实验 2

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实验目的

1、掌握静态路由的配置

2、掌握 RIP 的配置

3、掌握 OSPF 的配置

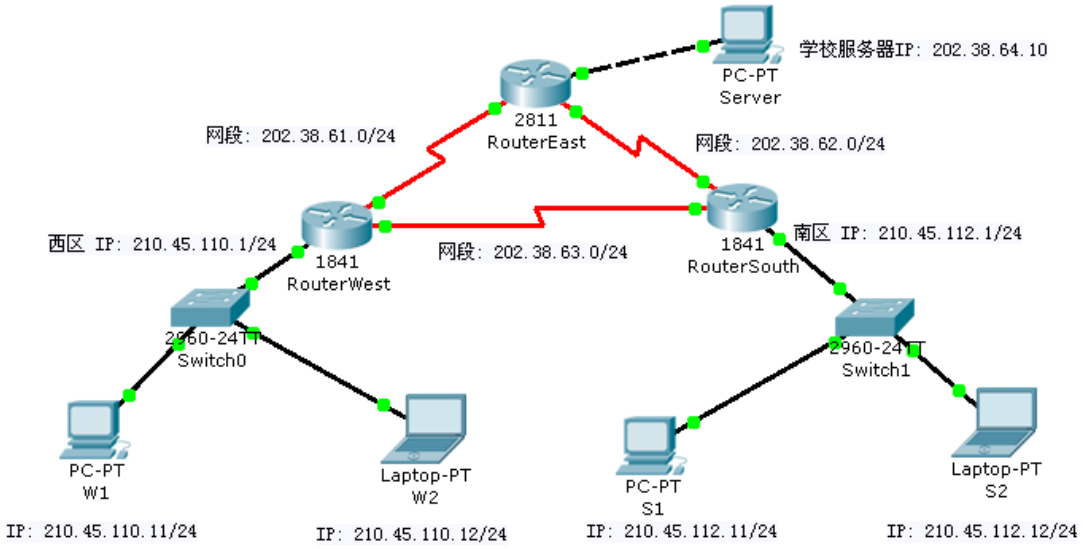
实验环境

环境：模拟软件 Cisco Packet Tracer 5.2。

器材：Cisco 2811 路由器 1 台，Cisco 1841 交换机 2 台，2960 交换机 2 台，PC 机 5 台，连接线若干。

实验内容

西区两台主机 W1、W2 通过交换机 Switch0 连接至西区路由器 RouteWest，南区两台主机 S1、S2 通过交换机 Switch1 连接至南区路由器 RouterSouth，东区学校服务器 Server 直接连接至路由器 RouterEast，三台路由器通过串行链路相连。



路由器端口连接及 IP 地址：

Device	Interfaces		IP
	From	To	
RouterWest	Serial 0/0/0 (DTE)	RouterEast, Serial 0/0/0	202.38.61.11/24
	Serial 0/0/1 (DCE)	RouterSouth, Serial 0/0/1	202.38.63.11/24
	FastEthernet 0/0	Switch0	210.45.110.1/24
RouterSouth	Serial 0/0/0 (DTE)	RouterEast, Serial 0/0/1	202.38.62.11/24
	Serial 0/0/1 (DTE)	RouterWest, Serial 0/0/1	202.38.63.12/24
	FastEthernet 0/0	Switch1	210.45.112.1/24
RouterEast	Serial 0/0/0 (DCE)	RouterWest, Serial 0/0/0	202.38.61.1/24
	Serial 0/0/1 (DCE)	RouterSouth, Serial 0/0/0	202.38.62.1/24
	FastEthernet 0/0	PC Server	202.38.64.1/24

❖ 思考题：

上表中，路由器的 IP 地址分配是否存在浪费现象？若存在，请给出一种节省 IP 的分配方案。

答：存在地址浪费现象，节省 IP 的分配方案：

Device	Interfaces		IP
	From	To	
RouterWest	Serial 0/0/0 (DTE)	RouterEast, Serial 0/0/0	202.38.61.1/30
	Serial 0/0/1 (DCE)	RouterSouth, Serial 0/0/1	202.38.63.2/30
	FastEthernet 0/0	Switch0	210.45.110.1/24
RouterSouth	Serial 0/0/0 (DTE)	RouterEast, Serial 0/0/1	202.38.62.1/30
	Serial 0/0/1 (DTE)	RouterWest, Serial 0/0/1	202.38.63.1/30
	FastEthernet 0/0	Switch1	210.45.112.1/24

RouterEast	**Serial 0/0/0 (DCE)**	**RouterWest, Serial 0/0/0**	**202.38.61.2/30**
	Serial 0/0/1 (DCE)	**RouterSouth, Serial 0/0/0**	**202.38.62.2/30**
	FastEthernet 0/0	**PC Server**	**202.38.64.1/24**

交换机端口连接：

Switch0 Interfaces		**Switch1 Interfaces**	
From	**To**	**From**	**To**
FastEthernet 0/1	**PC W1**	**FastEthernet 0/1**	**PC S1**
FastEthernet 0/2	**PC W2**	**FastEthernet 0/2**	**PC S2**
FastEthernet 0/11	**RouterWest, FastEthernet 0/0**	**FastEthernet 0/11**	**RouterSouth, FastEthernet 0/0**

主机 IP 地址和网关：

PC	**IP**	**Gateway**
W1	**210.45.110.11/24**	**210.45.110.1**
W2	**210.45.110.12/24**	**210.45.110.1**
S1	**210.45.112.11/24**	**210.45.112.1**
S2	**210.45.112.12/24**	**210.45.112.1**
Server	**202.38.64.10/24**	**202.38.64.1**

- ❖ 首先配置各台主机的 IP 地址、子网掩码和默认网关。
- ❖ 主机配置完后，回答【问题 1】：

每台主机相互 ping，查看哪些主机可以连通，哪些不可以？为什么？

答：如下图可知，主机 W1 和 W2 可以相互 ping 通，但都不能 ping 通 S1、S2 和 Server，同理，主机 S1 和 S2 可以相互 ping 通，但都不能 ping 通 W1、W2 和 Server，而 Server 不能 ping 通主机 W1、W2、S1 和 S2。

原因：主机 W1、W2 与交换机 Switch0 互连，主机 S1、S2 与交换机 Switch1 互连，所以主机 W1 和 W2 可以相互 ping 通，主机 S1 和 S2 可以相互 ping 通。而路由器的端口没有进行配置，其路由表也没有配置，所以 W1 和 W2、S1 和 S2、Server 三者间均不互通。

W1 ping W2：

```
C:\>ping 210.45.110.12

Pinging 210.45.110.12 with 32 bytes of data:

Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128

Ping statistics for 210.45.110.12:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

W1 ping S1：

```
C:\>ping 210.45.112.11

Pinging 210.45.112.11 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 210.45.112.11:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

W1 ping S2：

```
C:\>ping 210.45.112.12

Pinging 210.45.112.12 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 210.45.112.12:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

W1 ping Server：

```
C:\>ping 202.38.64.10

Pinging 202.38.64.10 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 202.38.64.10:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

每台主机相互 tracert，跟踪数据报使用的路由，查看是在哪里出的问题？

答：W1 tracert W2：

```
C:\>tracert 210.45.110.12

Tracing route to 210.45.110.12 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.12

Trace complete.
```

W1 tracert S1：

```
C:\>tracert 210.45.112.11

Tracing route to 210.45.112.11 over a maximum of 30 hops:

  1    *         *         *         Request timed out.
  2    *         *         *         Request timed out.
  3    *         *         *         Request timed out.
  4    *         *         *         Request timed out.
  5    *         *         *         Request timed out.
  6    *         *         *         Request timed out.
  7    *         *         *         Request timed out.
  8    *         *         *         Request timed out.
  9    *         *         *         Request timed out.
  10    *         *         *         Request timed out.
```

W1 tracert Server：

```
C:\>tracert 202.38.64.10

Tracing route to 202.38.64.10 over a maximum of 30 hops:

  1    *         *         *         Request timed out.
  2    *         *         *         Request timed out.
  3    *         *         *         Request timed out.
  4    *         *         *         Request timed out.
  5    *         *         *         Request timed out.
  6    *         *         *         Request timed out.
  7    *         *         *         Request timed out.
  8    *         *         *         Request timed out.
```

由上图可知，路由器的 ip 地址没有配置，路由器的路由表也没有进行配置。

在 RouterWest 上配置 IP 地址

- 进入特权模式：

Switch>enable

- 进入全局设置模式

Switch#configure terminal

- 在 FastEthernet 0/0 上配置 IP 地址：

RouterWest(config)#interface fastEthernet 0/0

RouterWest(config-if)#ip address 210.45.110.1 255.255.255.0

RouterWest(config-if)#no shutdown

RouterWest(config-if)#exit

- 在 Serial 0/0/0 上配置 IP 地址：

RouterWest(config)#interface serial 0/0/0

RouterWest(config-if)#ip address 202.38.61.11 255.255.255.0

RouterWest(config-if)#no shutdown

RouterWest(config-if)#exit

- 在 Serial 0/0/1 上配置 IP 地址：

RouterWest(config)#interface serial 0/0/1

RouterWest(config-if)#ip address 202.38.63.11 255.255.255.0

RouterWest(config-if)#clock rate 128000

RouterWest(config-if)#no shutdown

RouterWest(config-if)#exit

在 RouterSouth 上配置 IP 地址

- 在 FastEthernet 0/0 上配置 IP 地址：

RouterWest(config)#interface fastEthernet 0/0

RouterWest(config-if)#ip address 210.45.112.1 255.255.255.0

RouterWest(config-if)#no shutdown

RouterWest(config-if)#exit

- 在 Serial 0/0/0 上配置 IP 地址：

RouterWest(config)#interface serial 0/0/0

RouterWest(config-if)#ip address 202.38.62.11 255.255.255.0

RouterWest(config-if)#no shutdown

RouterWest(config-if)#exit

- 在 Serial 0/0/1 上配置 IP 地址：

RouterWest(config)#interface serial 0/0/1

RouterWest(config-if)#ip address 202.38.63.12 255.255.255.0

RouterWest(config-if)#no shutdown

RouterWest(config-if)#exit

在 RouterEast 上配置 IP 地址

- 在 FastEthernet 0/0 上配置 IP 地址：

RouterEast(config)#interface fastEthernet 0/0

RouterEast(config-if)#ip address 202.38.64.1 255.255.255.0

RouterEast(config-if)#no shutdown

RouterEast(config-if)#exit

- 在 Serial 0/0/0 上配置 IP 地址：

RouterEast(config)#interface serial 0/0/0

RouterEast(config-if)#ip address 202.38.61.1 255.255.255.0

RouterEast(config-if)#clock rate 128000

RouterEast(config-if)#no shutdown

RouterEast(config-if)#exit

- 在 Serial 0/0/1 上配置 IP 地址：

RouterEast(config)#interface serial 0/0/1

RouterEast(config-if)#ip address 202.38.62.1 255.255.255.0

RouterEast(config-if)#clock rate 128000

RouterEast(config-if)#no shutdown

RouterEast(config-if)#exit

❖ 配置完路由器 IP 地址后，回答【问题 2】：每台主机相互 ping，查看哪些主机可以连通，哪些不可以？为什么？

答：W1 ping W2：

```
C:\>ping 210.45.110.12

Pinging 210.45.110.12 with 32 bytes of data:

Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128

Ping statistics for 210.45.110.12:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

W1 ping S1：

```
C:\>ping 210.45.112.11

Pinging 210.45.112.11 with 32 bytes of data:

Reply from 210.45.110.1: Destination host unreachable.
Reply from 210.45.110.1: Destination host unreachable.
Reply from 210.45.110.1: Destination host unreachable.
Reply from 210.45.110.1: Destination host unreachable.

Ping statistics for 210.45.112.11:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

W1 ping S2：

```
C:\>ping 210.45.112.12

Pinging 210.45.112.12 with 32 bytes of data:

Reply from 210.45.110.1: Destination host unreachable.
Reply from 210.45.110.1: Destination host unreachable.
Reply from 210.45.110.1: Destination host unreachable.
Reply from 210.45.110.1: Destination host unreachable.

Ping statistics for 210.45.112.12:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

W1 ping Server：

```
C:\>ping 202.38.64.10

Pinging 202.38.64.10 with 32 bytes of data:

Reply from 210.45.110.1: Destination host unreachable.
Reply from 210.45.110.1: Destination host unreachable.
Reply from 210.45.110.1: Destination host unreachable.
Reply from 210.45.110.1: Destination host unreachable.

Ping statistics for 202.38.64.10:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

由上图可知，主机 W1 和 W2 可以相互 ping 通，但都不能 ping 通 S1、S2 和 Server，同理，主机 S1 和 S2 可以相互 ping 通，但都不能 ping 通 W1、W2 和 Server，而 Server 不能 ping 通主机 W1、W2、S1 和 S2。

原因：主机 W1、W2 与交换机 Switch0 互连，主机 S1、S2 与交换机 Switch1 互连，所以主机 W1 和 W2 可以相互 ping 通，主机 S1 和 S2 可以相互 ping 通。而从图中可以得知，路由器的路由表没有配置，所以 W1 和 W2、S1 和 S2、Server 三者间均不互通。

配置路由前查看路由表（West）：

```
Router>show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

C    202.38.61.0/24 is directly connected, Serial0/0/0
C    202.38.63.0/24 is directly connected, Serial0/0/1
C    210.45.110.0/24 is directly connected, FastEthernet0/0
```

配置路由前查看路由表（South）：

```
Router>show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

C    202.38.62.0/24 is directly connected, Serial0/0/0
C    202.38.63.0/24 is directly connected, Serial0/0/1
C    210.45.112.0/24 is directly connected, FastEthernet0/0
```

配置路由前查看路由表（East）：

```
Router#show ip route
Codes: L - local, 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, E - EGP
       i - IS-IS, 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

     202.38.61.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.61.0/24 is directly connected, Serial0/0/0
L       202.38.61.1/32 is directly connected, Serial0/0/0
     202.38.62.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.62.0/24 is directly connected, Serial0/0/1
L       202.38.62.1/32 is directly connected, Serial0/0/1
     202.38.64.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.64.0/24 is directly connected, FastEthernet0/0
L       202.38.64.1/32 is directly connected, FastEthernet0/0
```

在路由器上配置静态路由：

- ❖ RouterWest

RouterWest(config)#ip route 202.38.64.0 255.255.255.0 202.38.61.1

RouterWest(config)#ip route 210.45.112.0 255.255.255.0 202.38.63.12

- ❖ RouterSouth

RouterSouth(config)#ip route 202.38.64.0 255.255.255.0 202.38.62.1

RouterSouth(config)#ip route 210.45.110.0 255.255.255.0 202.38.63.11

- ❖ RouterEast

RouterEast(config)#ip route 210.45.110.0 255.255.255.0 202.38.61.11

RouterEast(config)#ip route 210.45.112.0 255.255.255.0 202.38.62.11

RouterWest	**Serial 0/0/0 (DTE)**	**RouterEast, Serial 0/0/0**	**202.38.61.11/24**
	Serial 0/0/1 (DCE)	**RouterSouth, Serial 0/0/1**	**202.38.63.11/24**
	FastEthernet 0/0	**Switch0**	**210.45.110.1/24**
RouterSouth	**Serial 0/0/0 (DTE)**	**RouterEast, Serial 0/0/1**	**202.38.62.11/24**
	Serial 0/0/1 (DTE)	**RouterWest, Serial 0/0/1**	**202.38.63.12/24**

	FastEthernet 0/0	**Switch1**	**210.45.112.1/24**
RouterEast	**Serial 0/0/0 (DCE)**	**RouterWest, Serial 0/0/0**	**202.38.61.1/24**
	Serial 0/0/1 (DCE)	**RouterSouth, Serial 0/0/0**	**202.38.62.1/24**
	FastEthernet 0/0	**PC Server**	**202.38.64.1/24**

查看 RouterWest 的路由表：

```
Router>show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

C    202.38.61.0/24 is directly connected, Serial0/0/0
C    202.38.63.0/24 is directly connected, Serial0/0/1
S    202.38.64.0/24 [1/0] via 202.38.61.1
C    210.45.110.0/24 is directly connected, FastEthernet0/0
S    210.45.112.0/24 [1/0] via 202.38.63.12
```

查看 RouterSouth 的路由表：

```
Router>show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

C    202.38.62.0/24 is directly connected, Serial0/0/0
C    202.38.63.0/24 is directly connected, Serial0/0/1
S    202.38.64.0/24 [1/0] via 202.38.62.1
S    210.45.110.0/24 [1/0] via 202.38.63.11
C    210.45.112.0/24 is directly connected, FastEthernet0/0
```

查看 RouterEast 的路由表：

```
Router>show ip route
Codes: L - local, 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, E - EGP
       i - IS-IS, 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

     202.38.61.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.61.0/24 is directly connected, Serial0/0/0
L       202.38.61.1/32 is directly connected, Serial0/0/0
     202.38.62.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.62.0/24 is directly connected, Serial0/0/1
L       202.38.62.1/32 is directly connected, Serial0/0/1
     202.38.64.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.64.0/24 is directly connected, FastEthernet0/0
L       202.38.64.1/32 is directly connected, FastEthernet0/0
S    210.45.110.0/24 [1/0] via 202.38.61.11
S    210.45.112.0/24 [1/0] via 202.38.62.11
```

- ❖ 配置完路由器路由后回答以下问题：

每台主机相互 ping，查看哪些主机可以连通，哪些不可以？为什么？

答：W1 ping W2：

```
C:\>ping 210.45.110.12

Pinging 210.45.110.12 with 32 bytes of data:

Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128

Ping statistics for 210.45.110.12:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

W1 ping S1：

```
C:\>ping 210.45.112.11

Pinging 210.45.112.11 with 32 bytes of data:

Request timed out.
Reply from 210.45.112.11: bytes=32 time=8ms TTL=126
Reply from 210.45.112.11: bytes=32 time=7ms TTL=126
Reply from 210.45.112.11: bytes=32 time=7ms TTL=126

Ping statistics for 210.45.112.11:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
    Minimum = 7ms, Maximum = 8ms, Average = 7ms
```

W1 ping S2：

```
C:\>ping 210.45.112.12

Pinging 210.45.112.12 with 32 bytes of data:

Request timed out.
Reply from 210.45.112.12: bytes=32 time=7ms TTL=126
Reply from 210.45.112.12: bytes=32 time=8ms TTL=126
Reply from 210.45.112.12: bytes=32 time=7ms TTL=126

Ping statistics for 210.45.112.12:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
    Minimum = 7ms, Maximum = 8ms, Average = 7ms
```

W1 ping Server：

```
C:\>ping 202.38.64.10

Pinging 202.38.64.10 with 32 bytes of data:

Request timed out.
Reply from 202.38.64.10: bytes=32 time=7ms TTL=126
Reply from 202.38.64.10: bytes=32 time=8ms TTL=126
Reply from 202.38.64.10: bytes=32 time=9ms TTL=126

Ping statistics for 202.38.64.10:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
    Minimum = 7ms, Maximum = 9ms, Average = 8ms
```

由上图可知，主机 W1, W2, S1, S2 和 Server 两两间可以相互 ping 通，因为三个路由表均配置了静态路由，各个子网均是互连的。

每台主机相互 tracert，跟踪数据报使用的路由，查看数据包经过的路由器。

答：W1 tracert W2：

```
C:\>tracert 210.45.110.12

Tracing route to 210.45.110.12 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.12

Trace complete.
```

W1 tracert S1：

```
C:\>tracert 210.45.112.11

Tracing route to 210.45.112.11 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.1
  2    4 ms      0 ms      0 ms      202.38.63.12
  3    0 ms      0 ms      0 ms      210.45.112.11

Trace complete.
```

W1 tracert S2：

```
C:\>tracert 210.45.112.12

Tracing route to 210.45.112.12 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.1
  2    6 ms      2 ms      2 ms      202.38.63.12
  3    0 ms      2 ms      0 ms      210.45.112.12

Trace complete.
```

W1 tracert Server：

```
C:\>tracert 202.38.64.10

Tracing route to 202.38.64.10 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.1
  2    5 ms      0 ms      0 ms      202.38.61.1
  3    0 ms      0 ms      2 ms      202.38.64.10

Trace complete.
```

疑问？

```
PC>ping 210.45.112.12

Pinging 210.45.112.12 with 32 bytes of data:

Request timed out.
Reply from 210.45.112.12: bytes=32 time=23ms TTL=126
Reply from 210.45.112.12: bytes=32 time=18ms TTL=126
Reply from 210.45.112.12: bytes=32 time=25ms TTL=126

Ping statistics for 210.45.112.12:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
    Minimum = 18ms, Maximum = 25ms, Average = 22ms
```

为什么第一个总是丢包？试试 arp –a ？

答：执行 arp –a 后：

```
C:\>arp -a
  Internet Address      Physical Address      Type
  210.45.110.1          0002.164e.d801        dynamic
  210.45.110.12         0001.96b9.4e99        dynamic
```

W1 的 ARP 缓存中没有 S2 的 MAC 地址，因此在发送 ICMP 分组前，先由 ARP 协议获取 MAC 地址，而 ARP 协议会通知 ping 程序它将丢弃报文，所以第一个总是丢包。

- 在各台路由器上删除静态路由

RouterWest(config)#no ip route 202.38.64.0 255.255.255.0 202.38.61.1

RouterWest(config)#no ip route 210.45.112.0 255.255.255.0 202.38.63.12

RouterSouth(config)#no ip route 202.38.64.0 255.255.255.0 202.38.62.1

RouterSouth(config)#no ip route 210.45.110.0 255.255.255.0 202.38.63.11

RouterEast(config)#no ip route 210.45.110.0 255.255.255.0 202.38.61.11

RouterEast(config)#no ip route 210.45.112.0 255.255.255.0 202.38.62.11

- 在 RouterWest 上配置 RIP 路由

启动 RIP 进程

  - RouterWest(config)#route rip

配置 RIP 版本

  - RouterWest(config-router)#version 1

激活参与 RIP v1 的接口

  - RouterWest(config-router)#network 202.38.61.0
  - RouterWest(config-router)#network 202.38.63.0
  - RouterWest(config-router)#network 210.45.110.0
  - RouterWest(config-router)#exit

- 在 RouterSouth 上配置 RIP 路由

RouterSouth(config)#router rip

RouterSouth(config-router)#version 1

RouterSouth(config-router)#network 202.38.62.0

RouterSouth(config-router)#network 202.38.63.0

RouterSouth(config-router)#network 210.45.112.0

RouterSouth(config-router)#exit

- ❖ 在 RouterEast 上配置 RIP 路由

RouterEast(config)#router rip

RouterEast(config-router)#version 1

RouterEast(config-router)#network 202.38.61.0

RouterEast(config-router)#network 202.38.62.0

RouterEast(config-router)#network 202.38.64.0

RouterEast(config-router)#exit

查看 RouterWest 的路由表：

```
Router#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

C    202.38.61.0/24 is directly connected, Serial0/0/0
R    202.38.62.0/24 [120/1] via 202.38.63.12, 00:00:05, Serial0/0/1
                    [120/1] via 202.38.61.1, 00:00:00, Serial0/0/0
C    202.38.63.0/24 is directly connected, Serial0/0/1
R    202.38.64.0/24 [120/1] via 202.38.61.1, 00:00:00, Serial0/0/0
C    210.45.110.0/24 is directly connected, FastEthernet0/0
R    210.45.112.0/24 [120/1] via 202.38.63.12, 00:00:05, Serial0/0/1
```

查看 RouterWest 的 IP 路由协议配置和统计信息：

```
Router#show ip protocols
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 0 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Redistributing: rip
Default version control: send version 1, receive 1
  Interface              Send  Recv  Triggered RIP  Key-chain
  Serial0/0/0            1     1
  Serial0/0/1            1     1
  FastEthernet0/0        1     1
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
          202.38.61.0
          202.38.63.0
          210.45.110.0
Passive Interface(s):
Routing Information Sources:
          Gateway         Distance      Last Update
          202.38.63.12          120      00:00:00
          202.38.61.1           120      00:00:11
Distance: (default is 120)
```

查看 **RouterWest** 的 **RIP** 路由数据库：

```
Router#show ip rip database
202.38.61.0/24    auto-summary
202.38.61.0/24    directly connected, Serial0/0/0
202.38.62.0/24    auto-summary
202.38.62.0/24
    [1] via 202.38.63.12, 00:00:02, Serial0/0/1    [1] via 202.38.61.1,
00:00:12, Serial0/0/0
202.38.63.0/24    auto-summary
202.38.63.0/24    directly connected, Serial0/0/1
202.38.64.0/24    auto-summary
202.38.64.0/24
    [1] via 202.38.61.1, 00:00:12, Serial0/0/0
210.45.110.0/24    auto-summary
210.45.110.0/24    directly connected, FastEthernet0/0
210.45.112.0/24    auto-summary
210.45.112.0/24
    [1] via 202.38.63.12, 00:00:02, Serial0/0/1
```

查看 **RouterSouth** 的路由表：

```
Router#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

R    202.38.61.0/24 [120/1] via 202.38.63.11, 00:00:07, Serial0/0/1
                    [120/1] via 202.38.62.1, 00:00:22, Serial0/0/0
C    202.38.62.0/24 is directly connected, Serial0/0/0
C    202.38.63.0/24 is directly connected, Serial0/0/1
R    202.38.64.0/24 [120/1] via 202.38.62.1, 00:00:22, Serial0/0/0
R    210.45.110.0/24 [120/1] via 202.38.63.11, 00:00:07, Serial0/0/1
C    210.45.112.0/24 is directly connected, FastEthernet0/0
```

查看 **RouterSouth** 的 **IP** 路由协议配置和统计信息:

```
Router#show ip protocols
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 6 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Redistributing: rip
Default version control: send version 1, receive 1
  Interface              Send  Recv  Triggered RIP  Key-chain
  Serial0/0/0            1     1
  Serial0/0/1            1     1
  FastEthernet0/0        1     1
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
          202.38.62.0
          202.38.63.0
          210.45.112.0
Passive Interface(s):
Routing Information Sources:
          Gateway         Distance      Last Update
          202.38.63.11          120      00:00:12
          202.38.62.1           120      00:00:29
Distance: (default is 120)
```

查看 RouterSouth 的 RIP 路由数据库:

```
Router#show ip rip database
202.38.61.0/24    auto-summary
202.38.61.0/24
    [1] via 202.38.63.11, 00:00:13, Serial0/0/1    [1] via 202.38.62.1,
00:00:00, Serial0/0/0
202.38.62.0/24    auto-summary
202.38.62.0/24    directly connected, Serial0/0/0
202.38.63.0/24    auto-summary
202.38.63.0/24    directly connected, Serial0/0/1
202.38.64.0/24    auto-summary
202.38.64.0/24
    [1] via 202.38.62.1, 00:00:00, Serial0/0/0
210.45.110.0/24    auto-summary
210.45.110.0/24
    [1] via 202.38.63.11, 00:00:13, Serial0/0/1
210.45.112.0/24    auto-summary
210.45.112.0/24    directly connected, FastEthernet0/0
```

查看 RouterEast 的路由表：

```
Router#show ip route
Codes: L - local, 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, E - EGP
       i - IS-IS, 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

     202.38.61.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.61.0/24 is directly connected, Serial0/0/0
L       202.38.61.1/32 is directly connected, Serial0/0/0
     202.38.62.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.62.0/24 is directly connected, Serial0/0/1
L       202.38.62.1/32 is directly connected, Serial0/0/1
R    202.38.63.0/24 [120/1] via 202.38.61.11, 00:00:05, Serial0/0/0
                    [120/1] via 202.38.62.11, 00:00:02, Serial0/0/1
     202.38.64.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.64.0/24 is directly connected, FastEthernet0/0
L       202.38.64.1/32 is directly connected, FastEthernet0/0
R    210.45.110.0/24 [120/1] via 202.38.61.11, 00:00:05, Serial0/0/0
R    210.45.112.0/24 [120/1] via 202.38.62.11, 00:00:02, Serial0/0/1
```

查看 RouterEast 的 IP 路由协议配置和统计信息：

```
Router#show ip protocols
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 23 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Redistributing: rip
Default version control: send version 1, receive 1
  Interface              Send  Recv  Triggered RIP  Key-chain
  Serial0/0/0            1     1
  Serial0/0/1            1     1
  FastEthernet0/0        1     1
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
          202.38.61.0
          202.38.62.0
          202.38.64.0
Passive Interface(s):
Routing Information Sources:
          Gateway         Distance      Last Update
          202.38.61.11          120      00:00:20
          202.38.62.11          120      00:00:01
Distance: (default is 120)
```

查看 RouterEast 的 RIP 路由数据库：

```
Router#show ip rip database
202.38.61.0/24    auto-summary
202.38.61.0/24    directly connected, Serial0/0/0
202.38.62.0/24    auto-summary
202.38.62.0/24    directly connected, Serial0/0/1
202.38.63.0/24    auto-summary
202.38.63.0/24
    [1] via 202.38.61.11, 00:00:22, Serial0/0/0    [1] via 202.38.62.11,
00:00:03, Serial0/0/1
202.38.64.0/24    auto-summary
202.38.64.0/24    directly connected, FastEthernet0/0
210.45.110.0/24    auto-summary
210.45.110.0/24
    [1] via 202.38.61.11, 00:00:22, Serial0/0/0
210.45.112.0/24    auto-summary
210.45.112.0/24
    [1] via 202.38.62.11, 00:00:03, Serial0/0/1
```

- ❖ 配置完路由器路由后回答以下问题：

每台主机相互 ping，查看哪些主机可以连通，哪些不可以？为什么？

答：W1 ping W2：

```
C:\>ping 210.45.110.12

Pinging 210.45.110.12 with 32 bytes of data:

Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128

Ping statistics for 210.45.110.12:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

W1 ping S1：

```
C:\>ping 210.45.112.11

Pinging 210.45.112.11 with 32 bytes of data:

Reply from 210.45.112.11: bytes=32 time=7ms TTL=126
Reply from 210.45.112.11: bytes=32 time=4ms TTL=126
Reply from 210.45.112.11: bytes=32 time=3ms TTL=126
Reply from 210.45.112.11: bytes=32 time=4ms TTL=126

Ping statistics for 210.45.112.11:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 3ms, Maximum = 7ms, Average = 4ms
```

W1 ping S2：

```
C:\>ping 210.45.112.12

Pinging 210.45.112.12 with 32 bytes of data:

Reply from 210.45.112.12: bytes=32 time=7ms TTL=126
Reply from 210.45.112.12: bytes=32 time=1ms TTL=126
Reply from 210.45.112.12: bytes=32 time=4ms TTL=126
Reply from 210.45.112.12: bytes=32 time=4ms TTL=126

Ping statistics for 210.45.112.12:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 7ms, Average = 4ms
```

W1 ping Server：

```
C:\>ping 202.38.64.10

Pinging 202.38.64.10 with 32 bytes of data:

Reply from 202.38.64.10: bytes=32 time=9ms TTL=126
Reply from 202.38.64.10: bytes=32 time=4ms TTL=126
Reply from 202.38.64.10: bytes=32 time=4ms TTL=126
Reply from 202.38.64.10: bytes=32 time=5ms TTL=126

Ping statistics for 202.38.64.10:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 4ms, Maximum = 9ms, Average = 5ms
```

由上图可知，主机 W1, W2, S1, S2 和 Server 两两间可以相互 ping 通，因为三个路由器均配置了 RIP 路由，各个子网均是互连的。

每台主机相互 tracert，跟踪数据报使用的路由，查看数据包经过的路由器。

答：W1 tracert W2：

```
C:\>tracert 210.45.110.12

Tracing route to 210.45.110.12 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.12

Trace complete.
```

W1 tracert S1：

```
C:\>tracert 210.45.112.11

Tracing route to 210.45.112.11 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.1
  2    4 ms      0 ms      0 ms      202.38.63.12
  3    0 ms      0 ms      0 ms      210.45.112.11

Trace complete.
```

W1 tracert S2：

```
C:\>tracert 210.45.112.12

Tracing route to 210.45.112.12 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.1
  2    6 ms      2 ms      2 ms      202.38.63.12
  3    0 ms      2 ms      0 ms      210.45.112.12

Trace complete.
```

W1 tracert Server：

```
C:\>tracert 202.38.64.10

Tracing route to 202.38.64.10 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.1
  2    5 ms      0 ms      0 ms      202.38.61.1
  3    0 ms      0 ms      2 ms      202.38.64.10

Trace complete.
```

- 在各台路由器上关闭 RIP
- RouterWest(config)#no router rip
- RouterSouth(config)#no router rip
- RouterEast(config)#no route rip
- 启动 OSPF 进程
  - RouterWest(config)#router ospf 1
- 配置路由器 ID
  - RouterWest(config-router)#router-id 1.1.1.1
- 在相应接口上发送和接收 OSPF 数据包
  - RouterWest(config-router)#network 210.45.110.0 0.0.0.255 area 0

- RouterWest(config-router)#network 202.38.61.0 0.0.0.255 area 0
- RouterWest(config-router)#network 202.38.63.0 0.0.0.255 area 0
- RouterWest(config-router)#exit

- 在 RouterSouth 上配置 OSPF 路由
  - RouterSouth(config)#route ospf 1
  - RouterSouth(config-router)#router-id 2.2.2.2
  - RouterSouth(config-router)#network 210.45.112.0 0.0.0.255 area 0
  - RouterSouth(config-router)#network 202.38.62.0 0.0.0.255 area 0
  - RouterSouth(config-router)#network 202.38.63.0 0.0.0.255 area 0
  - RouterSouth(config-router)#exit
- 在 RouterEast 上配置 OSPF 路由
  - RouterEast(config)#route ospf 1
  - RouterEast(config-router)#router-id 3.3.3.3
  - RouterEast(config-router)#network 202.38.64.0 0.0.0.255 area 0
  - RouterEast(config-router)#network 202.38.61.0 0.0.0.255 area 0
  - RouterEast(config-router)#network 202.38.62.0 0.0.0.255 area 0
  - RouterEast(config-router)#exit

查看 RouterWest 的路由表：

```
Router>show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

C    202.38.61.0/24 is directly connected, Serial0/0/0
O    202.38.62.0/24 [110/128] via 202.38.61.1, 00:03:50, Serial0/0/0
                    [110/128] via 202.38.63.12, 00:03:50, Serial0/0/1
C    202.38.63.0/24 is directly connected, Serial0/0/1
O    202.38.64.0/24 [110/65] via 202.38.61.1, 00:04:20, Serial0/0/0
C    210.45.110.0/24 is directly connected, FastEthernet0/0
O    210.45.112.0/24 [110/65] via 202.38.63.12, 00:05:42, Serial0/0/1
```

查看 RouterWest 的 IP 路由协议配置和统计信息：

```
Router>show ip protocols

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 1.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    210.45.110.0 0.0.0.255 area 0
    202.38.61.0 0.0.0.255 area 0
    202.38.63.0 0.0.0.255 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    1.1.1.1              110      00:05:13
    2.2.2.2              110      00:04:43
    3.3.3.3              110      00:04:43
  Distance: (default is 110)
```

查看 RouterWest 的 OSPF 进程 ID、路由器 ID、区域信息等：

```
Router>show ip ospf
 Routing Process "ospf 1" with ID 1.1.1.1
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 3
        Area has no authentication
        SPF algorithm executed 6 times
        Area ranges are
        Number of LSA 3. Checksum Sum 0x01c998
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

查看 RouterWest 的运行 OSPF 接口的信息：

```
Router>show ip ospf interface

FastEthernet0/0 is up, line protocol is up
  Internet address is 210.45.110.1/24, Area 0
  Process ID 1, Router ID 1.1.1.1, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 1.1.1.1, Interface address 210.45.110.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:03
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
Serial0/0/0 is up, line protocol is up
  Internet address is 202.38.61.11/24, Area 0
  Process ID 1, Router ID 1.1.1.1, Network Type POINT-TO-POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT-TO-POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:07
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 3.3.3.3
  Suppress hello for 0 neighbor(s)
Serial0/0/1 is up, line protocol is up
  Internet address is 202.38.63.11/24, Area 0
  Process ID 1, Router ID 1.1.1.1, Network Type POINT-TO-POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT-TO-POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:05
  Index 3/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 2.2.2.2
  Suppress hello for 0 neighbor(s)
```

查看 RouterWest 的 OSPF 邻居的基本信息：

```
Router>show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           0   FULL/  -        00:00:34    202.38.63.12    Serial0/0/1
3.3.3.3           0   FULL/  -        00:00:35    202.38.61.1     Serial0/0/0
```

查看 RouterWest 的 OSPF 链路状态数据库的信息：

```
Router>show ip ospf database
            OSPF Router with ID (1.1.1.1) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
1.1.1.1         1.1.1.1         441         0x80000005 0x00feb6 5
2.2.2.2         2.2.2.2         411         0x80000005 0x007e2e 5
3.3.3.3         3.3.3.3         411         0x80000005 0x004cb4 5
```

查看 RouterSouth 的路由表：

```
Router#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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    202.38.61.0/24 [110/128] via 202.38.62.1, 00:07:36, Serial0/0/0
                    [110/128] via 202.38.63.11, 00:07:36, Serial0/0/1
C    202.38.62.0/24 is directly connected, Serial0/0/0
C    202.38.63.0/24 is directly connected, Serial0/0/1
O    202.38.64.0/24 [110/65] via 202.38.62.1, 00:07:36, Serial0/0/0
O    210.45.110.0/24 [110/65] via 202.38.63.11, 00:09:26, Serial0/0/1
C    210.45.112.0/24 is directly connected, FastEthernet0/0
```

查看 RouterSouth 的 IP 路由协议配置和统计信息：

```
Router#show ip protocols

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 2.2.2.2
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    210.45.112.0 0.0.0.255 area 0
    202.38.62.0 0.0.0.255 area 0
    202.38.63.0 0.0.0.255 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    1.1.1.1              110      00:08:43
    2.2.2.2              110      00:08:13
    3.3.3.3              110      00:08:13
  Distance: (default is 110)
```

查看 RouterSouth 的 OSPF 进程 ID、路由器 ID、区域信息等：

```
Router#show ip ospf
 Routing Process "ospf 1" with ID 2.2.2.2
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 3
        Area has no authentication
        SPF algorithm executed 6 times
        Area ranges are
        Number of LSA 3. Checksum Sum 0x01c998
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

查看 RouterSouth 的运行 OSPF 接口的信息：

```
Router#show ip ospf interface

FastEthernet0/0 is up, line protocol is up
  Internet address is 210.45.112.1/24, Area 0
  Process ID 1, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 2.2.2.2, Interface address 210.45.112.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:08
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
Serial0/0/0 is up, line protocol is up
  Internet address is 202.38.62.11/24, Area 0
  Process ID 1, Router ID 2.2.2.2, Network Type POINT-TO-POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT-TO-POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:04
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 3.3.3.3
  Suppress hello for 0 neighbor(s)
Serial0/0/1 is up, line protocol is up
  Internet address is 202.38.63.12/24, Area 0
  Process ID 1, Router ID 2.2.2.2, Network Type POINT-TO-POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT-TO-POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:00
  Index 3/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 1.1.1.1
  Suppress hello for 0 neighbor(s)
```

查看 RouterSouth 的 OSPF 邻居的基本信息：

```
Router#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           0   FULL/  -        00:00:32    202.38.62.1     Serial0/0/0
1.1.1.1           0   FULL/  -        00:00:33    202.38.63.11    Serial0/0/1
```

查看 RouterSouth 的 OSPF 链路状态数据库的信息：

```
Router#show ip ospf database
            OSPF Router with ID (2.2.2.2) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
1.1.1.1         1.1.1.1         643         0x80000005 0x00feb6 5
2.2.2.2         2.2.2.2         613         0x80000005 0x007e2e 5
3.3.3.3         3.3.3.3         613         0x80000005 0x004cb4 5
```

查看 RouterEast 的路由表：

```
Router>show ip route
Codes: L - local, 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, E - EGP
       i - IS-IS, 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

     202.38.61.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.61.0/24 is directly connected, Serial0/0/0
L       202.38.61.1/32 is directly connected, Serial0/0/0
     202.38.62.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.62.0/24 is directly connected, Serial0/0/1
L       202.38.62.1/32 is directly connected, Serial0/0/1
O    202.38.63.0/24 [110/128] via 202.38.61.11, 00:11:30, Serial0/0/0
                    [110/128] via 202.38.62.11, 00:11:30, Serial0/0/1
     202.38.64.0/24 is variably subnetted, 2 subnets, 2 masks
C       202.38.64.0/24 is directly connected, FastEthernet0/0
L       202.38.64.1/32 is directly connected, FastEthernet0/0
O    210.45.110.0/24 [110/65] via 202.38.61.11, 00:12:00, Serial0/0/0
O    210.45.112.0/24 [110/65] via 202.38.62.11, 00:11:30, Serial0/0/1
```

查看 RouterEast 的 IP 路由协议配置和统计信息：

```
Router>show ip protocols

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 3.3.3.3
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    202.38.64.0 0.0.0.255 area 0
    202.38.61.0 0.0.0.255 area 0
    202.38.62.0 0.0.0.255 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    1.1.1.1              110      00:12:29
    2.2.2.2              110      00:11:59
    3.3.3.3              110      00:11:59
  Distance: (default is 110)
```

查看 RouterEast 的 OSPF 进程 ID、路由器 ID、区域信息等：

```
Router>show ip osf
% Incomplete command.
Router>show ip ospf
 Routing Process "ospf 1" with ID 3.3.3.3
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 3
        Area has no authentication
        SPF algorithm executed 3 times
        Area ranges are
        Number of LSA 3. Checksum Sum 0x01c998
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

查看 RouterEast 的运行 OSPF 接口的信息：

```
Router>show ip ospf interface

FastEthernet0/0 is up, line protocol is up
  Internet address is 202.38.64.1/24, Area 0
  Process ID 1, Router ID 3.3.3.3, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 3.3.3.3, Interface address 202.38.64.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:08
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
Serial0/0/0 is up, line protocol is up
  Internet address is 202.38.61.1/24, Area 0
  Process ID 1, Router ID 3.3.3.3, Network Type POINT-TO-POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT-TO-POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:06
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 1.1.1.1
  Suppress hello for 0 neighbor(s)
Serial0/0/1 is up, line protocol is up
  Internet address is 202.38.62.1/24, Area 0
  Process ID 1, Router ID 3.3.3.3, Network Type POINT-TO-POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT-TO-POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:07
  Index 3/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 2.2.2.2
  Suppress hello for 0 neighbor(s)
```

查看 RouterEast 的 OSPF 邻居的基本信息：

```
Router>show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           0   FULL/  -        00:00:37    202.38.61.11    Serial0/0/0
2.2.2.2           0   FULL/  -        00:00:37    202.38.62.11    Serial0/0/1
```

查看 RouterEast 的 OSPF 链路状态数据库的信：

```
Router>show ip ospf database
            OSPF Router with ID (3.3.3.3) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
1.1.1.1         1.1.1.1         905         0x80000005 0x00feb6 5
3.3.3.3         3.3.3.3         875         0x80000005 0x004cb4 5
2.2.2.2         2.2.2.2         875         0x80000005 0x007e2e 5
```

❖ 配置完路由器路由后回答以下问题：

每台主机相互 ping，查看哪些主机可以连通，哪些不可以？为什么？

答：W1 ping W2：

```
C:\>ping 210.45.110.12

Pinging 210.45.110.12 with 32 bytes of data:

Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128
Reply from 210.45.110.12: bytes=32 time<1ms TTL=128

Ping statistics for 210.45.110.12:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

W1 ping S1：

```
C:\>ping 210.45.112.11

Pinging 210.45.112.11 with 32 bytes of data:

Reply from 210.45.112.11: bytes=32 time=7ms TTL=126
Reply from 210.45.112.11: bytes=32 time=4ms TTL=126
Reply from 210.45.112.11: bytes=32 time=3ms TTL=126
Reply from 210.45.112.11: bytes=32 time=4ms TTL=126

Ping statistics for 210.45.112.11:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 3ms, Maximum = 7ms, Average = 4ms
```

W1 ping S2：

```
C:\>ping 210.45.112.12

Pinging 210.45.112.12 with 32 bytes of data:

Reply from 210.45.112.12: bytes=32 time=7ms TTL=126
Reply from 210.45.112.12: bytes=32 time=1ms TTL=126
Reply from 210.45.112.12: bytes=32 time=4ms TTL=126
Reply from 210.45.112.12: bytes=32 time=4ms TTL=126

Ping statistics for 210.45.112.12:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 7ms, Average = 4ms
```

W1 ping Server：

```
C:\>ping 202.38.64.10

Pinging 202.38.64.10 with 32 bytes of data:

Reply from 202.38.64.10: bytes=32 time=9ms TTL=126
Reply from 202.38.64.10: bytes=32 time=4ms TTL=126
Reply from 202.38.64.10: bytes=32 time=4ms TTL=126
Reply from 202.38.64.10: bytes=32 time=5ms TTL=126

Ping statistics for 202.38.64.10:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 4ms, Maximum = 9ms, Average = 5ms
```

由上图可知，主机 W1, W2, S1, S2 和 Server 两两间可以相互 ping 通，因为三个路由器均配置了 OSPF 路由，各个子网均是互连的。

每台主机相互 tracert，跟踪数据报使用的路由，查看数据包经过的路由器。

答：W1 tracert W2：

```
C:\>tracert 210.45.110.12

Tracing route to 210.45.110.12 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.12

Trace complete.
```

W1 tracert S1：

```
C:\>tracert 210.45.112.11

Tracing route to 210.45.112.11 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.1
  2    4 ms      0 ms      0 ms      202.38.63.12
  3    0 ms      0 ms      0 ms      210.45.112.11

Trace complete.
```

W1 tracert S2：

```
C:\>tracert 210.45.112.12

Tracing route to 210.45.112.12 over a maximum of 30 hops:

  1    0 ms      0 ms      0 ms      210.45.110.1
  2    6 ms      2 ms      2 ms      202.38.63.12
  3    0 ms      2 ms      0 ms      210.45.112.12

Trace complete.
```

W1 tracert Server：

```
C:\>tracert 202.38.64.10

Tracing route to 202.38.64.10 over a maximum of 30 hops:

  1    0 ms       0 ms       0 ms       210.45.110.1
  2    5 ms       0 ms       0 ms       202.38.61.1
  3    0 ms       0 ms       2 ms       202.38.64.10

Trace complete.
```

课后实验

主机 A（192.168.137.1） ping 主机 B（192.168.137.23），ping 程序发送和接收的 ICMP 报文的内容是什么呢？

使用 wireshark 抓取 ping 程序发送的 ICMP 报文如下：

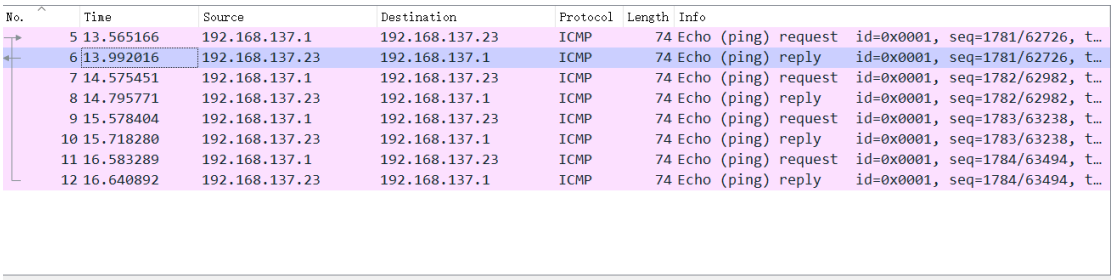
No.	Time	Source	Destination	Protocol	Length	Info
5	13.565166	192.168.137.1	192.168.137.23	ICMP	74	Echo (ping) request id=0x0001, seq=1781/62726, t…
6	13.992016	192.168.137.23	192.168.137.1	ICMP	74	Echo (ping) reply id=0x0001, seq=1781/62726, t…
7	14.575451	192.168.137.1	192.168.137.23	ICMP	74	Echo (ping) request id=0x0001, seq=1782/62982, t…
8	14.795771	192.168.137.23	192.168.137.1	ICMP	74	Echo (ping) reply id=0x0001, seq=1782/62982, t…
9	15.578404	192.168.137.1	192.168.137.23	ICMP	74	Echo (ping) request id=0x0001, seq=1783/63238, t…
10	15.718280	192.168.137.23	192.168.137.1	ICMP	74	Echo (ping) reply id=0x0001, seq=1783/63238, t…
11	16.583289	192.168.137.1	192.168.137.23	ICMP	74	Echo (ping) request id=0x0001, seq=1784/63494, t…
12	16.640892	192.168.137.23	192.168.137.1	ICMP	74	Echo (ping) reply id=0x0001, seq=1784/63494, t…

```
> Internet Protocol Version 4, Src: 192.168.137.1, Dst: 192.168.137.23
v Internet Control Message Protocol
    Type: 8 (Echo (ping) request)
    Code: 0
    Checksum: 0x4666 [correct]
    [Checksum Status: Good]
    Identifier (BE): 1 (0x0001)
    Identifier (LE): 256 (0x0100)
    Sequence Number (BE): 1781 (0x06f5)
    Sequence Number (LE): 62726 (0xf506)
    [Response frame: 6]
  v Data (32 bytes)
      Data: 6162636465666768696a6b6c6d6e6f707172737475767761626364656667686 9
      [Length: 32]
```

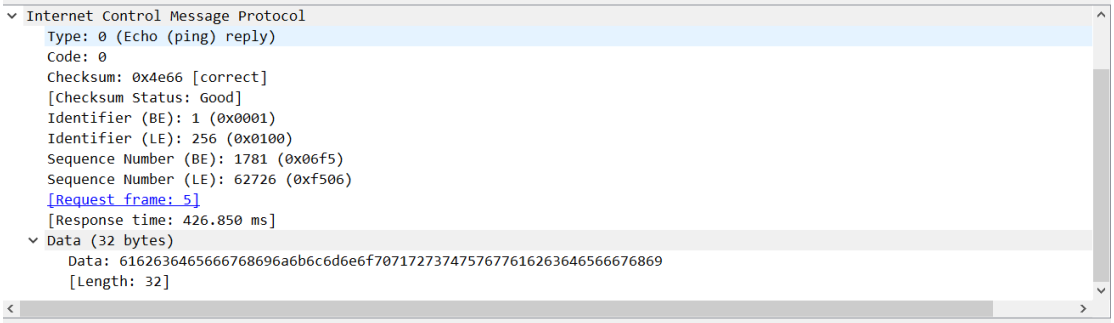
```
0000  64 a2 00 4f 29 7a fa e4  e3 79 76 24 08 00 45 00   d··O)z·· ·yv$··E·
0010  00 3c e9 56 00 00 40 01  fe 00 c0 a8 89 01 c0 a8   ·<·V··@· ········
0020  89 17 08 00 46 66 00 01  06 f5 61 62 63 64 65 66   ····Ff·· ··abcdef
0030  67 68 69 6a 6b 6c 6d 6e  6f 70 71 72 73 74 75 76   ghijklmn opqrstuv
0040  77 61 62 63 64 65 66 67  68 69                    wabcdefg hi
```

从图中可知，类型为 8，代码为 0，检验和为 0x4666，标识符为 1，序号为 1781，数据为 0x6162636465666768696a6b6c6d6e6f707172737475767761626364656667686 9。

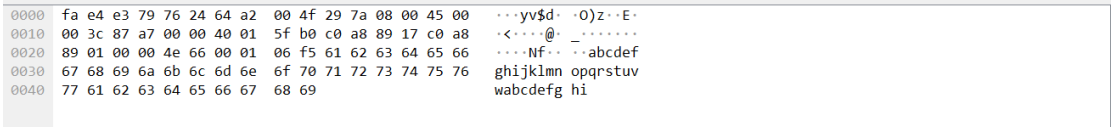
ping 程序接收到的 ICMP 报文为：



No.	Time	Source	Destination	Protocol	Length	Info
5	13.565166	192.168.137.1	192.168.137.23	ICMP	74	Echo (ping) request id=0x0001, seq=1781/62726, t…
6	13.992016	192.168.137.23	192.168.137.1	ICMP	74	Echo (ping) reply id=0x0001, seq=1781/62726, t…
7	14.575451	192.168.137.1	192.168.137.23	ICMP	74	Echo (ping) request id=0x0001, seq=1782/62982, t…
8	14.795771	192.168.137.23	192.168.137.1	ICMP	74	Echo (ping) reply id=0x0001, seq=1782/62982, t…
9	15.578404	192.168.137.1	192.168.137.23	ICMP	74	Echo (ping) request id=0x0001, seq=1783/63238, t…
10	15.718280	192.168.137.23	192.168.137.1	ICMP	74	Echo (ping) reply id=0x0001, seq=1783/63238, t…
11	16.583289	192.168.137.1	192.168.137.23	ICMP	74	Echo (ping) request id=0x0001, seq=1784/63494, t…
12	16.640892	192.168.137.23	192.168.137.1	ICMP	74	Echo (ping) reply id=0x0001, seq=1784/63494, t…



```
Internet Control Message Protocol
    Type: 0 (Echo (ping) reply)
    Code: 0
    Checksum: 0x4e66 [correct]
    [Checksum Status: Good]
    Identifier (BE): 1 (0x0001)
    Identifier (LE): 256 (0x0100)
    Sequence Number (BE): 1781 (0x06f5)
    Sequence Number (LE): 62726 (0xf506)
    [Request frame: 5]
    [Response time: 426.850 ms]
  Data (32 bytes)
      Data: 6162636465666768696a6b6c6d6e6f707172737475767761626364656667686 9
      [Length: 32]
```



```
0000  fa e4 e3 79 76 24 64 a2  00 4f 29 7a 08 00 45 00   ···yv$d· ·O)z··E·
0010  00 3c 87 a7 00 00 40 01  5f b0 c0 a8 89 17 c0 a8   ·<····@· _·····
0020  89 01 00 00 4e 66 00 01  06 f5 61 62 63 64 65 66   ····Nf·· ··abcdef
0030  67 68 69 6a 6b 6c 6d 6e  6f 70 71 72 73 74 75 76   ghijklmn opqrstuv
0040  77 61 62 63 64 65 66 67  68 69                    wabcdefg hi
```

从图中可知，类型为 0，代码为 0，检验和为 0x4e66，标识符为 1，序号为 1781，数据为 0x6162636465666768696a6b6c6d6e6f707172737475767761626364656667686 9。

由上可见，有请求报文发送的数据，被回答报文重复。