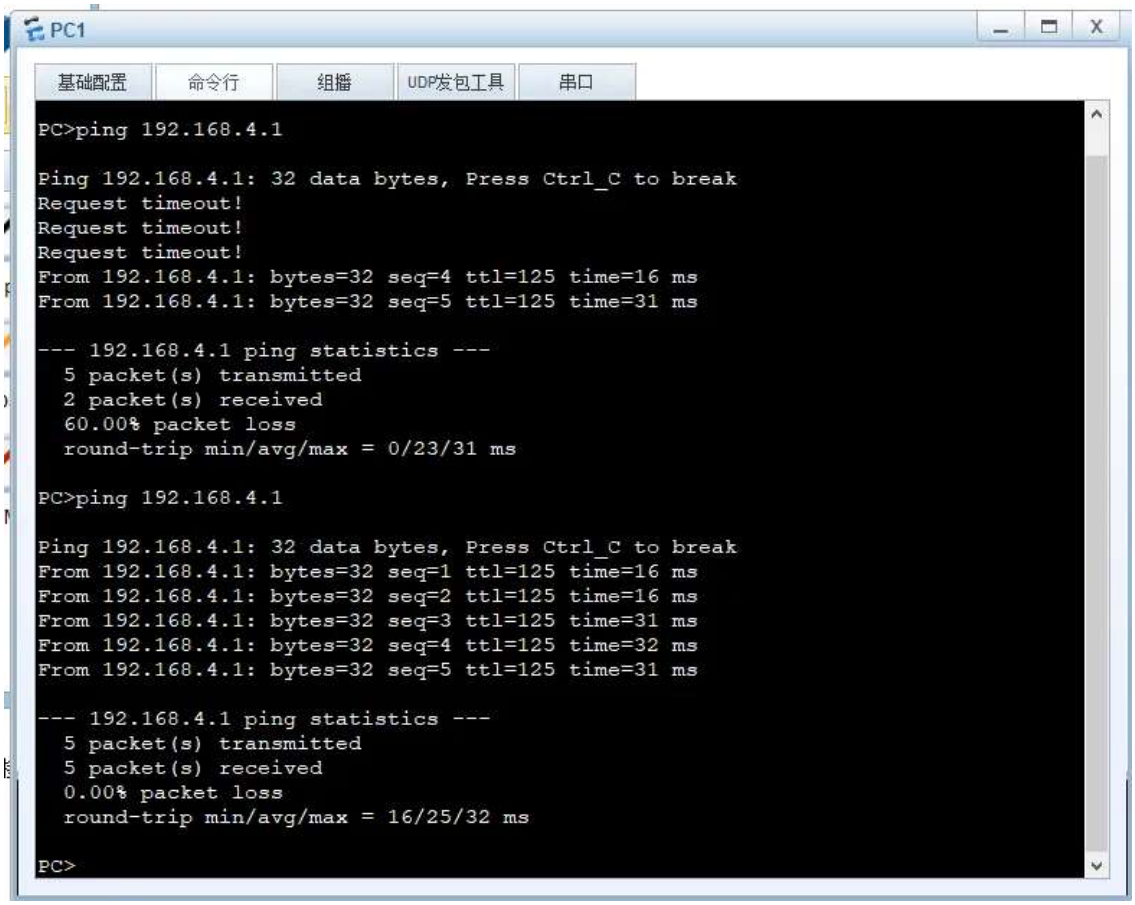
Part2

任务一

第一部分：完成以下任务并回答问题

1. **按照要求搭建拓扑，完成相关PC与路由器的配置，配置成功 PC1 应能 ping PC2，截图。并在图中指出网络中共有几个子网，每个子网的地址及掩码是什么?**





共有四个子网

子网 1（PC1 和 AR1 连接的网络）：网络地址：192.168.1.0子网掩码：255.255.255.0

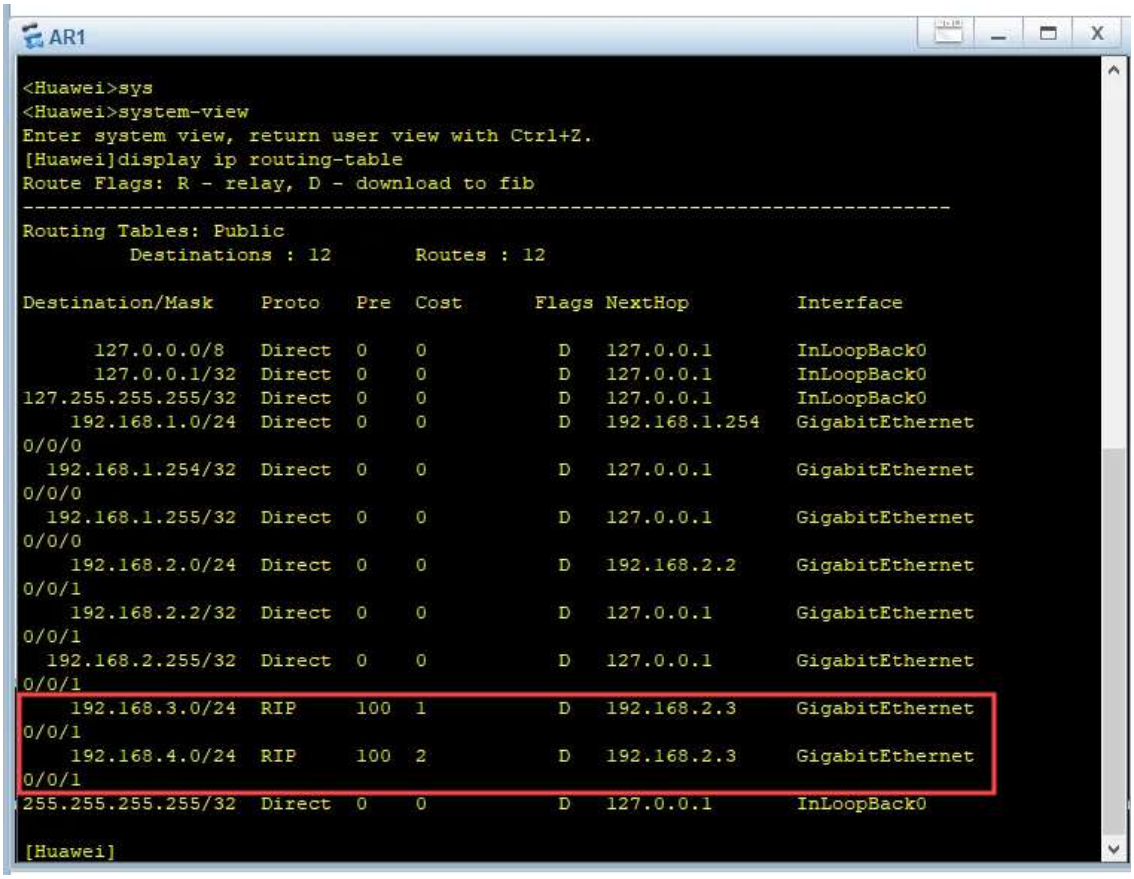
子网 2（AR1 和 AR2 之间的网络）：网络地址：192.168.2.0子网掩码：255.255.255.0

子网 3（AR2 和 AR3 之间的网络）：网络地址：192.168.3.0子网掩码：255.255.255.0

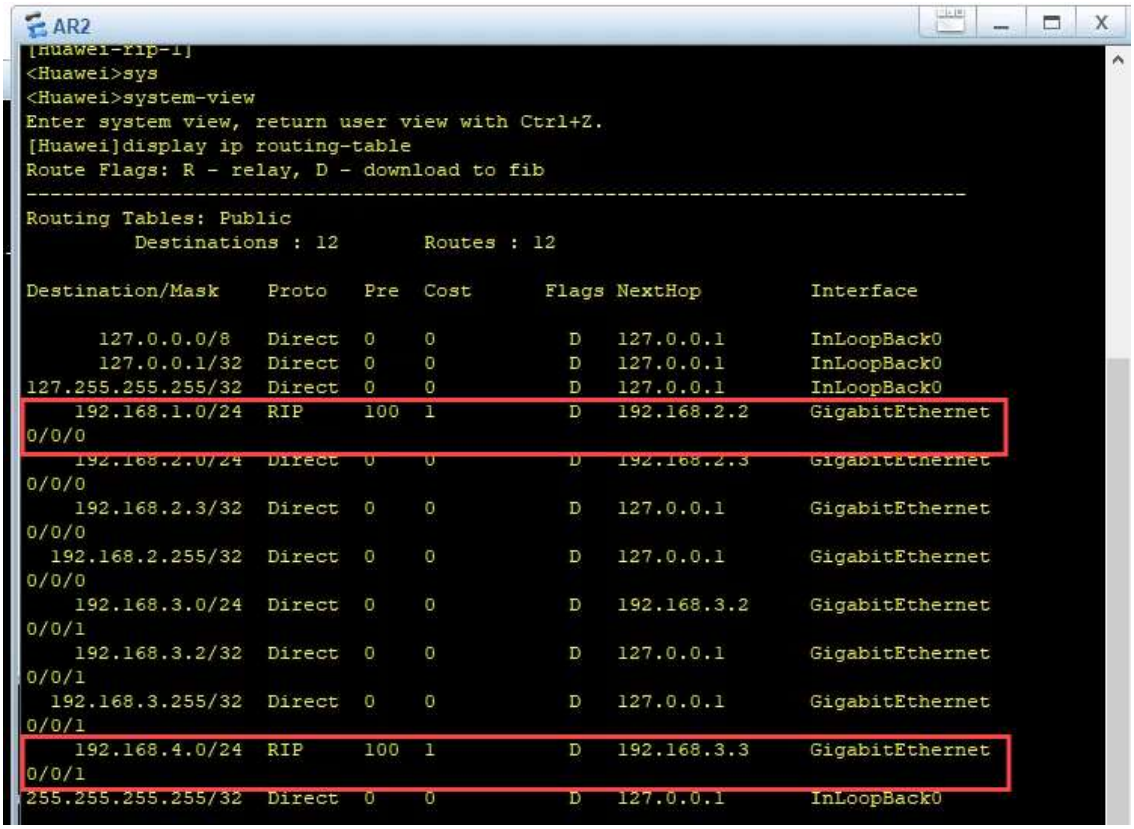
子网 4（AR3 和 PC2 连接的网络）：网络地址：192.168.4.0子网掩码：255.255.255.0

2. **查看各个路由器的中的IP路由表，截图并用红色的框标识出RIP协议产生的路由表项。**

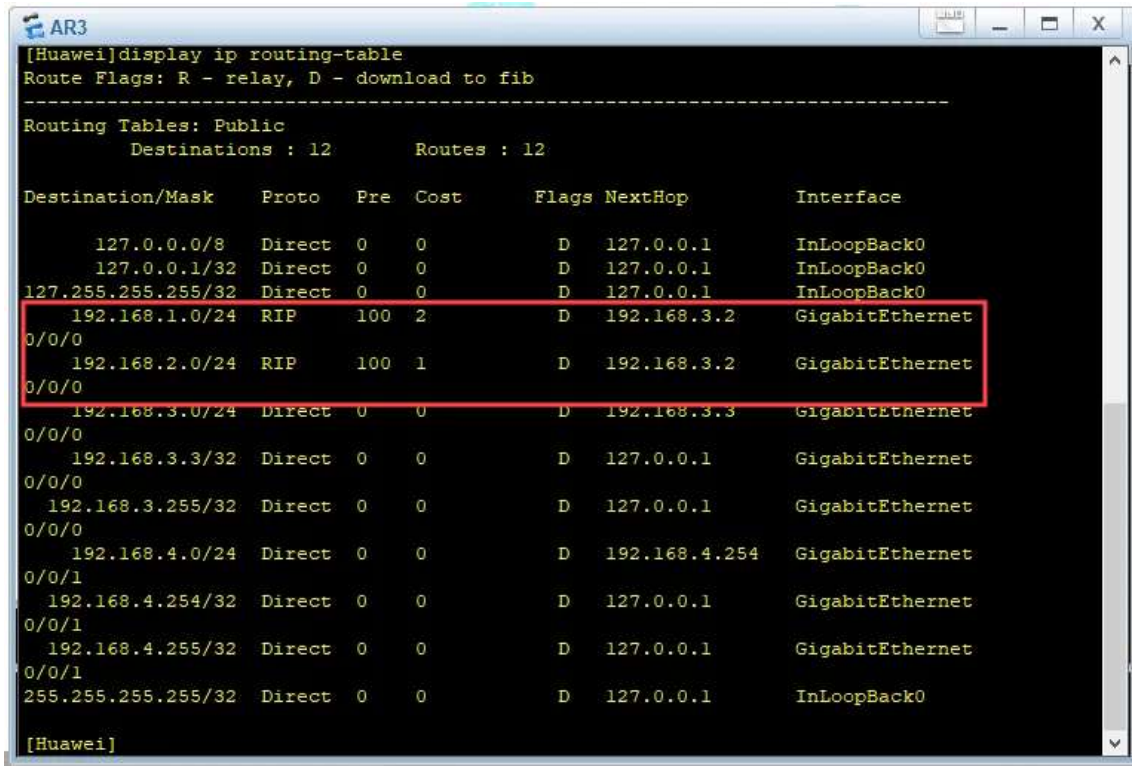
AR1的IP路由表:



AR2的IP路由表:

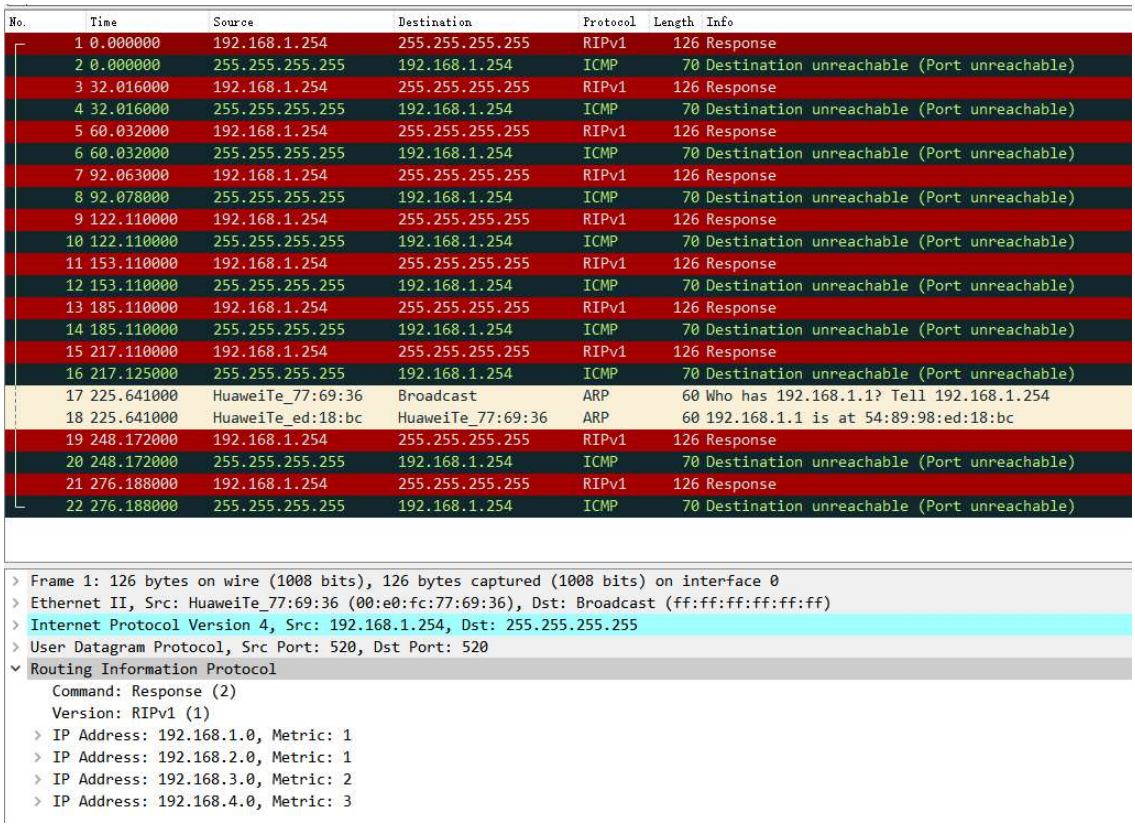


AR3的IP路由表:



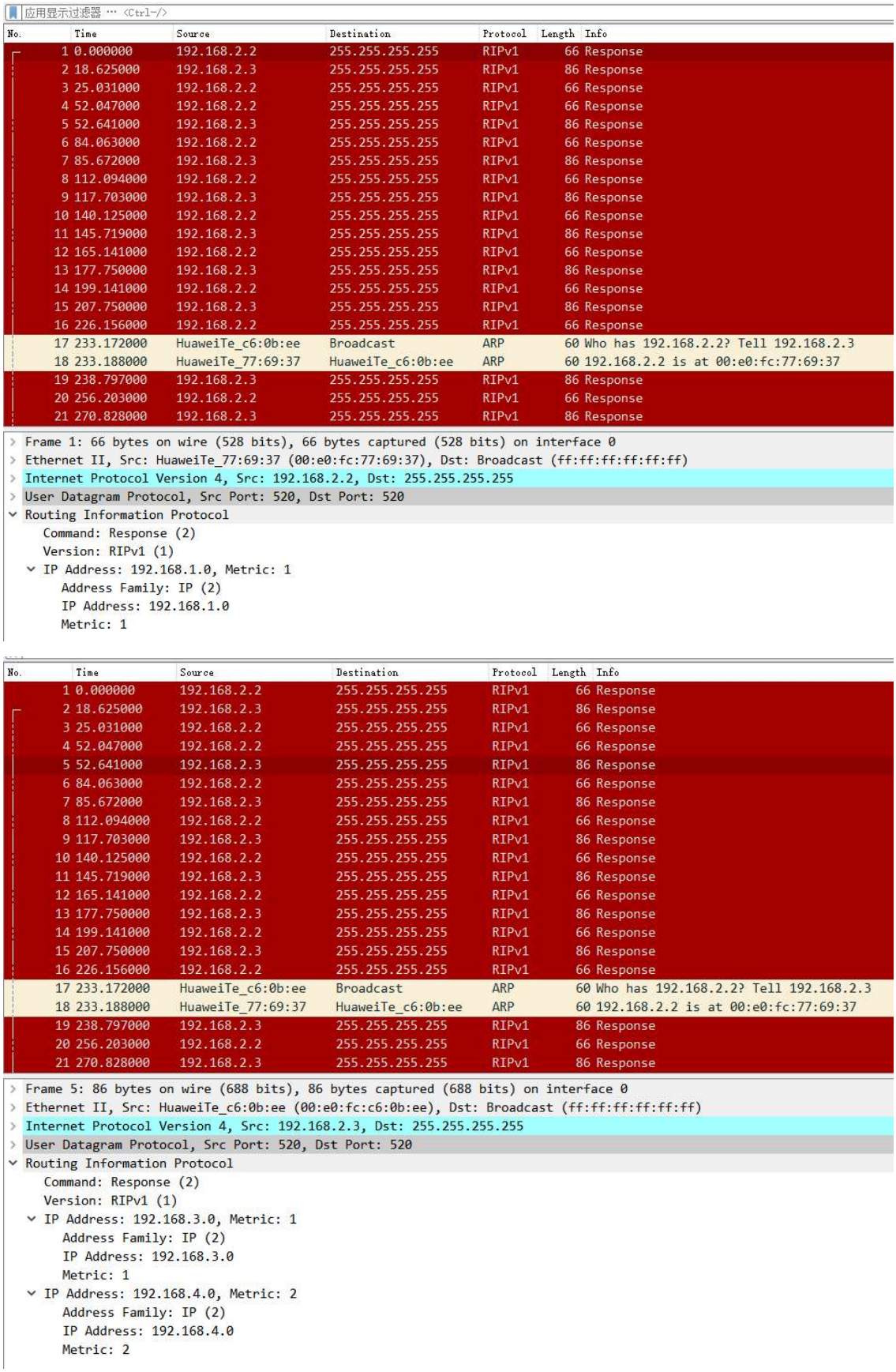
3. **在各个路由器端口进行抓包，观察RIP协议报文，截图举例说明报文各字段的含义。并说明路由器中的IP路由表中的RIP路由表项是如何由RIP协议报文中的距离向量计算得出的，举一个例子即可。**

AR1 GE0/0/0



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.254	255.255.255.255	RIPv1	126	Response
2	0.000000	255.255.255.255	192.168.1.254	ICMP	70	Destination unreachable (Port unreachable)
3	32.016000	192.168.1.254	255.255.255.255	RIPv1	126	Response
4	32.016000	255.255.255.255	192.168.1.254	ICMP	70	Destination unreachable (Port unreachable)
5	60.032000	192.168.1.254	255.255.255.255	RIPv1	126	Response
6	60.032000	255.255.255.255	192.168.1.254	ICMP	70	Destination unreachable (Port unreachable)
7	92.063000	192.168.1.254	255.255.255.255	RIPv1	126	Response
8	92.078000	255.255.255.255	192.168.1.254	ICMP	70	Destination unreachable (Port unreachable)
9	122.110000	192.168.1.254	255.255.255.255	RIPv1	126	Response
10	122.110000	255.255.255.255	192.168.1.254	ICMP	70	Destination unreachable (Port unreachable)
11	153.110000	192.168.1.254	255.255.255.255	RIPv1	126	Response
12	153.110000	255.255.255.255	192.168.1.254	ICMP	70	Destination unreachable (Port unreachable)
13	185.110000	192.168.1.254	255.255.255.255	RIPv1	126	Response
14	185.110000	255.255.255.255	192.168.1.254	ICMP	70	Destination unreachable (Port unreachable)
15	217.110000	192.168.1.254	255.255.255.255	RIPv1	126	Response
16	217.125000	255.255.255.255	192.168.1.254	ICMP	70	Destination unreachable (Port unreachable)
17	225.641000	HuaweiTe_77:69:36	Broadcast	ARP	60	Who has 192.168.1.1? Tell 192.168.1.254
18	225.641000	HuaweiTe_ed:18:bc	HuaweiTe_77:69:36	ARP	60	192.168.1.1 is at 54:89:98:ed:18:bc
19	248.172000	192.168.1.254	255.255.255.255	RIPv1	126	Response
20	248.172000	255.255.255.255	192.168.1.254	ICMP	70	Destination unreachable (Port unreachable)
21	276.188000	192.168.1.254	255.255.255.255	RIPv1	126	Response
22	276.188000	255.255.255.255	192.168.1.254	ICMP	70	Destination unreachable (Port unreachable)

AR1 GE0/0/1



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.2.2	255.255.255.255	RIPv1	66	Response
2	18.625000	192.168.2.3	255.255.255.255	RIPv1	86	Response
3	25.031000	192.168.2.2	255.255.255.255	RIPv1	66	Response
4	52.047000	192.168.2.2	255.255.255.255	RIPv1	66	Response
5	52.641000	192.168.2.3	255.255.255.255	RIPv1	86	Response
6	84.063000	192.168.2.2	255.255.255.255	RIPv1	66	Response
7	85.672000	192.168.2.3	255.255.255.255	RIPv1	86	Response
8	112.094000	192.168.2.2	255.255.255.255	RIPv1	66	Response
9	117.703000	192.168.2.3	255.255.255.255	RIPv1	86	Response
10	140.125000	192.168.2.2	255.255.255.255	RIPv1	66	Response
11	145.719000	192.168.2.3	255.255.255.255	RIPv1	86	Response
12	165.141000	192.168.2.2	255.255.255.255	RIPv1	66	Response
13	177.750000	192.168.2.3	255.255.255.255	RIPv1	86	Response
14	199.141000	192.168.2.2	255.255.255.255	RIPv1	66	Response
15	207.750000	192.168.2.3	255.255.255.255	RIPv1	86	Response
16	226.156000	192.168.2.2	255.255.255.255	RIPv1	66	Response
17	233.172000	HuaweiTe_c6:0b:ee	Broadcast	ARP	60	Who has 192.168.2.2? Tell 192.168.2.3
18	233.188000	HuaweiTe_77:69:37	HuaweiTe_c6:0b:ee	ARP	60	192.168.2.2 is at 00:e0:fc:77:69:37
19	238.797000	192.168.2.3	255.255.255.255	RIPv1	86	Response
20	256.203000	192.168.2.2	255.255.255.255	RIPv1	66	Response
21	270.828000	192.168.2.3	255.255.255.255	RIPv1	86	Response

```
> Frame 1: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
> Ethernet II, Src: HuaweiTe_77:69:37 (00:e0:fc:77:69:37), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.2.2, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 520, Dst Port: 520
v Routing Information Protocol
    Command: Response (2)
    Version: RIPv1 (1)
  v IP Address: 192.168.1.0, Metric: 1
      Address Family: IP (2)
      IP Address: 192.168.1.0
      Metric: 1
```


No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.2.2	255.255.255.255	RIPv1	66	Response
2	18.625000	192.168.2.3	255.255.255.255	RIPv1	86	Response
3	25.031000	192.168.2.2	255.255.255.255	RIPv1	66	Response
4	52.047000	192.168.2.2	255.255.255.255	RIPv1	66	Response
5	52.641000	192.168.2.3	255.255.255.255	RIPv1	86	Response
6	84.063000	192.168.2.2	255.255.255.255	RIPv1	66	Response
7	85.672000	192.168.2.3	255.255.255.255	RIPv1	86	Response
8	112.094000	192.168.2.2	255.255.255.255	RIPv1	66	Response
9	117.703000	192.168.2.3	255.255.255.255	RIPv1	86	Response
10	140.125000	192.168.2.2	255.255.255.255	RIPv1	66	Response
11	145.719000	192.168.2.3	255.255.255.255	RIPv1	86	Response
12	165.141000	192.168.2.2	255.255.255.255	RIPv1	66	Response
13	177.750000	192.168.2.3	255.255.255.255	RIPv1	86	Response
14	199.141000	192.168.2.2	255.255.255.255	RIPv1	66	Response
15	207.750000	192.168.2.3	255.255.255.255	RIPv1	86	Response
16	226.156000	192.168.2.2	255.255.255.255	RIPv1	66	Response
17	233.172000	HuaweiTe_c6:0b:ee	Broadcast	ARP	60	Who has 192.168.2.2? Tell 192.168.2.3
18	233.188000	HuaweiTe_77:69:37	HuaweiTe_c6:0b:ee	ARP	60	192.168.2.2 is at 00:e0:fc:77:69:37
19	238.797000	192.168.2.3	255.255.255.255	RIPv1	86	Response
20	256.203000	192.168.2.2	255.255.255.255	RIPv1	66	Response
21	270.828000	192.168.2.3	255.255.255.255	RIPv1	86	Response

```
> Frame 5: 86 bytes on wire (688 bits), 86 bytes captured (688 bits) on interface 0
> Ethernet II, Src: HuaweiTe_c6:0b:ee (00:e0:fc:c6:0b:ee), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.2.3, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 520, Dst Port: 520
v Routing Information Protocol
    Command: Response (2)
    Version: RIPv1 (1)
  v IP Address: 192.168.3.0, Metric: 1
      Address Family: IP (2)
      IP Address: 192.168.3.0
      Metric: 1
  v IP Address: 192.168.4.0, Metric: 2
      Address Family: IP (2)
      IP Address: 192.168.4.0
      Metric: 2
```

举例说明:

- **报文各字段的含义**

  在RIP报文中，主要字段包括以下几个部分：

1. 报文头（Header）：
    - 命令（Command）

      表示该RIP报文的类型。常见的值有：
        - 1：请求（Request）报文
        - 2：响应（Response）报文
    - 版本（Version）：RIP协议的版本
2. 路由条目（Routing Entries）： 每个条目包含以下字段：
    - 地址簇标识符（Address Family）：通常为2，表示IPv4地址。
    - 路由地址（IP Address）：目的网络的IP地址。
    - 跳数（Metric）：到达该网络的距离（跳数），最大值为15，表示不可达。

- **如何计算路由表项**

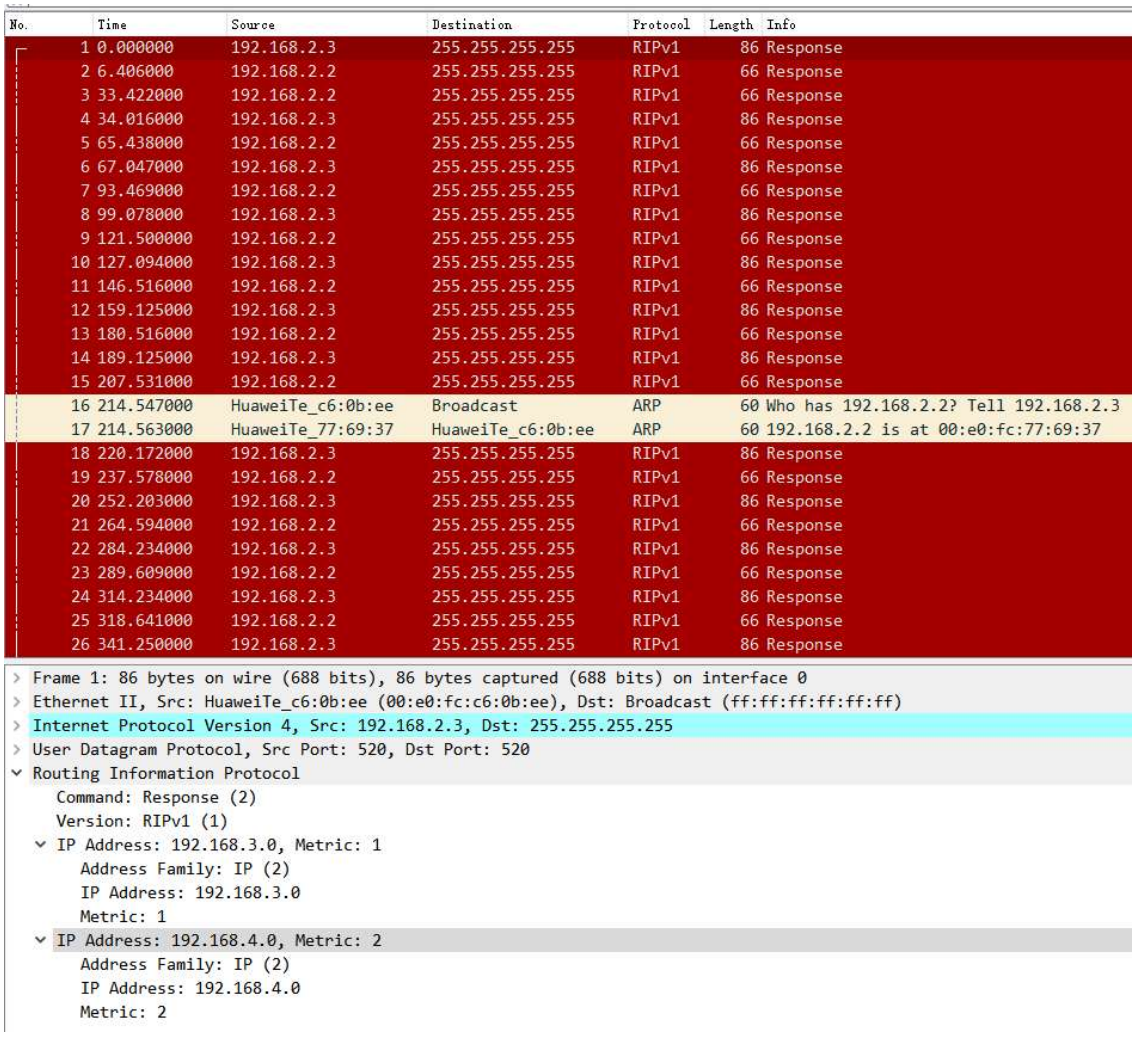
当 AR1 收到邻居路由器的 RIP 报文时：

- 如果是新的路由条目，则添加到路由表。
- 如果度量值更小（意味着更优的路径），则更新路由表中的现有条目。
- 如果度量值更大，则通常不会更新路由表，

(2) 计算过程：

- 192.168.3.0/24 :Metric 为 1，下一跳地址为192.168.2.3 。
- 192.168.4.0/24 :Metric 为 2。下一跳地址： 192.168.2.3 。

AR2 GE0/0/0



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.2.3	255.255.255.255	RIPv1	86	Response
2	6.406000	192.168.2.2	255.255.255.255	RIPv1	66	Response
3	33.422000	192.168.2.2	255.255.255.255	RIPv1	66	Response
4	34.016000	192.168.2.3	255.255.255.255	RIPv1	86	Response
5	65.438000	192.168.2.2	255.255.255.255	RIPv1	66	Response
6	67.047000	192.168.2.3	255.255.255.255	RIPv1	86	Response
7	93.469000	192.168.2.2	255.255.255.255	RIPv1	66	Response
8	99.078000	192.168.2.3	255.255.255.255	RIPv1	86	Response
9	121.500000	192.168.2.2	255.255.255.255	RIPv1	66	Response
10	127.094000	192.168.2.3	255.255.255.255	RIPv1	86	Response
11	146.516000	192.168.2.2	255.255.255.255	RIPv1	66	Response
12	159.125000	192.168.2.3	255.255.255.255	RIPv1	86	Response
13	180.516000	192.168.2.2	255.255.255.255	RIPv1	66	Response
14	189.125000	192.168.2.3	255.255.255.255	RIPv1	86	Response
15	207.531000	192.168.2.2	255.255.255.255	RIPv1	66	Response
16	214.547000	HuaweiTe_c6:0b:ee	Broadcast	ARP	60	Who has 192.168.2.2? Tell 192.168.2.3
17	214.563000	HuaweiTe_77:69:37	HuaweiTe_c6:0b:ee	ARP	60	192.168.2.2 is at 00:e0:fc:77:69:37
18	220.172000	192.168.2.3	255.255.255.255	RIPv1	86	Response
19	237.578000	192.168.2.2	255.255.255.255	RIPv1	66	Response
20	252.203000	192.168.2.3	255.255.255.255	RIPv1	86	Response
21	264.594000	192.168.2.2	255.255.255.255	RIPv1	66	Response
22	284.234000	192.168.2.3	255.255.255.255	RIPv1	86	Response
23	289.609000	192.168.2.2	255.255.255.255	RIPv1	66	Response
24	314.234000	192.168.2.3	255.255.255.255	RIPv1	86	Response
25	318.641000	192.168.2.2	255.255.255.255	RIPv1	66	Response
26	341.250000	192.168.2.3	255.255.255.255	RIPv1	86	Response

```
> Frame 1: 86 bytes on wire (688 bits), 86 bytes captured (688 bits) on interface 0
> Ethernet II, Src: HuaweiTe_c6:0b:ee (00:e0:fc:c6:0b:ee), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.2.3, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 520, Dst Port: 520
v Routing Information Protocol
    Command: Response (2)
    Version: RIPv1 (1)
  v IP Address: 192.168.3.0, Metric: 1
      Address Family: IP (2)
      IP Address: 192.168.3.0
      Metric: 1
  v IP Address: 192.168.4.0, Metric: 2
      Address Family: IP (2)
      IP Address: 192.168.4.0
      Metric: 2
```

No.	Time	Source	Destination	Protocol	Length	Info
19	237.578000	192.168.2.2	255.255.255.255	RIPv1	66	Response
20	252.203000	192.168.2.3	255.255.255.255	RIPv1	86	Response
21	264.594000	192.168.2.2	255.255.255.255	RIPv1	66	Response
22	284.234000	192.168.2.3	255.255.255.255	RIPv1	86	Response
23	289.609000	192.168.2.2	255.255.255.255	RIPv1	66	Response
24	314.234000	192.168.2.3	255.255.255.255	RIPv1	86	Response
25	318.641000	192.168.2.2	255.255.255.255	RIPv1	66	Response
26	341.250000	192.168.2.3	255.255.255.255	RIPv1	86	Response
27	344.656000	192.168.2.2	255.255.255.255	RIPv1	66	Response
28	366.266000	192.168.2.3	255.255.255.255	RIPv1	86	Response
29	373.656000	192.168.2.2	255.255.255.255	RIPv1	66	Response
30	395.313000	192.168.2.3	255.255.255.255	RIPv1	86	Response
31	401.688000	192.168.2.2	255.255.255.255	RIPv1	66	Response
32	421.328000	192.168.2.3	255.255.255.255	RIPv1	86	Response
33	430.703000	192.168.2.2	255.255.255.255	RIPv1	66	Response
34	450.328000	192.168.2.3	255.255.255.255	RIPv1	86	Response
35	455.688000	192.168.2.2	255.255.255.255	RIPv1	66	Response
36	478.375000	192.168.2.3	255.255.255.255	RIPv1	86	Response
37	484.719000	192.168.2.2	255.255.255.255	RIPv1	66	Response
38	507.391000	192.168.2.3	255.255.255.255	RIPv1	86	Response
39	513.734000	192.168.2.2	255.255.255.255	RIPv1	66	Response
40	532.375000	192.168.2.3	255.255.255.255	RIPv1	86	Response
41	544.797000	192.168.2.2	255.255.255.255	RIPv1	66	Response
42	561.391000	192.168.2.3	255.255.255.255	RIPv1	86	Response
43	579.797000	192.168.2.2	255.255.255.255	RIPv1	66	Response
44	590.422000	192.168.2.3	255.255.255.255	RIPv1	86	Response

```
> Frame 37: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
> Ethernet II, Src: HuaweiTe_77:69:37 (00:e0:fc:77:69:37), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.2.2, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 520, Dst Port: 520
v Routing Information Protocol
    Command: Response (2)
    Version: RIPv1 (1)
  v IP Address: 192.168.1.0, Metric: 1
      Address Family: IP (2)
      IP Address: 192.168.1.0
      Metric: 1
```

AR2 GE0/0/1

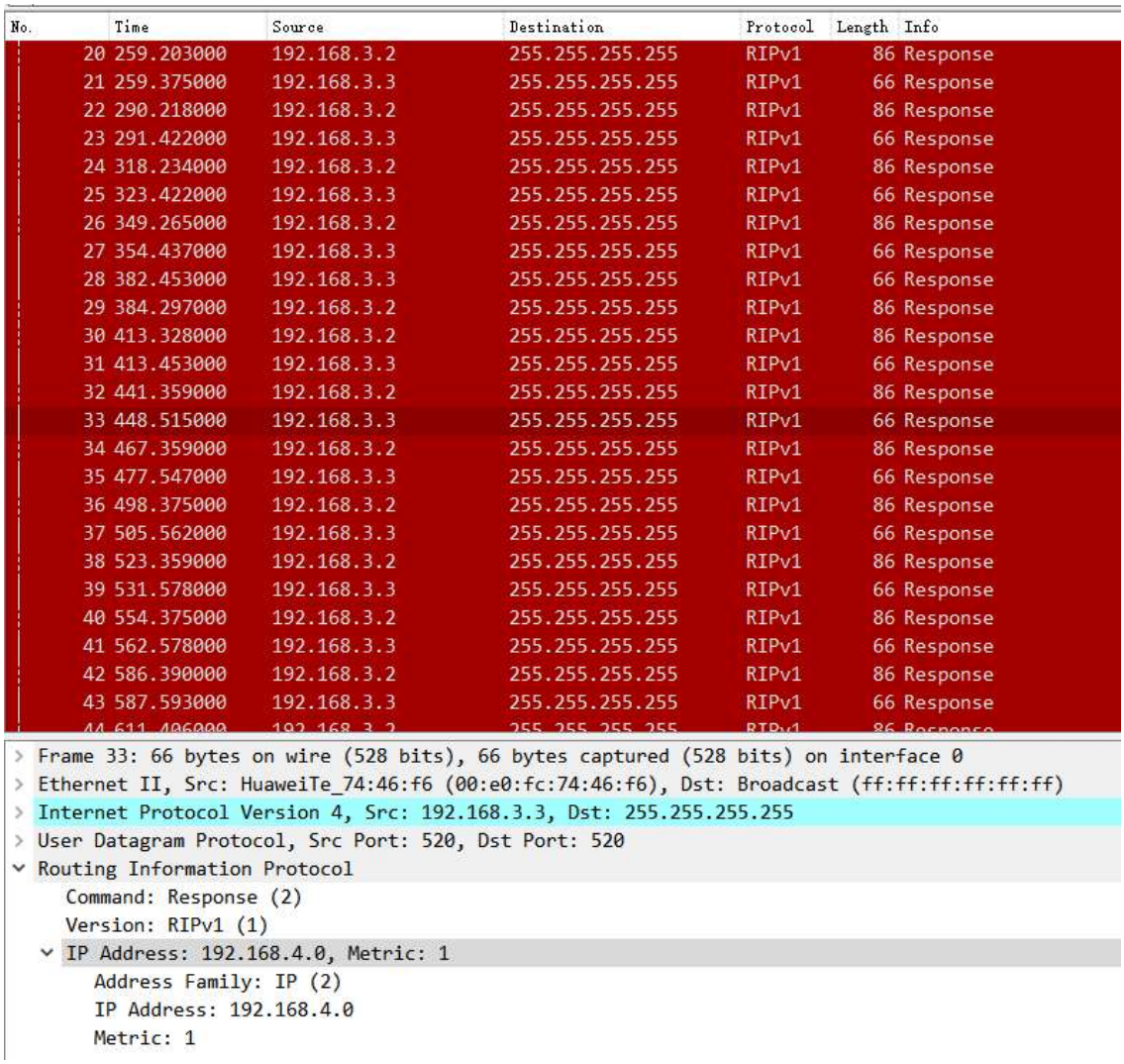
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.3.2	255.255.255.255	RIPv1	86	Response
2	10.266000	192.168.3.3	255.255.255.255	RIPv1	66	Response
3	31.016000	192.168.3.2	255.255.255.255	RIPv1	86	Response
4	36.281000	192.168.3.3	255.255.255.255	RIPv1	66	Response
5	64.031000	192.168.3.2	255.255.255.255	RIPv1	86	Response
6	70.297000	192.168.3.3	255.255.255.255	RIPv1	66	Response
7	89.063000	192.168.3.2	255.255.255.255	RIPv1	86	Response
8	104.297000	192.168.3.3	255.255.255.255	RIPv1	66	Response
9	116.078000	192.168.3.2	255.255.255.255	RIPv1	86	Response
10	137.313000	192.168.3.3	255.255.255.255	RIPv1	66	Response
11	148.109000	192.168.3.2	255.255.255.255	RIPv1	86	Response
12	169.328000	192.168.3.3	255.255.255.255	RIPv1	66	Response
13	176.109000	192.168.3.2	255.255.255.255	RIPv1	86	Response
14	197.344000	192.168.3.3	255.255.255.255	RIPv1	66	Response
15	204.141000	192.168.3.2	255.255.255.255	RIPv1	86	Response
16	222.547000	HuaweiTe_c6:0b:ef	Broadcast	ARP	60	Who has 192.168.3.3? Tell 192.168.3.2
17	222.563000	HuaweiTe_74:46:f6	HuaweiTe_c6:0b:ef	ARP	60	192.168.3.3 is at 00:e0:fc:74:46:f6
18	229.188000	192.168.3.2	255.255.255.255	RIPv1	86	Response
19	229.375000	192.168.3.3	255.255.255.255	RIPv1	66	Response
20	259.391000	192.168.3.3	255.255.255.255	RIPv1	66	Response

```
> Frame 1: 86 bytes on wire (688 bits), 86 bytes captured (688 bits) on interface 0
> Ethernet II, Src: HuaweiTe_c6:0b:ef (00:e0:fc:c6:0b:ef), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.3.2, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 520, Dst Port: 520
v Routing Information Protocol
    Command: Response (2)
    Version: RIPv1 (1)
  v IP Address: 192.168.1.0, Metric: 2
      Address Family: IP (2)
      IP Address: 192.168.1.0
      Metric: 2
  v IP Address: 192.168.2.0, Metric: 1
      Address Family: IP (2)
      IP Address: 192.168.2.0
      Metric: 1
```

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.3.2	255.255.255.255	RIPv1	86	Response
2	10.266000	192.168.3.3	255.255.255.255	RIPv1	66	Response
3	31.016000	192.168.3.2	255.255.255.255	RIPv1	86	Response
4	36.281000	192.168.3.3	255.255.255.255	RIPv1	66	Response
5	64.031000	192.168.3.2	255.255.255.255	RIPv1	86	Response
6	70.297000	192.168.3.3	255.255.255.255	RIPv1	66	Response
7	89.063000	192.168.3.2	255.255.255.255	RIPv1	86	Response
8	104.297000	192.168.3.3	255.255.255.255	RIPv1	66	Response
9	116.078000	192.168.3.2	255.255.255.255	RIPv1	86	Response
10	137.313000	192.168.3.3	255.255.255.255	RIPv1	66	Response
11	148.109000	192.168.3.2	255.255.255.255	RIPv1	86	Response
12	169.328000	192.168.3.3	255.255.255.255	RIPv1	66	Response
13	176.109000	192.168.3.2	255.255.255.255	RIPv1	86	Response
14	197.344000	192.168.3.3	255.255.255.255	RIPv1	66	Response
15	204.141000	192.168.3.2	255.255.255.255	RIPv1	86	Response
16	222.547000	HuaweiTe_c6:0b:ef	Broadcast	ARP	60	Who has 192.168.3.3? Tell 192.168.3.2
17	222.563000	HuaweiTe_74:46:f6	HuaweiTe_c6:0b:ef	ARP	60	192.168.3.3 is at 00:e0:fc:74:46:f6
18	229.188000	192.168.3.2	255.255.255.255	RIPv1	86	Response
19	229.375000	192.168.3.3	255.255.255.255	RIPv1	66	Response
20	259.391000	192.168.3.3	255.255.255.255	RIPv1	66	Response

```
> Frame 12: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
> Ethernet II, Src: HuaweiTe_74:46:f6 (00:e0:fc:74:46:f6), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.3.3, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 520, Dst Port: 520
v Routing Information Protocol
    Command: Response (2)
    Version: RIPv1 (1)
  v IP Address: 192.168.4.0, Metric: 1
      Address Family: IP (2)
      IP Address: 192.168.4.0
      Metric: 1
```

AR3 GE0/0/0



No.	Time	Source	Destination	Protocol	Length	Info
20	259.203000	192.168.3.2	255.255.255.255	RIPv1	86	Response
21	259.375000	192.168.3.3	255.255.255.255	RIPv1	66	Response
22	290.218000	192.168.3.2	255.255.255.255	RIPv1	86	Response
23	291.422000	192.168.3.3	255.255.255.255	RIPv1	66	Response
24	318.234000	192.168.3.2	255.255.255.255	RIPv1	86	Response
25	323.422000	192.168.3.3	255.255.255.255	RIPv1	66	Response
26	349.265000	192.168.3.2	255.255.255.255	RIPv1	86	Response
27	354.437000	192.168.3.3	255.255.255.255	RIPv1	66	Response
28	382.453000	192.168.3.3	255.255.255.255	RIPv1	66	Response
29	384.297000	192.168.3.2	255.255.255.255	RIPv1	86	Response
30	413.328000	192.168.3.2	255.255.255.255	RIPv1	86	Response
31	413.453000	192.168.3.3	255.255.255.255	RIPv1	66	Response
32	441.359000	192.168.3.2	255.255.255.255	RIPv1	86	Response
33	448.515000	192.168.3.3	255.255.255.255	RIPv1	66	Response
34	467.359000	192.168.3.2	255.255.255.255	RIPv1	86	Response
35	477.547000	192.168.3.3	255.255.255.255	RIPv1	66	Response
36	498.375000	192.168.3.2	255.255.255.255	RIPv1	86	Response
37	505.562000	192.168.3.3	255.255.255.255	RIPv1	66	Response
38	523.359000	192.168.3.2	255.255.255.255	RIPv1	86	Response
39	531.578000	192.168.3.3	255.255.255.255	RIPv1	66	Response
40	554.375000	192.168.3.2	255.255.255.255	RIPv1	86	Response
41	562.578000	192.168.3.3	255.255.255.255	RIPv1	66	Response
42	586.390000	192.168.3.2	255.255.255.255	RIPv1	86	Response
43	587.593000	192.168.3.3	255.255.255.255	RIPv1	66	Response
44	611.406000	192.168.3.2	255.255.255.255	RIPv1	86	Response

No.	Time	Source	Destination	Protocol	Length	Info
20	259.203000	192.168.3.2	255.255.255.255	RIPv1	86	Response
21	259.375000	192.168.3.3	255.255.255.255	RIPv1	66	Response
22	290.218000	192.168.3.2	255.255.255.255	RIPv1	86	Response
23	291.422000	192.168.3.3	255.255.255.255	RIPv1	66	Response
24	318.234000	192.168.3.2	255.255.255.255	RIPv1	86	Response
25	323.422000	192.168.3.3	255.255.255.255	RIPv1	66	Response
26	349.265000	192.168.3.2	255.255.255.255	RIPv1	86	Response
27	354.437000	192.168.3.3	255.255.255.255	RIPv1	66	Response
28	382.453000	192.168.3.3	255.255.255.255	RIPv1	66	Response
29	384.297000	192.168.3.2	255.255.255.255	RIPv1	86	Response
30	413.328000	192.168.3.2	255.255.255.255	RIPv1	86	Response
31	413.453000	192.168.3.3	255.255.255.255	RIPv1	66	Response
32	441.359000	192.168.3.2	255.255.255.255	RIPv1	86	Response
33	448.515000	192.168.3.3	255.255.255.255	RIPv1	66	Response
34	467.359000	192.168.3.2	255.255.255.255	RIPv1	86	Response
35	477.547000	192.168.3.3	255.255.255.255	RIPv1	66	Response
36	498.375000	192.168.3.2	255.255.255.255	RIPv1	86	Response
37	505.562000	192.168.3.3	255.255.255.255	RIPv1	66	Response
38	523.359000	192.168.3.2	255.255.255.255	RIPv1	86	Response
39	531.578000	192.168.3.3	255.255.255.255	RIPv1	66	Response
40	554.375000	192.168.3.2	255.255.255.255	RIPv1	86	Response
41	562.578000	192.168.3.3	255.255.255.255	RIPv1	66	Response
42	586.390000	192.168.3.2	255.255.255.255	RIPv1	86	Response
43	587.593000	192.168.3.3	255.255.255.255	RIPv1	66	Response
44	611.406000	192.168.3.2	255.255.255.255	RIPv1	86	Response

```
> Frame 30: 86 bytes on wire (688 bits), 86 bytes captured (688 bits) on interface 0
> Ethernet II, Src: HuaweiTe_c6:0b:ef (00:e0:fc:c6:0b:ef), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.3.2, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 520, Dst Port: 520
v Routing Information Protocol
    Command: Response (2)
    Version: RIPv1 (1)
  v IP Address: 192.168.1.0, Metric: 2
      Address Family: IP (2)
      IP Address: 192.168.1.0
      Metric: 2
  v IP Address: 192.168.2.0, Metric: 1
      Address Family: IP (2)
      IP Address: 192.168.2.0
      Metric: 1
```

AR3 GE0/0/1

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.4.254	255.255.255.255	RIPv1	126	Response
2	0.000000	255.255.255.255	192.168.4.254	ICMP	70	Destination unreachable (Port unreachable)
3	35.016000	192.168.4.254	255.255.255.255	RIPv1	126	Response
4	35.016000	255.255.255.255	192.168.4.254	ICMP	70	Destination unreachable (Port unreachable)
5	66.016000	192.168.4.254	255.255.255.255	RIPv1	126	Response
6	66.016000	255.255.255.255	192.168.4.254	ICMP	70	Destination unreachable (Port unreachable)
7	99.016000	192.168.4.254	255.255.255.255	RIPv1	126	Response
8	99.032000	255.255.255.255	192.168.4.254	ICMP	70	Destination unreachable (Port unreachable)
9	124.032000	192.168.4.254	255.255.255.255	RIPv1	126	Response
10	124.047000	255.255.255.255	192.168.4.254	ICMP	70	Destination unreachable (Port unreachable)
11	151.047000	192.168.4.254	255.255.255.255	RIPv1	126	Response
12	151.047000	255.255.255.255	192.168.4.254	ICMP	70	Destination unreachable (Port unreachable)
13	183.078000	192.168.4.254	255.255.255.255	RIPv1	126	Response
14	183.078000	255.255.255.255	192.168.4.254	ICMP	70	Destination unreachable (Port unreachable)
15	194.563000	HuaweiTe_74:46:f7	Broadcast	ARP	60	Who has 192.168.4.1? Tell 192.168.4.254
16	194.563000	HuaweiTe_ba:76:60	HuaweiTe_74:46:f7	ARP	60	192.168.4.1 is at 54:89:98:ba:76:60
17	211.094000	192.168.4.254	255.255.255.255	RIPv1	126	Response
18	211.094000	255.255.255.255	192.168.4.254	ICMP	70	Destination unreachable (Port unreachable)
19	239.125000	192.168.4.254	255.255.255.255	RIPv1	126	Response
20	239.125000	255.255.255.255	192.168.4.254	ICMP	70	Destination unreachable (Port unreachable)
21	264.125000	192.168.4.254	255.255.255.255	RIPv1	126	Response

```
> Frame 1: 126 bytes on wire (1008 bits), 126 bytes captured (1008 bits) on interface 0
> Ethernet II, Src: HuaweiTe_74:46:f7 (00:e0:fc:74:46:f7), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.4.254, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 520, Dst Port: 520
v Routing Information Protocol
    Command: Response (2)
    Version: RIPv1 (1)
  > IP Address: 192.168.1.0, Metric: 3
  > IP Address: 192.168.2.0, Metric: 2
  > IP Address: 192.168.3.0, Metric: 1
  > IP Address: 192.168.4.0, Metric: 1
```

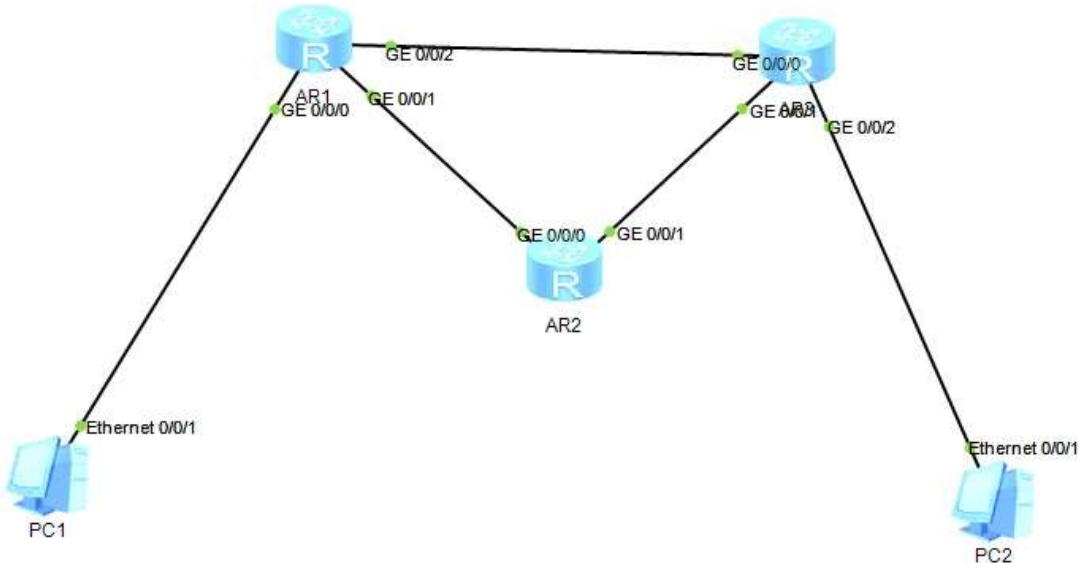
4. RIP协议中，距离向量的传递是在邻居之间，还是距离向量会直接传播到全网？传递的距离向量是完整的距离向量吗？截图举例说明。

邻居之间传递，不是完整的距离向量

例如AR1的GE0/0/1收到来自AR2的GE0/0/0向子网广播的消息，子网中只有它们两个邻居；距离向量的并不会包括1和2信息，这可能是因为RIP的水平分割机制，能够偶防止产生环路。

第二部分：完成以下任务并回答问题

1. 按照要求搭建新的拓扑，完成相关路由器的配置（AR1和AR3的新端口的配置、RIP路由协议的配置）。并在图中指出网络中共有几个子网，每个子网的IP及掩码是什么？



```
PC>ping 192.168.4.1

Ping 192.168.4.1: 32 data bytes, Press Ctrl_C to break
Request timeout!
Request timeout!
From 192.168.4.1: bytes=32 seq=3 ttl=126 time=16 ms
From 192.168.4.1: bytes=32 seq=4 ttl=126 time=31 ms
From 192.168.4.1: bytes=32 seq=5 ttl=126 time=16 ms

--- 192.168.4.1 ping statistics ---
  5 packet(s) transmitted
  3 packet(s) received
  40.00% packet loss
  round-trip min/avg/max = 0/21/31 ms

PC>ping 192.168.4.1

Ping 192.168.4.1: 32 data bytes, Press Ctrl_C to break
From 192.168.4.1: bytes=32 seq=1 ttl=126 time=15 ms
From 192.168.4.1: bytes=32 seq=2 ttl=126 time=16 ms
From 192.168.4.1: bytes=32 seq=3 ttl=126 time=31 ms
From 192.168.4.1: bytes=32 seq=4 ttl=126 time=16 ms
From 192.168.4.1: bytes=32 seq=5 ttl=126 time=31 ms

--- 192.168.4.1 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 15/21/31 ms

PC>
```

共有五个子网

子网 1（PC1 和 AR1 连接的网络）网络地址： 192.168.1.0子网掩码： 255.255.255.0

子网 2（AR1 和 AR2 之间的网络）网络地址： 192.168.2.0子网掩码： 255.255.255.0

子网 3（AR2 和 AR3 之间的网络）网络地址： 192.168.3.0子网掩码： 255.255.255.0

子网 4（PC2 和 AR3 连接的网络）网络地址： 192.168.4.0子网掩码： 255.255.255.0

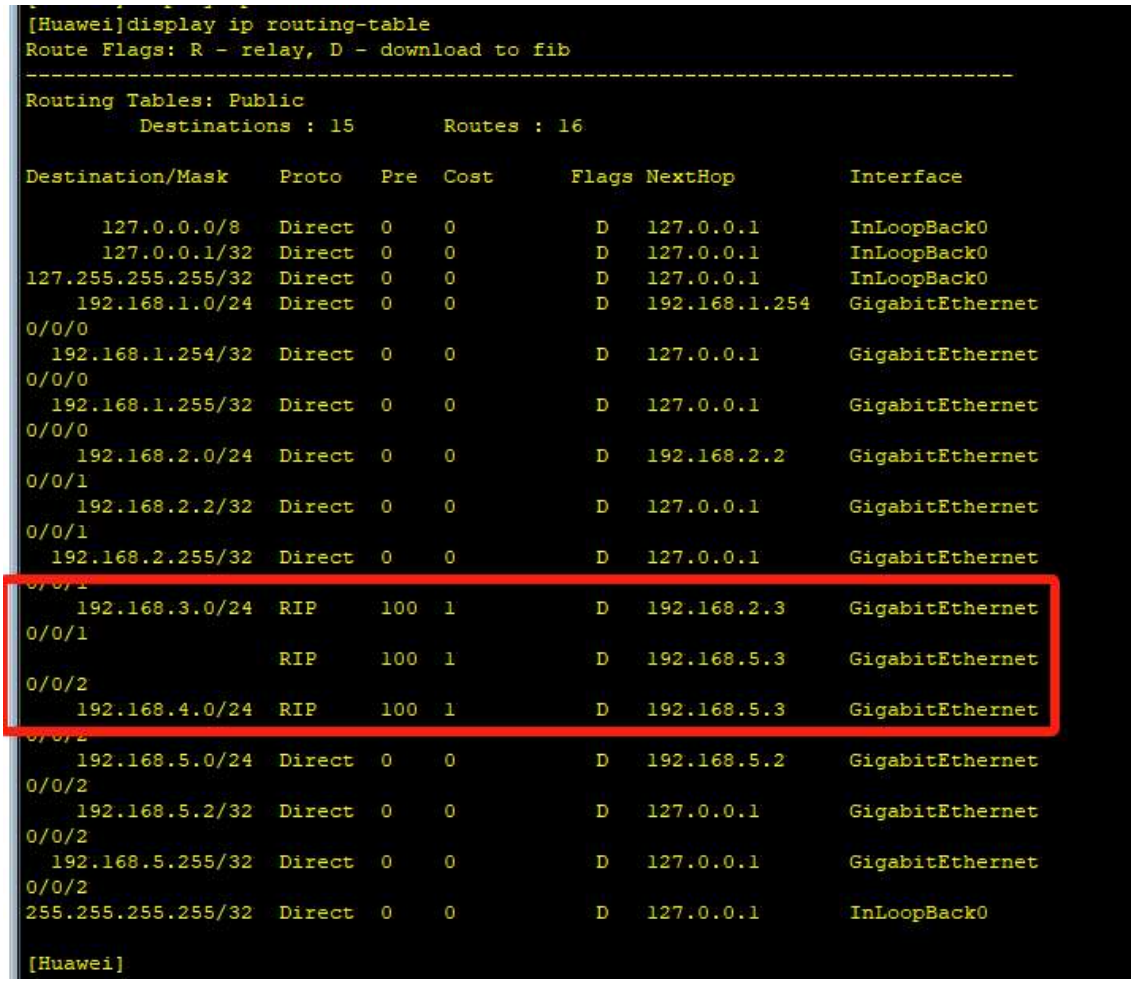
子网 5（AR1 和 AR3 连接的网络）网络地址： 192.168.5.0子网掩码： 255.255.255.0

2. 观察各个路由器的IP路由表变化，截图AR1和AR3的IP路由表；并在各个路由器端口进行抓包，说

明在改变网络拓扑后RIP报文中距离向量的变化，以及该变化如何影响IP路由表，截图并举例说

明。

AR1：



```
[Huawei]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 15        Routes : 16

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
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24  Direct  0    0           D   192.168.1.254   GigabitEthernet
0/0/0
  192.168.1.254/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
  192.168.1.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
    192.168.2.0/24  Direct  0    0           D   192.168.2.2     GigabitEthernet
0/0/1
    192.168.2.2/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/1
  192.168.2.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/1
    192.168.3.0/24  RIP     100  1           D   192.168.2.3     GigabitEthernet
0/0/1
                    RIP     100  1           D   192.168.5.3     GigabitEthernet
0/0/2
    192.168.4.0/24  RIP     100  1           D   192.168.5.3     GigabitEthernet
0/0/2
    192.168.5.0/24  Direct  0    0           D   192.168.5.2     GigabitEthernet
0/0/2
    192.168.5.2/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/2
  192.168.5.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/2
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0

[Huawei]
```

AR3：

```
[Huawei]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 15        Routes : 16

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
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24  RIP     100  1           D   192.168.5.2     GigabitEthernet
0/0/2
    192.168.2.0/24  RIP     100  1           D   192.168.3.2     GigabitEthernet
0/0/0
                    RIP     100  1           D   192.168.5.2     GigabitEthernet
0/0/2
    192.168.3.0/24  Direct  0    0           D   192.168.3.3     GigabitEthernet
0/0/0
    192.168.3.3/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
  192.168.3.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
    192.168.4.0/24  Direct  0    0           D   192.168.4.254   GigabitEthernet
0/0/1
  192.168.4.254/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/1
  192.168.4.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/1
    192.168.5.0/24  Direct  0    0           D   192.168.5.3     GigabitEthernet
0/0/2
    192.168.5.3/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/2
  192.168.5.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/2
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0

[Huawei]
```

AR3 GE0/0/0

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.5.3	255.255.255.255	RIPv1	86	Response
2	4.297000	192.168.5.2	255.255.255.255	RIPv1	86	Response

```
> Frame 2: 86 bytes on wire (688 bits), 86 bytes captured (688 bits) on interface 0
> Ethernet II, Src: HuaweiTe_cb:6c:62 (00:e0:fc:cb:6c:62), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.5.2, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 520, Dst Port: 520
v Routing Information Protocol
    Command: Response (2)
    Version: RIPv1 (1)
  > IP Address: 192.168.1.0, Metric: 1
  > IP Address: 192.168.2.0, Metric: 1
```

AR3 GE0/0/1

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.3.2	255.255.255.255	RIPv1	86	Response
2	7.265000	192.168.3.3	255.255.255.255	RIPv1	106	Response

```
> Frame 1: 86 bytes on wire (688 bits), 86 bytes captured (688 bits) on interface 0
> Ethernet II, Src: HuaweiTe_8c:79:0d (00:e0:fc:8c:79:0d), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
> Internet Protocol Version 4, Src: 192.168.3.2, Dst: 255.255.255.255
> User Datagram Protocol, Src Port: 520, Dst Port: 520
v Routing Information Protocol
    Command: Response (2)
    Version: RIPv1 (1)
  > IP Address: 192.168.1.0, Metric: 2
  > IP Address: 192.168.2.0, Metric: 1
```

举例说明：

以AR3为例

AR3收到了邻居到 192.168.1.0 和 192.168.2.0 的metric为1，到192.168.1.0的metric为2.并且路由到 192.168.2.0 的最短路由既可以通过AR1，也可以通过AR2，因此路由表项中有两个 192.168.3.0 的下一跳。

任务二

1. 按照要求搭建拓扑，完成相关PC与路由器的配置，配置成功PC1应能ping PC2，截图。

```
PC>ping 192.168.4.1

Ping 192.168.4.1: 32 data bytes, Press Ctrl_C to break
Request timeout!
From 192.168.4.1: bytes=32 seq=2 ttl=125 time=47 ms
From 192.168.4.1: bytes=32 seq=3 ttl=125 time=16 ms
From 192.168.4.1: bytes=32 seq=4 ttl=125 time=16 ms
From 192.168.4.1: bytes=32 seq=5 ttl=125 time=31 ms

--- 192.168.4.1 ping statistics ---
  5 packet(s) transmitted
  4 packet(s) received
  20.00% packet loss
  round-trip min/avg/max = 0/27/47 ms

PC>ping 192.168.4.1

Ping 192.168.4.1: 32 data bytes, Press Ctrl_C to break
From 192.168.4.1: bytes=32 seq=1 ttl=125 time=32 ms
From 192.168.4.1: bytes=32 seq=2 ttl=125 time=15 ms
From 192.168.4.1: bytes=32 seq=3 ttl=125 time=15 ms
From 192.168.4.1: bytes=32 seq=4 ttl=125 time=32 ms
From 192.168.4.1: bytes=32 seq=5 ttl=125 time=31 ms

--- 192.168.4.1 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 15/25/32 ms

PC>
```

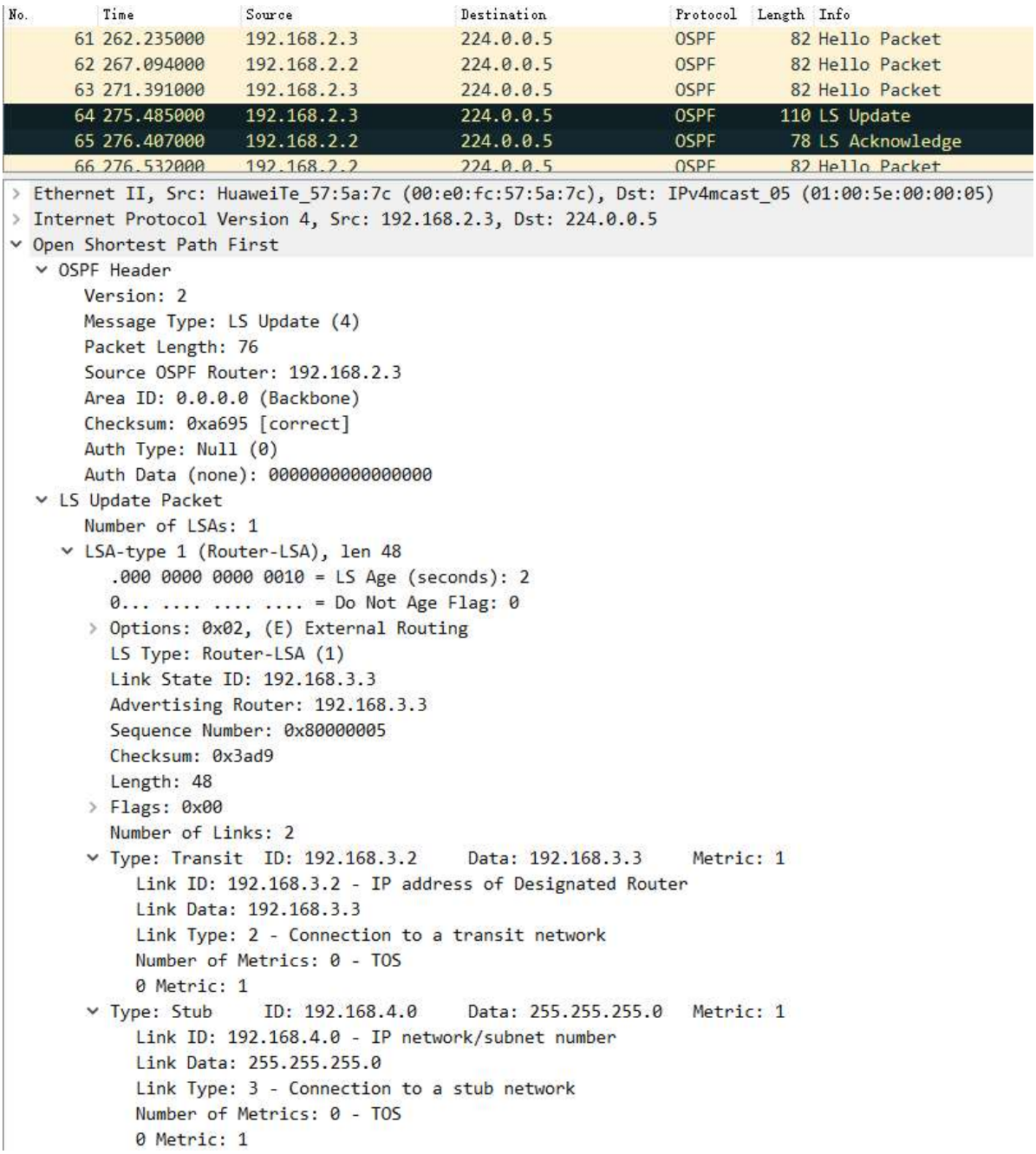
2. 查看各个路由器的中的IP路由表，截图并用红色的框标识出OSPF协议产生的路由表项。

```
<Huawei>sys
Enter system view, return user view with Ctrl+Z.
[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
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24  Direct  0    0           D   192.168.1.254   GigabitEthernet
0/0/0
  192.168.1.254/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
  192.168.1.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
    192.168.2.0/24  Direct  0    0           D   192.168.2.2     GigabitEthernet
0/0/1
    192.168.2.2/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/1
  192.168.2.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
    192.168.3.0/24  OSPF    10   2           D   192.168.2.3     GigabitEthernet
0/0/1
    192.168.4.0/24  OSPF    10   3           D   192.168.2.3     GigabitEthernet
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

```
<Huawei>sys
Enter system view, return user view with Ctrl+Z.
[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
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    192.168.1.0/24  OSPF    10   2           D   192.168.2.2     GigabitEthernet
0/0/0
    192.168.2.0/24  Direct  0    0           D   192.168.2.3     GigabitEthernet
0/0/0
    192.168.2.3/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
  192.168.2.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
    192.168.3.0/24  Direct  0    0           D   192.168.3.2     GigabitEthernet
0/0/1
    192.168.3.2/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/1
  192.168.3.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
    192.168.4.0/24  OSPF    10   2           D   192.168.3.3     GigabitEthernet
0/0/1
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

```
<Huawei>sys
Enter system view, return user view with Ctrl+Z.
[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
    192.168.1.0/24  OSPF    10   3           D   192.168.3.2     GigabitEthernet
0/0/0
    192.168.2.0/24  OSPF    10   2           D   192.168.3.2     GigabitEthernet
0/0/0
    192.168.3.0/24  Direct  0    0           D   192.168.3.3     GigabitEthernet
0/0/0
    192.168.3.3/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
  192.168.3.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
    192.168.4.0/24  Direct  0    0           D   192.168.4.254   GigabitEthernet
0/0/1
  192.168.4.254/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/1
  192.168.4.255/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/1
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

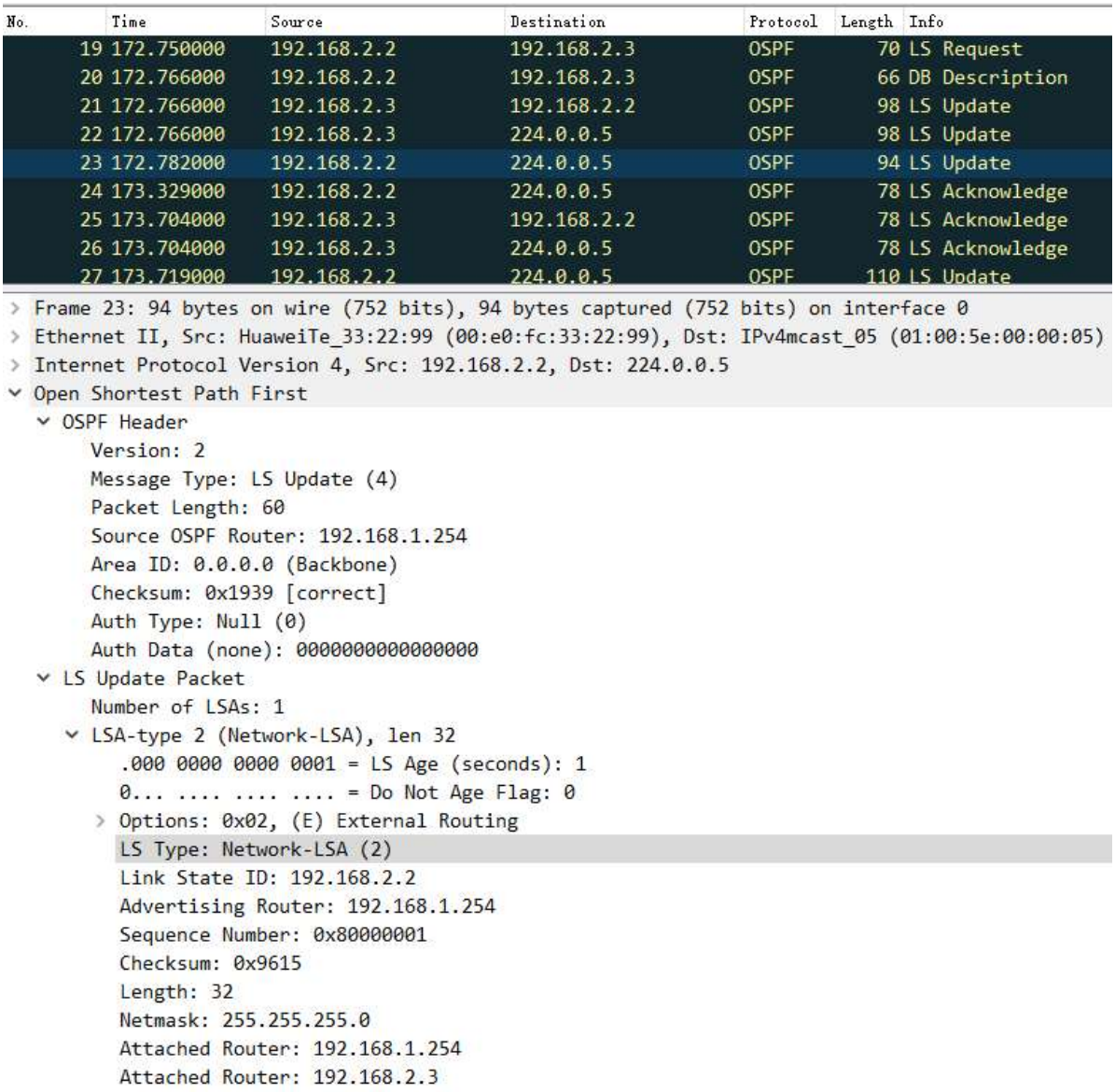
3. 在各个路由器端口进行抓包，观察OSPF协议中LS Update Packet，截图举例说明Router-LSA和Network-LSA各自的作用与区别。并说明路由器中的IP路由表中的OSPF路由表项是如何由OSPF协议报文中的LSA计算得出的，截图并说明。



Router-LSA：

- 作用：Router-LSA是由OSPF路由器自己发出的LSA，描述了路由器的所有直接连接的网络接口及其状态。这些信息用于向其他路由器广播本路由器所连接的各个链路的状态，包括接口IP地址、接口的网络掩码、与其他路由器之间的连接状态等。
- 具体信息：
  - 来源路由器：192.168.2.3
  - 通告类型：Router-LSA
  - 通告的链路ID：192.168.3.2
  - 链路数据：192.168.3.3

- 链路类型：Transit 链路（广播）
- Metric：1



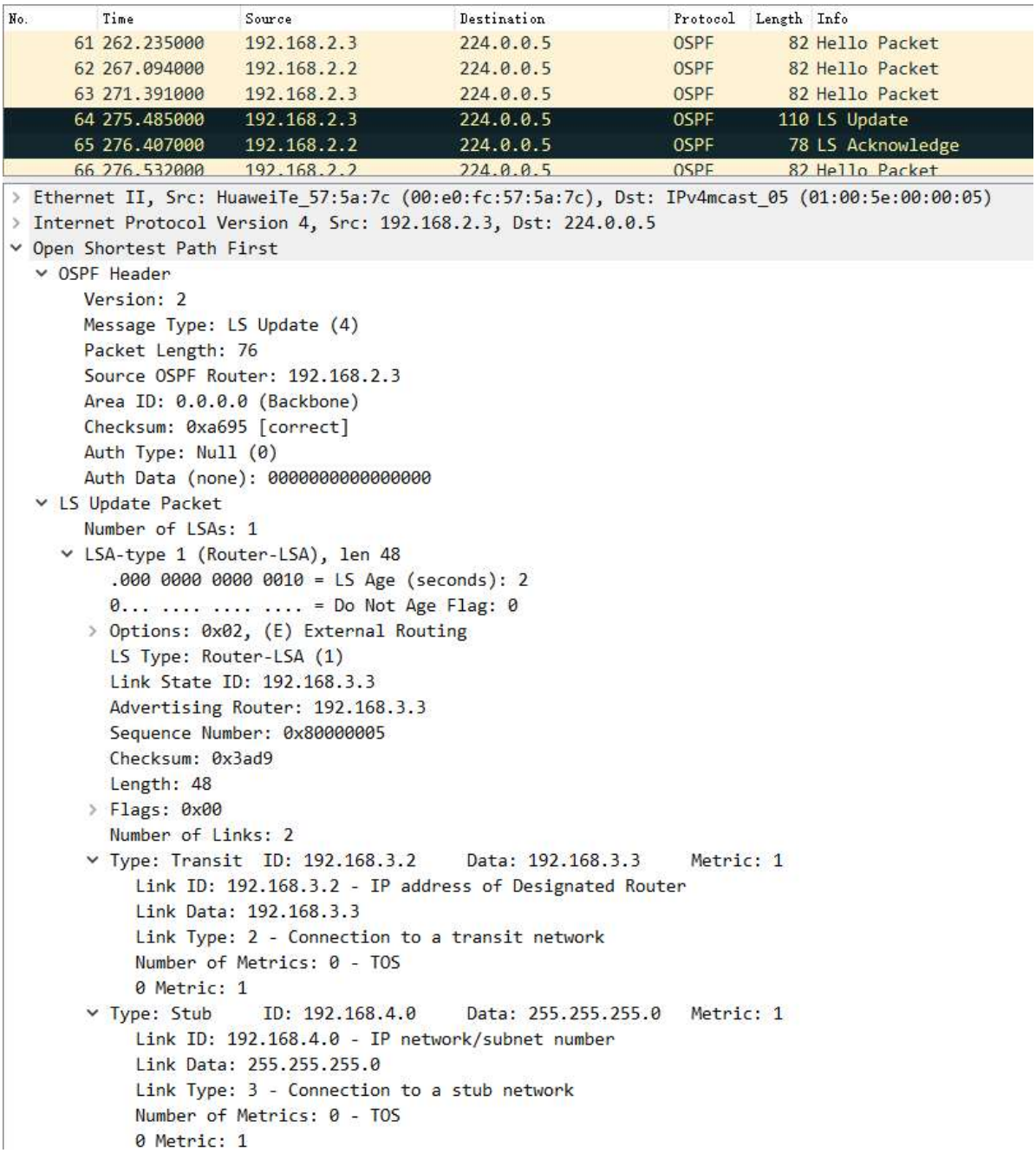
No.	Time	Source	Destination	Protocol	Length	Info
19	172.750000	192.168.2.2	192.168.2.3	OSPF	70	LS Request
20	172.766000	192.168.2.2	192.168.2.3	OSPF	66	DB Description
21	172.766000	192.168.2.3	192.168.2.2	OSPF	98	LS Update
22	172.766000	192.168.2.3	224.0.0.5	OSPF	98	LS Update
23	172.782000	192.168.2.2	224.0.0.5	OSPF	94	LS Update
24	173.329000	192.168.2.2	224.0.0.5	OSPF	78	LS Acknowledge
25	173.704000	192.168.2.3	192.168.2.2	OSPF	78	LS Acknowledge
26	173.704000	192.168.2.3	224.0.0.5	OSPF	78	LS Acknowledge
27	173.719000	192.168.2.2	224.0.0.5	OSPF	110	LS Update

```
> Frame 23: 94 bytes on wire (752 bits), 94 bytes captured (752 bits) on interface 0
> Ethernet II, Src: HuaweiTe_33:22:99 (00:e0:fc:33:22:99), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 192.168.2.2, Dst: 224.0.0.5
v Open Shortest Path First
  v OSPF Header
      Version: 2
      Message Type: LS Update (4)
      Packet Length: 60
      Source OSPF Router: 192.168.1.254
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0x1939 [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  v LS Update Packet
      Number of LSAs: 1
    v LSA-type 2 (Network-LSA), len 32
        .000 0000 0000 0001 = LS Age (seconds): 1
        0... .... .... .... = Do Not Age Flag: 0
      > Options: 0x02, (E) External Routing
        LS Type: Network-LSA (2)
        Link State ID: 192.168.2.2
        Advertising Router: 192.168.1.254
        Sequence Number: 0x80000001
        Checksum: 0x9615
        Length: 32
        Netmask: 255.255.255.0
        Attached Router: 192.168.1.254
        Attached Router: 192.168.2.3
```

Network-LSA：

- 作用：Network-LSA是由OSPF网络中的“指定路由器”发出的，用于描述一个网络段内的所有路由器的信息。它用于广播一个网络中所有路由器的状态，并提供网络内路由器之间的链路信息。Network-LSA是在广播型网络（如Ethernet）上使用的。
- 具体信息：
  - 来源路由器：192.168.1.254
  - 通告类型：Network-LSA

- 通告的网络地址:192.168.2.0
- 子网掩码：255.255.255.0
- 连接的路由器：192.168.1.254 192.168.2.3



No.	Time	Source	Destination	Protocol	Length	Info
61	262.235000	192.168.2.3	224.0.0.5	OSPF	82	Hello Packet
62	267.094000	192.168.2.2	224.0.0.5	OSPF	82	Hello Packet
63	271.391000	192.168.2.3	224.0.0.5	OSPF	82	Hello Packet
64	275.485000	192.168.2.3	224.0.0.5	OSPF	110	LS Update
65	276.407000	192.168.2.2	224.0.0.5	OSPF	78	LS Acknowledge
66	276.532000	192.168.2.2	224.0.0.5	OSPF	82	Hello Packet

```
> Ethernet II, Src: HuaweiTe_57:5a:7c (00:e0:fc:57:5a:7c), Dst: IPv4mcast_05 (01:00:5e:00:00:05)
> Internet Protocol Version 4, Src: 192.168.2.3, Dst: 224.0.0.5
v Open Shortest Path First
  v OSPF Header
      Version: 2
      Message Type: LS Update (4)
      Packet Length: 76
      Source OSPF Router: 192.168.2.3
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0xa695 [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  v LS Update Packet
      Number of LSAs: 1
    v LSA-type 1 (Router-LSA), len 48
        .000 0000 0000 0010 = LS Age (seconds): 2
        0... .... .... .... = Do Not Age Flag: 0
      > Options: 0x02, (E) External Routing
        LS Type: Router-LSA (1)
        Link State ID: 192.168.3.3
        Advertising Router: 192.168.3.3
        Sequence Number: 0x80000005
        Checksum: 0x3ad9
        Length: 48
      > Flags: 0x00
        Number of Links: 2
      v Type: Transit  ID: 192.168.3.2     Data: 192.168.3.3     Metric: 1
          Link ID: 192.168.3.2 - IP address of Designated Router
          Link Data: 192.168.3.3
          Link Type: 2 - Connection to a transit network
          Number of Metrics: 0 - TOS
          0 Metric: 1
      v Type: Stub     ID: 192.168.4.0     Data: 255.255.255.0   Metric: 1
          Link ID: 192.168.4.0 - IP network/subnet number
          Link Data: 255.255.255.0
          Link Type: 3 - Connection to a stub network
          Number of Metrics: 0 - TOS
          0 Metric: 1
```

路由器IP路由表项的计算： OSPF路由器根据收到的LSA信息来构建OSPF的路由表。OSPF协议通过LSA交换信息，使用SPF（Shortest Path First）算法计算出到达每个目标网络的最短路径，并将计算结果放入路由表中。LSA提供了路由器的链路状态信息，而OSPF根据这些信息计算出最短路径树（SPT），然后根据SPT填充路由表。

举例说明：

截图中的LS Update包显示路由器 `192.168.3.3` 通告它直连了一个 Stub 网络 `192.168.4.0/24`，代价为 1。此 LSA 包是网络拓扑信息的更新，提供了通向 `192.168.4.0/24` 的具体路径信息。

而在收到该 LS Update包之前，路由器已经通过先前的 LSA 和 SPF 计算，路由器已经知道 `192.168.3.0/24` 的拓扑路径，并且到 `192.168.3.3` 的下一跳和链路代价(`192.168.3.0/24` 的 OSPF 路由项是通过 SPF 计算出的，下一跳为 `192.168.2.3`，代价为 2)

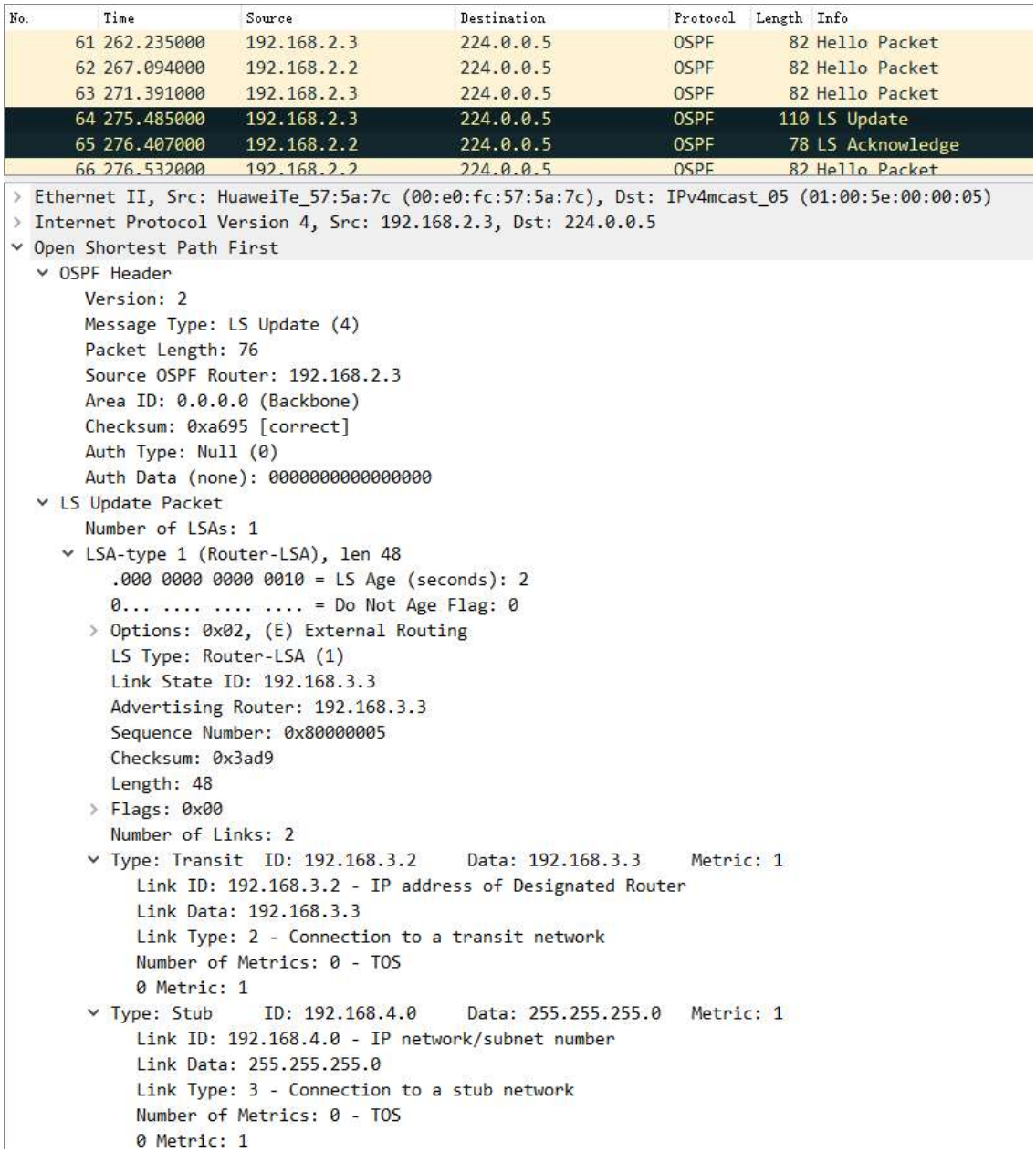
在收到此 LSA Update 包后，OSPF 使用 SPF 算法将 `192.168.4.0/24` 加入路径计算， 结合已有的拓扑结构计算出到达 `192.168.4.0/24` 的路径总代价 = 到 `192.168.3.3` 的代价（metric=2） + Stub 网络代价（metric=1）

最终路由器通过 SPF 计算得出：到达 `192.168.4.0/24` 的路径最短路径为下一跳：`192.168.2.3` 总代价：3 ，得到新路由表项

4. OSPF协议中的LSA信息传递是在邻居间交换还是在全网传递，截图并说明

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.2.3	224.0.0.5	OSPF	82	Hello Packet
2	0.547000	192.168.2.2	224.0.0.5	OSPF	82	Hello Packet
3	9.172000	192.168.2.3	224.0.0.5	OSPF	82	Hello Packet
4	10.485000	192.168.2.2	224.0.0.5	OSPF	82	Hello Packet
5	18.329000	192.168.2.3	224.0.0.5	OSPF	82	Hello Packet
6	20.422000	192.168.2.2	224.0.0.5	OSPF	82	Hello Packet
7	27.485000	192.168.2.3	224.0.0.5	OSPF	82	Hello Packet
8	30.360000	192.168.2.2	224.0.0.5	OSPF	82	Hello Packet
9	36.657000	192.168.2.3	224.0.0.5	OSPF	82	Hello Packet
10	40.297000	192.168.2.2	224.0.0.5	OSPF	82	Hello Packet
11	45.813000	192.168.2.3	224.0.0.5	OSPF	82	Hello Packet
12	50.250000	192.168.2.2	224.0.0.5	OSPF	82	Hello Packet
13	54.969000	192.168.2.3	224.0.0.5	OSPF	82	Hello Packet
14	60.188000	192.168.2.2	224.0.0.5	OSPF	82	Hello Packet

```
> Internet Protocol Version 4, Src: 192.168.2.2, Dst: 224.0.0.5
v Open Shortest Path First
  v OSPF Header
      Version: 2
      Message Type: Hello Packet (1)
      Packet Length: 48
      Source OSPF Router: 192.168.1.254
      Area ID: 0.0.0.0 (Backbone)
      Checksum: 0xf1f1 [correct]
      Auth Type: Null (0)
      Auth Data (none): 0000000000000000
  v OSPF Hello Packet
      Network Mask: 255.255.255.0
      Hello Interval [sec]: 10
    v Options: 0x02, (E) External Routing
        0... .... = DN: Not set
        .0.. .... = O: Not set
        ..0. .... = (DC) Demand Circuits: Not supported
        ...0 .... = (L) LLS Data block: Not Present
        .... 0... = (N) NSSA: Not supported
        .... .0.. = (MC) Multicast: Not capable
        .... ..1. = (E) External Routing: Capable
        .... ...0 = (MT) Multi-Topology Routing: No
      Router Priority: 1
      Router Dead Interval [sec]: 40
      Designated Router: 192.168.2.2
      Backup Designated Router: 192.168.2.3
      Active Neighbor: 192.168.2.3
```



OSPF协议中，LSA信息是通过邻居之间的LSA交换进行的。在OSPF初始阶段，邻居路由器通过`Hello`报文确定邻居关系。路由器之间通过邻居关系交换LSA信息，每个路由器在与邻居路由器建立邻接关系后，会向邻居发送自己的LSA信息。 根据`Hello`报文的截图可以看到这是由邻居发过来的用于维护邻居关系和检测邻居的存活状态。

LSA信息从一个路由器通过洪泛机制传递到其所有的邻居，然后通过每个邻居继续传播，直到所有OSPF路由器都收到该信息。洪泛机制确保网络中的每个路由器都能够收到完整的链路状态信息。这样，网络中的所有路由器都能获得相同的网络视图。根据`update`报文的截图，AR1收到了并不是来自于自己的子网的路由器`192.168.3.3`的消息。