《网络与通信》课程实验报告

实验四：网络路由实验

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实验地点	计 706		实验时间	周三 7-8	
实验课表现	出勤、表现得分(10)		实验报告得分(40)		实验总分	
	操作结果得分(50)					

实验目的：

1. 学会为 Cisco 路由器配置网络 IP 接口，并配置静态路由实验。
2. 加深理解目前较广泛使用的域内路由协议 RIP 和 OSPF。
3. 掌握在 Cisco 路由器上配置 RIP 和 OSPF 路由协议。

实验内容：

通过使用 Netsim 路由模拟软件进行 Cisco 路由器静态和动态路由实验。

具体的实验内容，请参阅实验指导书。

实验要求：（学生对预习要求的回答）（10 分）　　得分：

- 简述RIP和OSPF动态路由协议的要点

➢ RIP：

RIP (Routing Information Protocol) (路由信息协议)是内部网关协议IGP中最先得到广泛使用的协议。它是一种分布式的、基于距离向量的动态路由选择协议，适合小型网络。RIP协议要求网络中的每一个路由器都要维护从它自己到其他每一个目的网络的距离记录。它的要点如下：

和哪些路由器交换信息？RIP只和直接相邻的路由器交换信息。这意味着一个路由器只知道与其相连的那些路由器的信息，而不了解整个网络的拓扑结构。

交换什么信息？RIP交换的信息是当前本路由器所知道的全部信息，即自己的路由表。每个路由器定期地广播自己的路由表给相邻的路由器。这个路由表包含了该路由器所知道的目的网络地址、跳数，以及下一跳的路由器信息。

在什么时候交换信息？RIP按照固定的时间间隔交换路由信息，例如，默认条件下每隔30秒。而当网络拓扑发生变化时，路由器也及时向相邻路由器通告拓扑变化后的路由信息。

怎么选择路由？RIP在路由选择上的核心原则是认为“距离短”的路由是好的路由。它使用跳数来度量路径的长度。RIP规定一条路径最多只能包含15个路由器，而当跳数达到16时，表示路径不可达。因此，RIP的路由选择受到路径长度的限制，它选择具有最少路由器的路径作为最佳路由，即使在网络中存在另一条高速但路由器较多的路径。由于RIP的设计限制，它适用于小型互联网，且不能在两个网络之间同时使用多条路由。

➢ OSPF：

OSPF(Open Shortest Path First)(开放最短路径优先)协议，是为克服RIP的缺点在1989年开发出来的。“开放”表明OSPF协议不是受某一家厂商控制，而是公开发表的。“最短路径优先”是因为使用了Dijkstra提出的最短路径算法。它采用分布式的链路状态协议，而不是RIP那样的距离向量协议，它支持大型网络。它的要点如下：

和哪些路由交换信息？OSPF路由器交换信息的对象是本自治系统（AS）内的所有路由器。AS是一个拥有独立的IP地址空间，由一个或多个IP地址前缀组成的一组网络和路由器。OSPF协议用于在同一个AS内的路由器之间交换信息。

交换什么信息？OSPF路由器使用洪泛法向本AS内的所有路由器发送链路状态信息。这些信息包括本路由器与相邻路由器的连接状态，以及连接的度量值（费用、距离、时延、带宽等）。链路状态信息描述了本路由器与其他路由器的相邻关系和连接属性。

在什么时候交换信息： 路由器只有在链路状态发生变化时才用洪泛法向所有路由器发送更新信息。当网络拓扑发生改变，例如某条链路断开或者新的链路建立，相关的路由器会检测到这些变化，并将新的链路状态信息洪泛给整个AS内的所有路由器。

关于链路状态数据库：链路状态数据库是OSPF协议中的核心组成部分，它详细描述了每个路由器与相邻路由器的连接状态和度量值，实现了对网络拓扑的精准描述。这个数据库为OSPF路由器提供了计算最短路径所需的数据，通过Dijkstra最短路径算法，路由器可以实时地计算到达网络中其他路由器的最短路径。定期的链路状态更新确保了数据库的准确性，从而保证了网络的快速收敛和最优路径的选择。

关于OSPF的区域：OSPF的区域概念将大型网络划分为多个相对独立的部分，每个区域内的路由器只需了解自身区域的拓扑信息。区域之间的连接由特定的路由器负责，它们传递路由信息、限制信息的传播范围，提高了网络的管理效率和安全性。

实验过程中遇到的问题如何解决的？（10 分）	得分：

问题 1：由于对英文网页不熟悉，不知该如何从网上下载 Cisco Packet Tracer。
解决：通过阅读网页提示，与同学不断实践，在 view course 后成功下载。

问题 2：在配置好路由器的 ip 与掩码之后，路由器之间的连线仍是红色。
解决：这是由于没有打开端口开关导致的，可以采用命令行输入”no shutdown”解决，也可以在图形化界面点击上端的打开按钮。

问题 3：没能在第一次实验时得到 Ethernet0 以及 Serial0 端口。
解决：这是由于第一次实验选用的是默认的 FastEthernet。所以需要在配置时在路由器上添加 WIC-1ENET 或是 WIC-2T 模块，添加完成后连线时就可看见相应的端口。

问题 4：在静态路由实验配置成功后，看到的 request 只有 1、2、3、4 没有 0。
解决：猜测可能是数据包传输时的顺序问题，再 ping 一次后就看到了 request 0。

问题 5：命令：Router(config-if)#show ip route 与 Router(config-if)#ping 无法执行。
解决：问题出在当前状态中，当前处于配置状态自然无法执行该命令，所以只需键入 end 退出配置状态，再 show 或者 ping 即可。

问题 6：在 RIP 动态路由实验时，当配置完成 Router2 开始 ping172.16.10.2 时出现了：.!!!! 的情况。
解决：猜测可能是数据传输时出现丢失等问题，上网查阅资料发现可能是 ARP 解析延迟、路由表查找延迟、设备启动延迟、ICMP 速率限制等原因导致第一次 ping 会出现问题，所以重新 ping 一次就得到了正常的结果。

问题 7：在静态路由实验中进行手动配置时，若以远程路由器的 ip 作为参数无法配置成功。
解决：这是由于我们配置时应该将网段作为参数，而非路由器的 ip，在本实验中使用命令：

ip route 10.1.1.2 255.255.255.0 12.10.5.1 是错误的，应该改为：ip route 10.1.1.0 255.255.255.0 12.10.5.1，这样就能解决这一问题。

本次实验的体会（结论）（10 分）　　得分：

本次实验的内容本身并不算困难，但是软件下载的过程中会遇到了不少麻烦，Netsim 无法使用，Cisco Packet Tracer 软件的下载与使用也是一个艰难的过程，但好在经过实践与指导书的阅读，最终还是完成了实验任务。

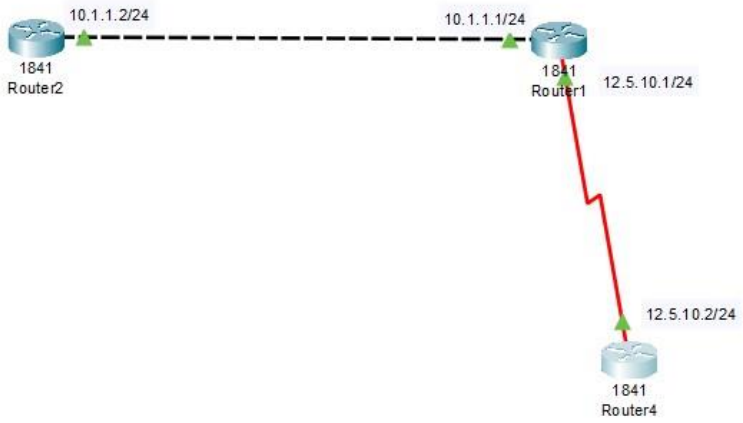
通过本次实验，我对静态路由与动态路由有了更加深入的了解，对 RIP 与 OSPF 的配置与原理也有了清楚的认识。虽说老师在课上已经讲过相关知识，但这次实验让我更直观的感受到了网络路由及其相关协议的神奇，也让我对课内理论知识有了更好的掌握。这次实验让我收获满满！

思考题：（10 分）

思考题 1：（4 分）　　得分：

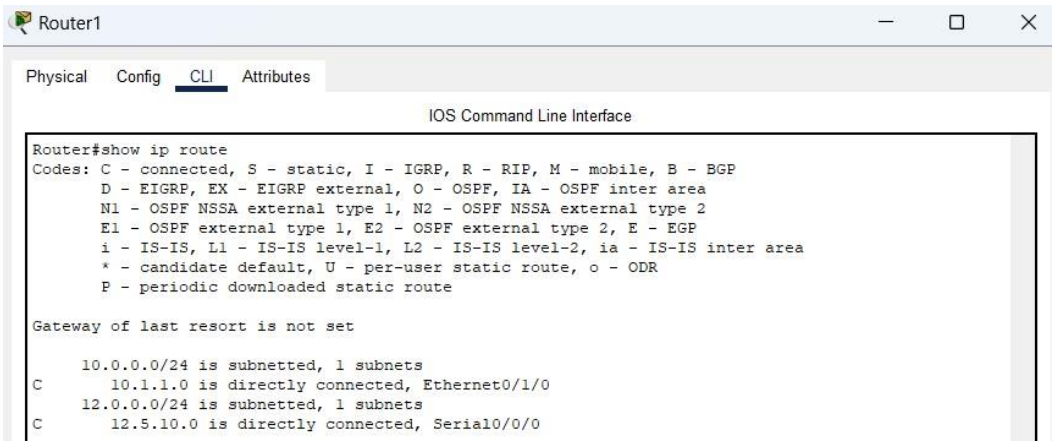
按照实验指导书的要求，按照实验指导书上的网络拓扑图，分别写出每台路由器上的静态路由表项。并使用 ping 进行连通性测试的结果。

网络拓扑图：

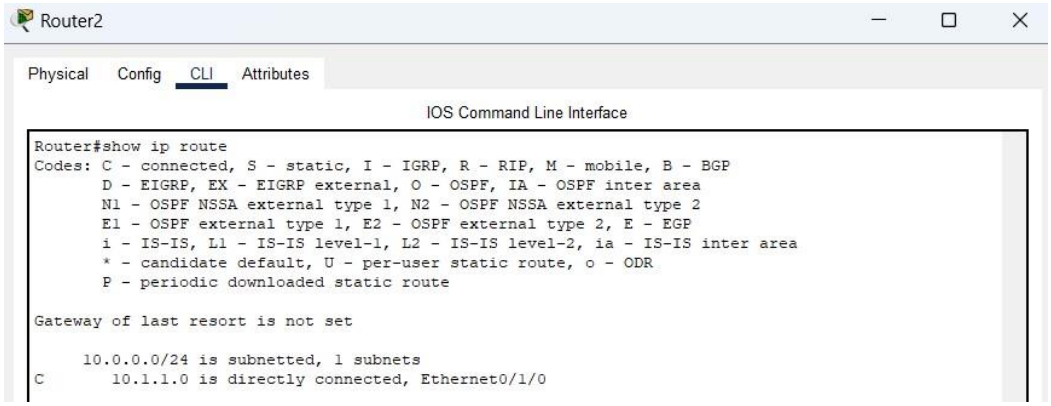


静态路由表项：

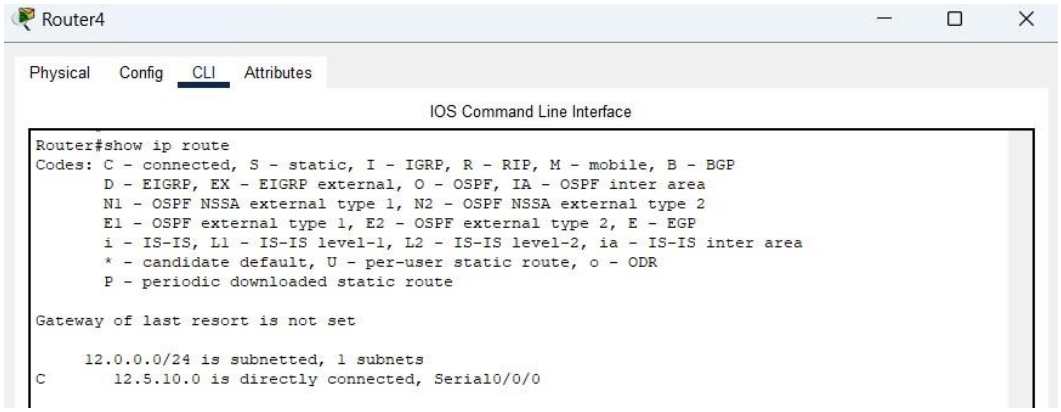
Router1：



Router2：

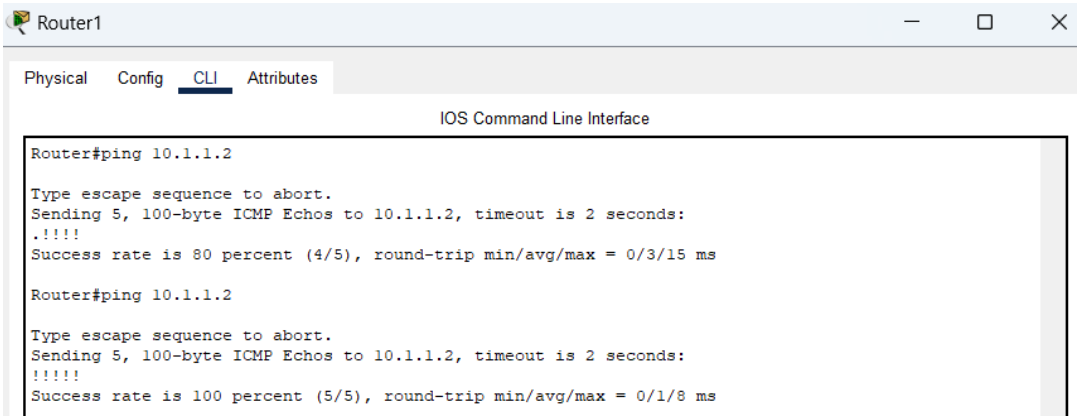


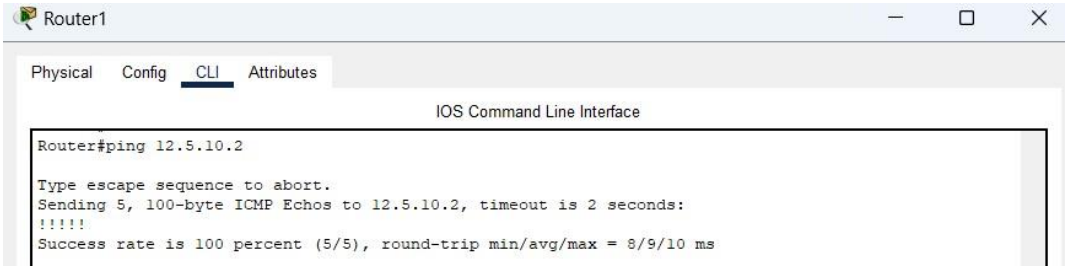
Router4：



Ping的连通性测试结果：

Router1 Ping Router2&Router4





Router2&Router4 Ping Router1

Router2

Physical Config CLI Attributes

IOS Command Line Interface

```
Router#ping 10.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms
```

Router4

Physical Config CLI Attributes

IOS Command Line Interface

```
Router#ping 12.5.10.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 12.5.10.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 7/8/9 ms
```

Router2 Ping Router4（&互换）（关键）

Router2

Physical Config CLI Attributes

IOS Command Line Interface

```
Router#ping 12.5.10.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 12.5.10.2, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

Router4

Physical Config CLI Attributes

IOS Command Line Interface

```
Router#ping 10.1.1.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.2, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

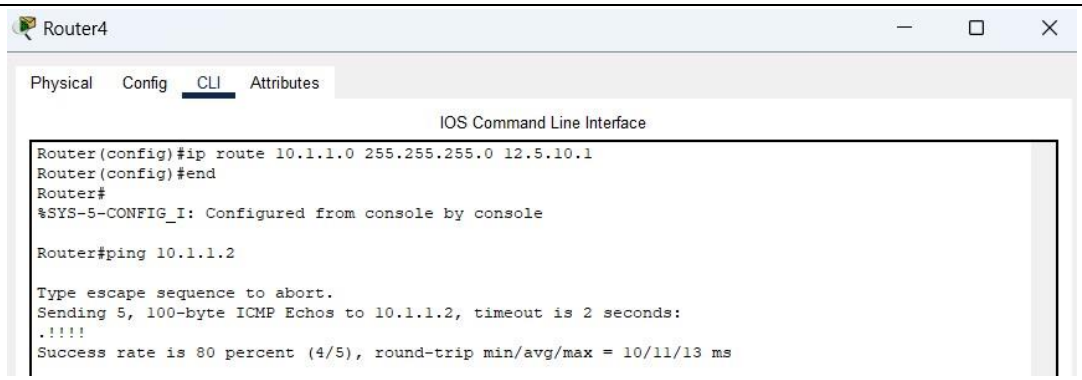
由此发现，在静态路由实验中，一台路由器无法 ping 通远端路由器，因为各个路由表的路由表项中只有相邻的路由信息，所以为了成功连通远端路由器，需要进行手动配置。

Router2

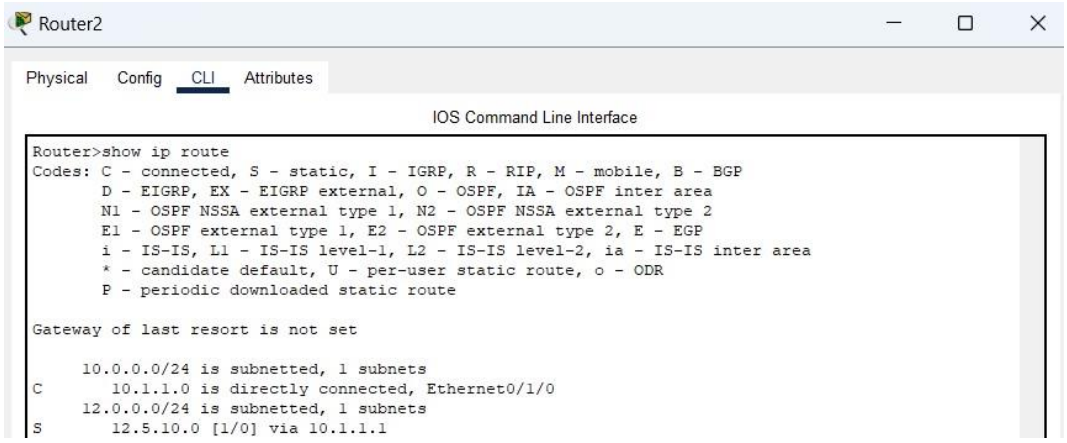
Physical Config CLI Attributes

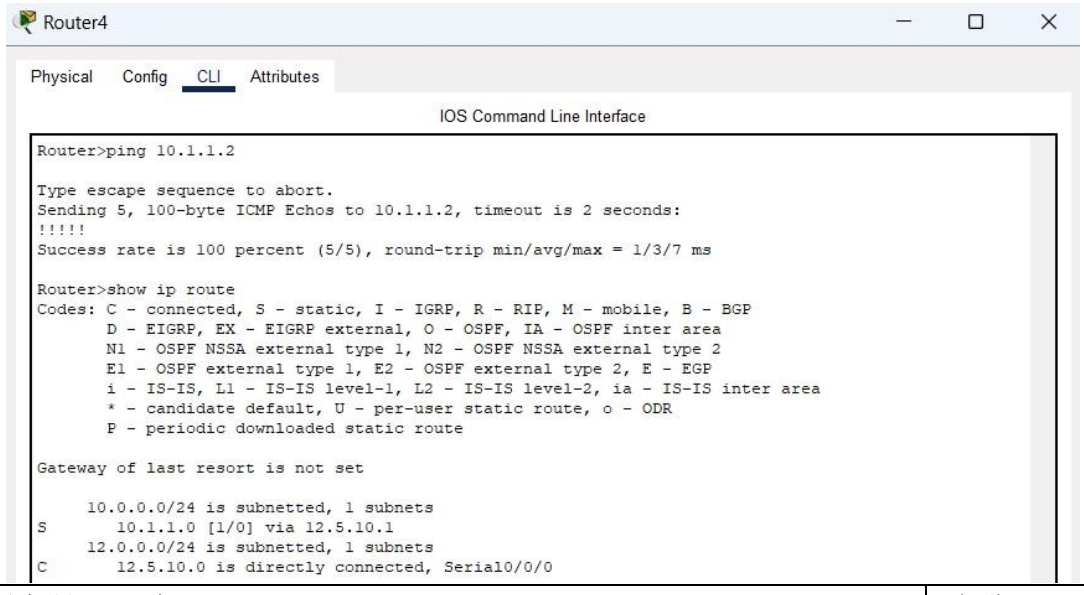
IOS Command Line Interface

```
Router(config)#ip route 12.5.10.2 255.255.255.0 10.1.1.1
%Inconsistent address and mask
Router(config)#ip route 12.5.10.0 255.255.255.0 10.1.1.1
Router(config)#end
Router#
%SYS-5-CONFIG_I: Configured from console by console

Router#ping 12.5.10.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 12.5.10.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/3/7 ms
```



可以发现，在我们手动配置路由表项之后，Router2 和 Router4 能够 ping 通，以下是此时 Router2 与 Router4 的路由表项：

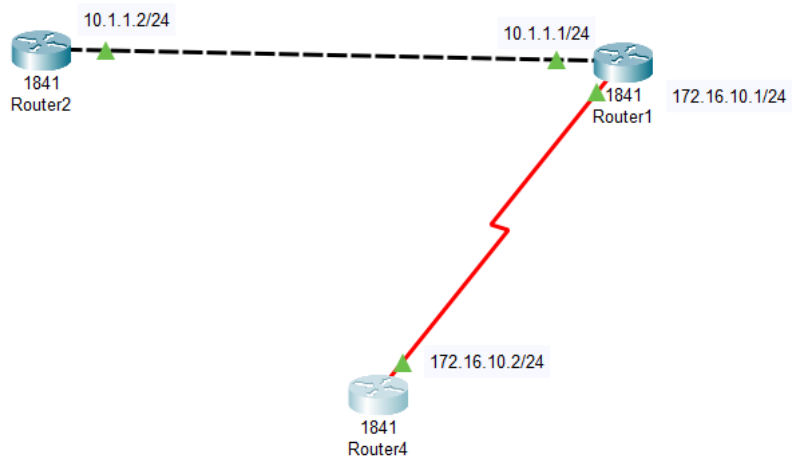




思考题2：（6分）	得分：

按照实验指导书，动态路由实验的要求，写出每台路由器上的 RIP 和 OSPF 路由表项。并写出 Ping 的连通性测试结果。

RIP网络拓扑图：



RIP路由表项：

Router1：

Router1

Physical Config CLI Attributes

IOS Command Line Interface

```
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

     10.0.0.0/24 is subnetted, 1 subnets
C       10.1.1.0 is directly connected, Ethernet0/1/0
     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.10.0 is directly connected, Serial0/0/0

Router#show ip protocols
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 25 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 any version
  Interface             Send  Recv  Triggered RIP  Key-chain
  Ethernet0/1/0         12 1
  Serial0/0/0           12 1
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
          10.0.0.0
          172.16.0.0
Passive Interface(s):
Routing Information Sources:
          Gateway         Distance      Last Update
Distance: (default is 120)
```

Router2：

Router2

Physical Config CLI Attributes

IOS Command Line Interface

```
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

     10.0.0.0/24 is subnetted, 1 subnets
C       10.1.1.0 is directly connected, Ethernet0/1/0
R    172.16.0.0/16 [120/1] via 10.1.1.1, 00:00:25, Ethernet0/1/0

Router#show ip protocols
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 26 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 any version
  Interface             Send  Recv  Triggered RIP  Key-chain
  Ethernet0/1/0         12 1
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
          10.0.0.0
Passive Interface(s):
Routing Information Sources:
          Gateway         Distance      Last Update
          10.1.1.1             120      00:00:03
Distance: (default is 120)
```

Router4：

Router4

Physical Config CLI Attributes

IOS Command Line Interface

```
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    10.0.0.0/8 [120/1] via 172.16.10.1, 00:00:15, Serial0/0/0
     172.16.0.0/24 is subnetted, 1 subnets
C       172.16.10.0 is directly connected, Serial0/0/0

Router#show ip protocols
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 15 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 any version
  Interface             Send  Recv  Triggered RIP  Key-chain
  Serial0/0/0           12 1
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
          172.16.0.0
Passive Interface(s):
Routing Information Sources:
          Gateway         Distance      Last Update
          172.16.10.1          120      00:00:25
Distance: (default is 120)
```

Ping的连通性测试结果：

Router1 Ping Router2&4

Router1

Physical Config CLI Attributes

IOS Command Line Interface

```
Router#ping 10.1.1.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 0/1/5 ms

Router#ping 10.1.1.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/5/12 ms

Router#ping 172.16.10.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.10.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 3/8/13 ms
```

Router2 Ping Router4（关键）

Router2

Physical Config CLI Attributes

IOS Command Line Interface

```
Router#ping 172.16.10.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.10.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/8/11 ms
```

Router4 Ping Router2（关键）

Router4

Physical Config CLI Attributes

IOS Command Line Interface

```
Router#ping 10.1.1.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/7/11 ms

Router#
```

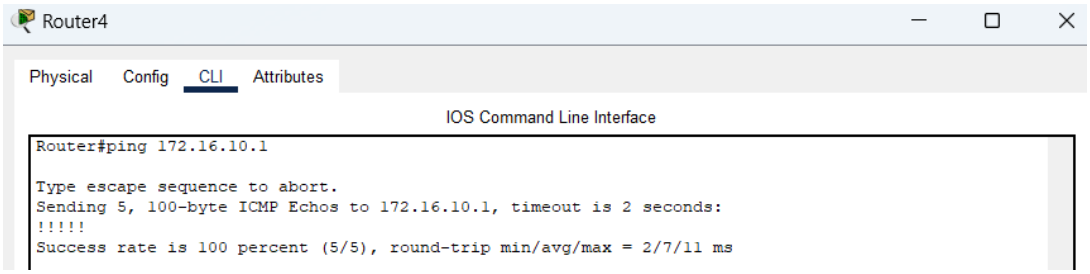
Router2&4 Ping Router1

Router2

Physical Config CLI Attributes

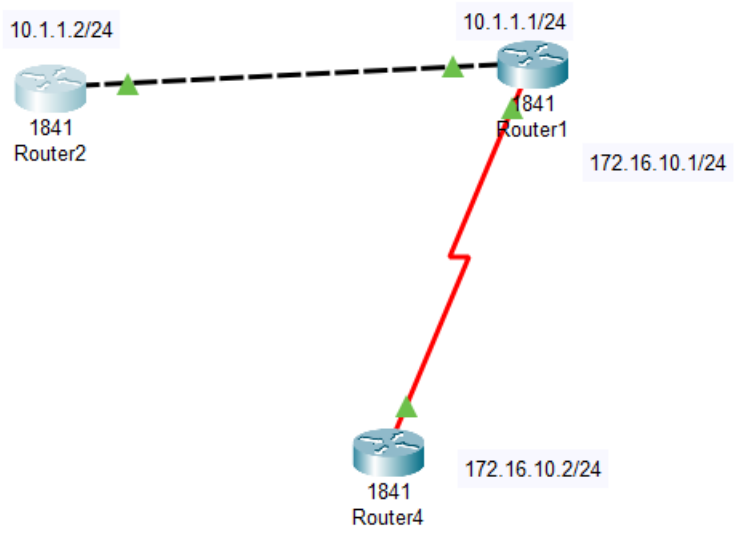
IOS Command Line Interface

```
Router#ping 10.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/1/6 ms
```



值得一提的是，由于RIP跳数限制，本次实验如果设计了一条超过15个路由器的路径，那么第一个路由器是无法与远端路由器ping通的。测试了一下，结果确实如此。

OSPF网络拓扑图：



OSPF路由表项：

Router1：

Router1

Physical Config CLI Attributes

IOS Command Line Interface

```
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

     10.0.0.0/24 is subnetted, 1 subnets
C       10.1.1.0 is directly connected, Ethernet0/1/0
C    172.16.0.0/16 is directly connected, Serial0/0/0

Router#show ip pro

Routing Protocol is "ospf 100"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 172.16.10.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    10.1.1.0 0.0.0.255 area 0
    172.16.0.0 0.0.255.255 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.1.1.2             110      00:04:24
    172.16.10.1          110      00:03:26
    172.16.10.2          110      00:03:26
  Distance: (default is 110)
```

Router1

Physical Config CLI Attributes

IOS Command Line Interface

```
Router>show ip ospf database
            OSPF Router with ID (172.16.10.1) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
172.16.10.2     172.16.10.2     188         0x80000002 0x00d115 2
172.16.10.1     172.16.10.1     159         0x80000005 0x00951d 3
10.1.1.2        10.1.1.2        159         0x80000002 0x006ea5 1

                Net Link States (Area 0)
Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.1        172.16.10.1     159         0x80000001 0x004fed
Router>show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
172.16.10.2       0   FULL/  -        00:00:33    172.16.10.2     Serial0/0/0
10.1.1.2          1   FULL/BDR        00:00:34    10.1.1.2        Ethernet0/1/0
Router>show ip ospf interface

Ethernet0/1/0 is up, line protocol is up
  Internet address is 10.1.1.1/24, Area 0
  Process ID 100, Router ID 172.16.10.1, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 172.16.10.1, Interface address 10.1.1.1
  Backup Designated Router (ID) 10.1.1.2, Interface address 10.1.1.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:05
  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 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.1.1.2  (Backup Designated Router)
  Suppress hello for 0 neighbor(s)
Serial0/0/0 is up, line protocol is up
  Internet address is 172.16.10.1/16, Area 0
  Process ID 100, Router ID 172.16.10.1, 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
```

Router2：

Router2

Physical Config CLI Attributes

IOS Command Line Interface

```
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

     10.0.0.0/24 is subnetted, 1 subnets
C       10.1.1.0 is directly connected, Ethernet0/1/0
O    172.16.0.0/16 [110/74] via 10.1.1.1, 00:05:43, Ethernet0/1/0

Router#show ip pro

Routing Protocol is "ospf 100"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 10.1.1.2
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    10.1.1.0 0.0.0.255 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.1.1.2             110      00:05:57
    172.16.10.1          110      00:04:58
    172.16.10.2          110      00:04:58
  Distance: (default is 110)
```

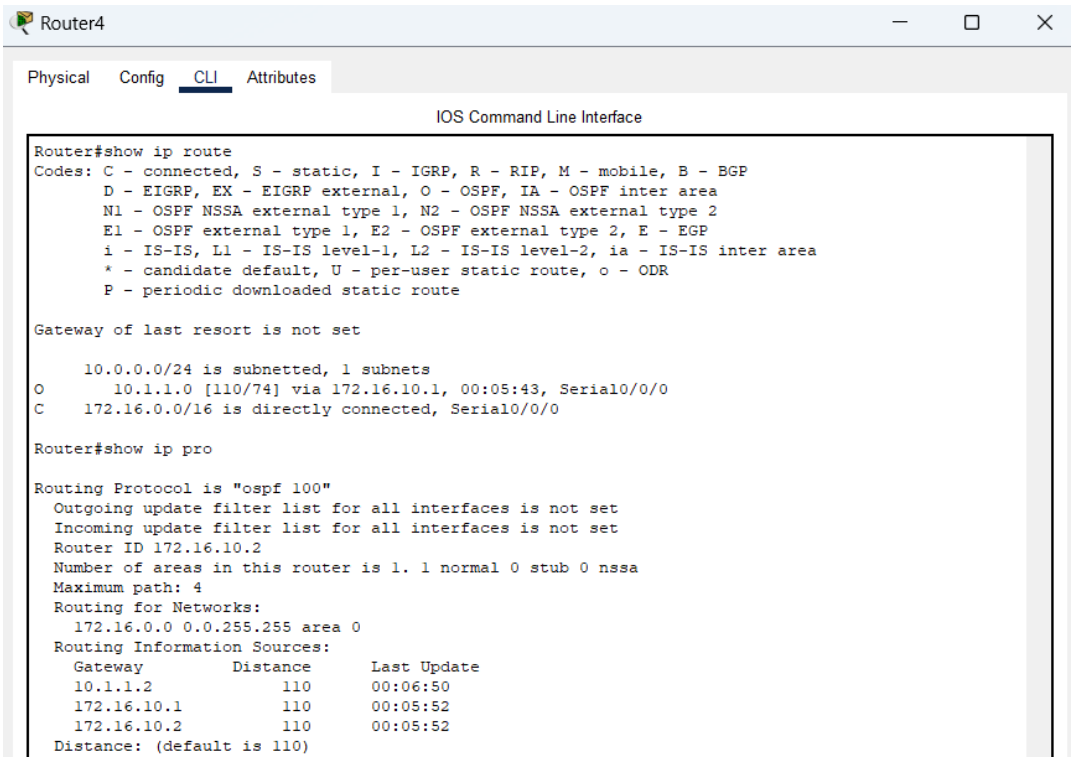
Router2

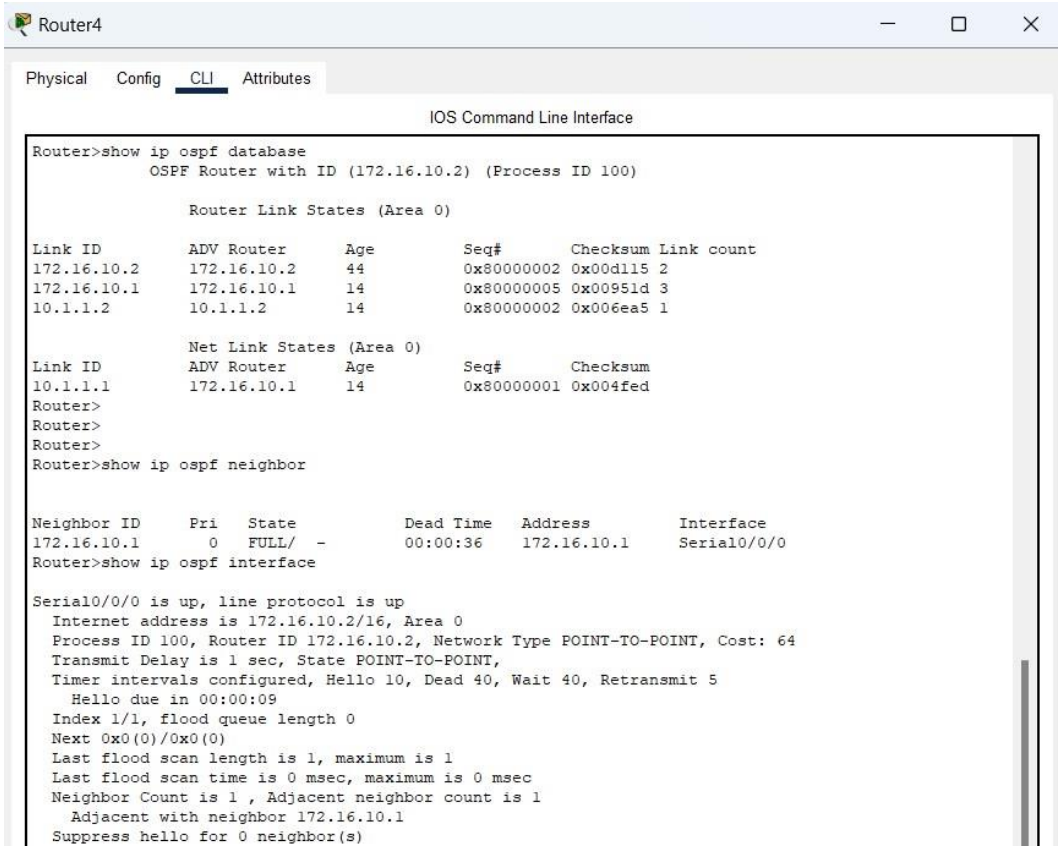
Physical Config CLI Attributes

IOS Command Line Interface

```
Router>show ip ospf database
            OSPF Router with ID (10.1.1.2) (Process ID 100)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
172.16.10.2     172.16.10.2     268         0x80000002 0x00d115 2
10.1.1.2        10.1.1.2        239         0x80000002 0x006ea5 1
172.16.10.1     172.16.10.1     239         0x80000005 0x00951d 3

                Net Link States (Area 0)
Link ID         ADV Router      Age         Seq#       Checksum
10.1.1.1        172.16.10.1     239         0x80000001 0x004fed
Router>show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
172.16.10.1       1   FULL/DR         00:00:38    10.1.1.1        Ethernet0/1/0
Router>show ip ospf interface

Ethernet0/1/0 is up, line protocol is up
  Internet address is 10.1.1.2/24, Area 0
  Process ID 100, Router ID 10.1.1.2, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 172.16.10.1, Interface address 10.1.1.1
  Backup Designated Router (ID) 10.1.1.2, Interface address 10.1.1.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:09
  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 1, Adjacent neighbor count is 1
    Adjacent with neighbor 172.16.10.1  (Designated Router)
  Suppress hello for 0 neighbor(s)
```

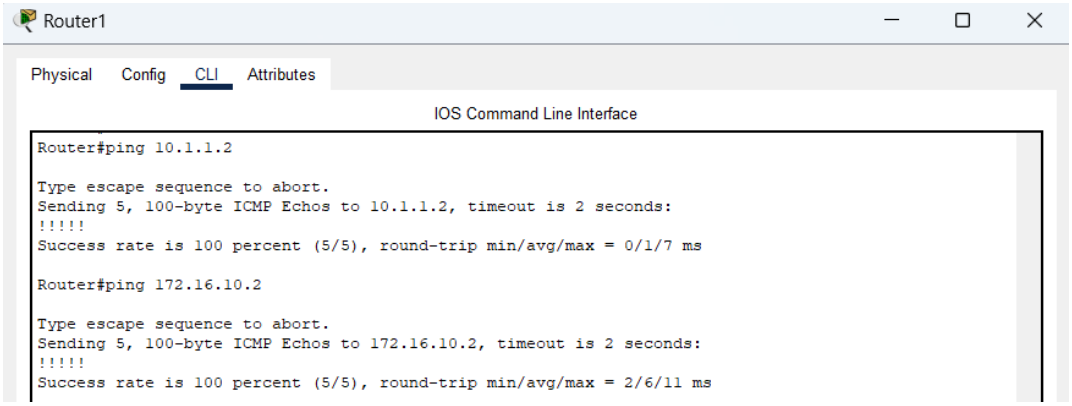
Router4：





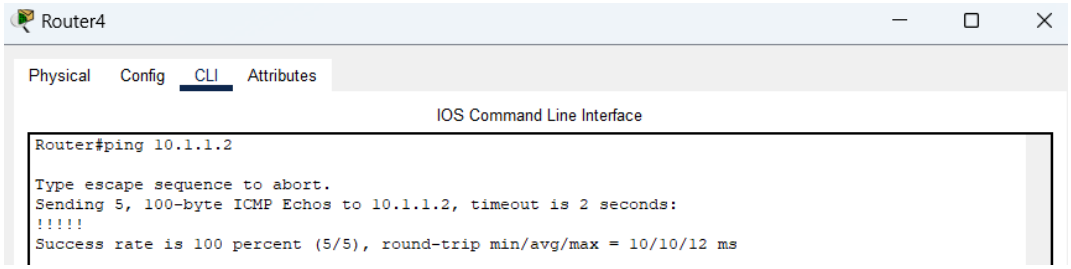
Ping的连通性测试结果：

Router1 Ping Router2&4

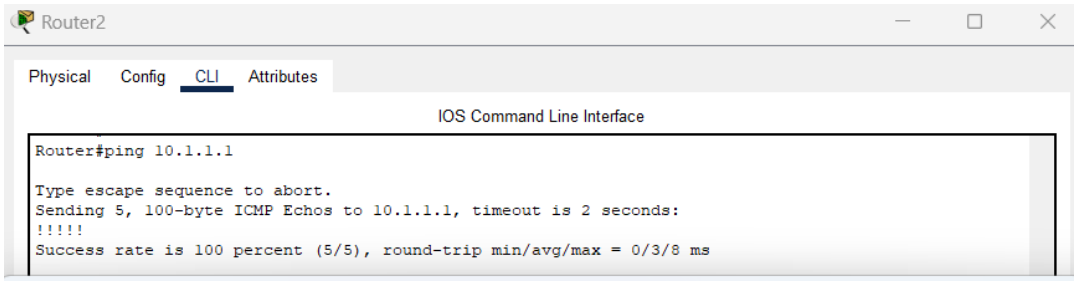


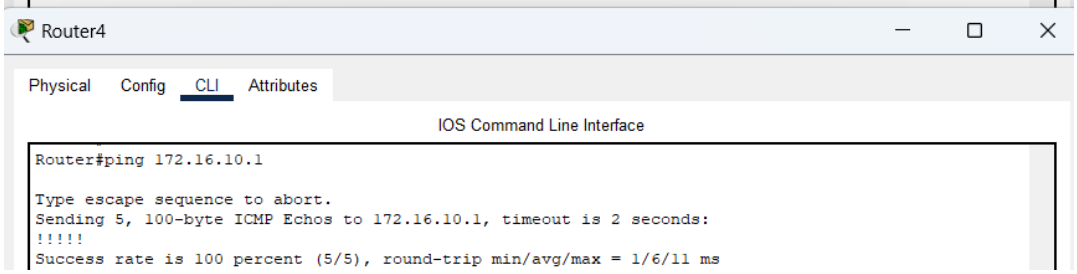
Router2 Ping Router4（关键）

Router4 Ping Router2（关键）



Router2&4 Ping Router1





指导教师评语：

日期：