

计算机网络实验报告

课程名称计算机网络成绩评定

实验项目名称IP 协议分析指导教师张伟

实验项目编号实验 4实验项目类型实验地点

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实验时间2024 年 4 月 17 日

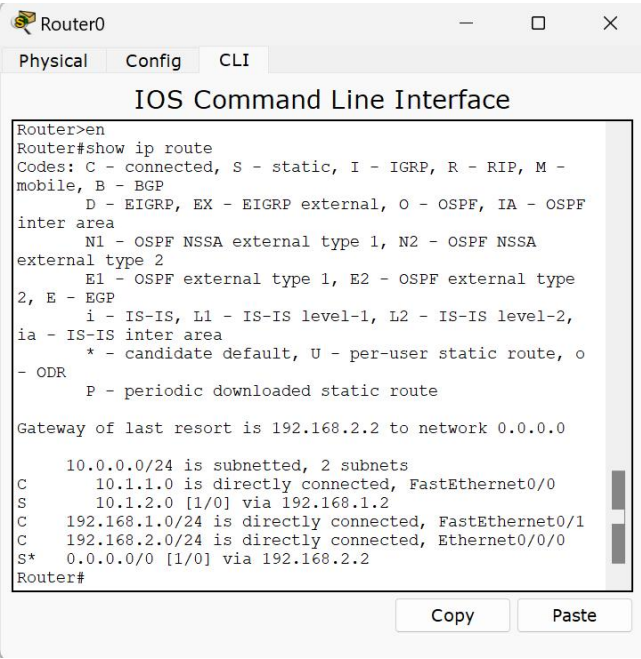
一、实验目的

- 1. 熟悉 IP 的报文格式及关键字段的含义。
- 2. 掌握 IP 地址的分配方法。
- 3. 理解路由器转发 IP 数据报的流程。

二、实验步骤与结果

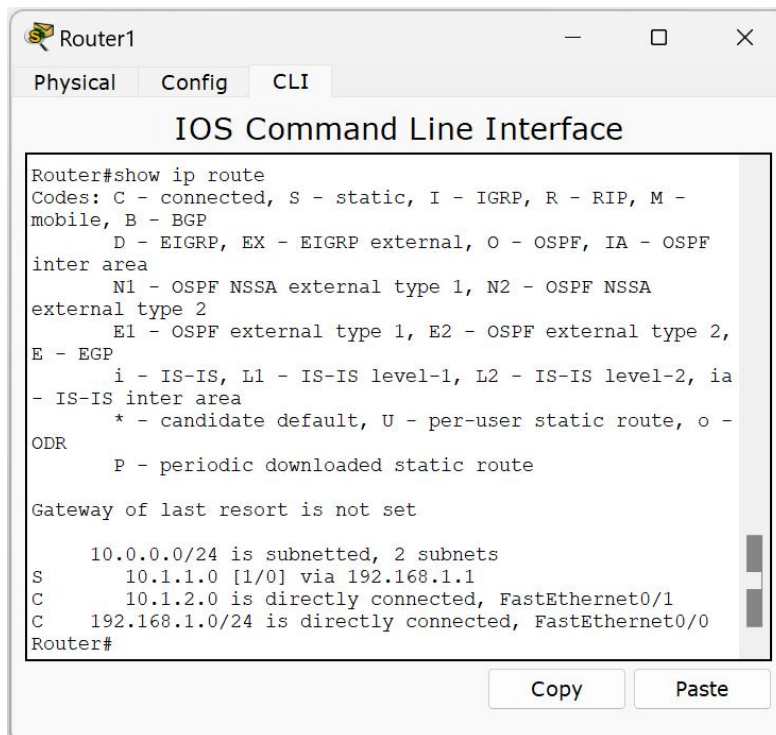
任务一：观察路由表：

1. 观察 Router0 的路由表



S 表示静态路由，C 表示直连路由，*表示默认路由

2. 观察 Router1 的路由表

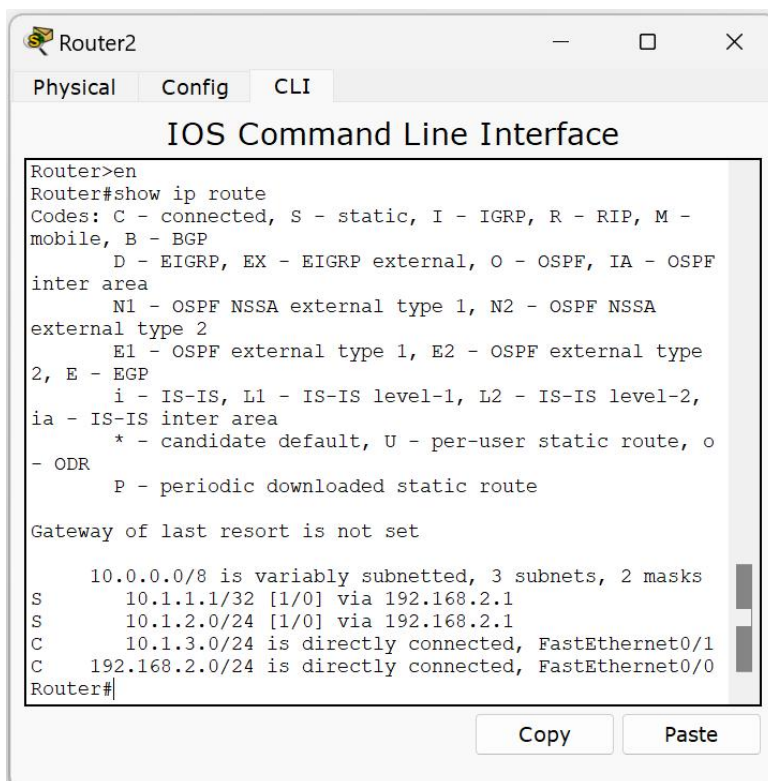


```
Router1
Physical Config CLI
IOS Command Line Interface
Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M -
mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF
inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA
external type 2
E1 - OSPF external type 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, 2 subnets
S 10.1.1.0 [1/0] via 192.168.1.1
C 10.1.2.0 is directly connected, FastEthernet0/1
C 192.168.1.0/24 is directly connected, FastEthernet0/0
Router#
```

3. 观察 Router2 的路由表



```
Router2
Physical Config CLI
IOS Command Line Interface
Router>en
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

10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
S 10.1.1.1/32 [1/0] via 192.168.2.1
S 10.1.2.0/24 [1/0] via 192.168.2.1
C 10.1.3.0/24 is directly connected, FastEthernet0/1
C 192.168.2.0/24 is directly connected, FastEthernet0/0
Router#
```

任务二：观察数据包的封装及字段变化

1. 观察 IP 数据报的内容

PDU Information at Device: Router0

OSI Model

Inbound PDU Details

Outbound PDU Details

PDU Formats

Ethernet II

0 4 8 4 9 tes

101010...1 0001.9 0001.9

011 740.88 6A5.85

TY DATA (VARIABLE FC

DE. LENGTH) S.

IP

0 4 8 6.9 11 its

4 IHL DSCP: IL: 28

ID: 0x3 0x 0x0

TTL: PRO: CHKSUM

SRC IP: 10.1.3.1

DST IP: 10.1.1.1

OPT: 0x0 0x0

DATA (VARIABLE LENGTH)

ICMP

0 8 6 11 its

TYPE: CODE CHECKSUM

ID: 0x9 SEQ

PDU Information at Device: Router0

OSI Model

Inbound PDU Details

Outbound PDU Details

PDU Formats

Ethernet II

0 4 8 4 9 tes

101010...1 0001.9 0050.0

011 627.AD F73.2D

TY DATA (VARIABLE FC

DE. LENGTH) S.

IP

0 4 8 6.9 11 its

4 IHL DSCP: IL: 28

ID: 0x3 0x 0x0

126 PRO: CHKSUM

SRC IP: 10.1.3.1

DST IP: 10.1.1.1

OPT: 0x0 0x0

DATA (VARIABLE LENGTH)

ICMP

0 8 6 11 its

TYPE: CODE CHECKSUM

ID: 0x9 SEQ

观察可以发现，Router0 接收的数据包和发送的数据包的源 IP 和目的 IP 是相同的，但源 MAC 地址和目的 MAC 地址是不同的，发现协议字段 (PRO) 的值为 1，这表明 IP 分组中封装了 ICMP 报文，而且 Outbound PDU 的 TTL 字段被减一。

任务三：观察路由器转发 IP 数据报的方式

1. 初始化并观察路由器的路由表：

Routing Table for Router0				
Type	Network	Port	Next Hop IP	Metric
S	0.0.0.0/0	---	192.168.2.2	1/0
C	10.1.1.0/24	FastEthern...	---	0/0
S	10.1.2.0/24	---	192.168.1.2	1/0
C	192.168.1.0...	FastEthern...	---	0/0
C	192.168.2.0...	Ethernet0/...	---	0/0

Routing Table for Router1				
Type	Network	Port	Next Hop IP	Metric
S	10.1.1.0/24	---	192.168.1.1	1/0
C	10.1.2.0/24	FastEthern...	---	0/0
C	192.168.1.0...	FastEthern...	---	0/0

Routing Table for Router2				
Type	Network	Port	Next Hop IP	Metric
S	10.1.1.1/32	---	192.168.2.1	1/0
S	10.1.2.0/24	---	192.168.2.1	1/0
C	10.1.3.0/24	FastEthern...	---	0/0
C	192.168.2.0...	FastEthern...	---	0/0

2. 观察 PC0 到 PC2 的往返过程

PDU Information at Device: Router0

OSI Model

Inbound PDU Details

Outb

At Device: Router0
Source: PC0
Destination: PC2

In Layers

Out Layers

Layer7

Layer6

Layer5

Layer4

Layer 3: IP Header
Src. IP: 10.1.1.1,
Dest. IP: 10.1.3.1
ICMP Message Type:
8

Layer 2: Ethernet II
Header
0001.9627.AD9B >>
0050.0F73.2D01

Layer 1: Port
FastEthernet0/0

Layer7

Layer6

Layer5

Layer4

Layer 3: IP Header
Src. IP: 10.1.1.1,
Dest. IP: 10.1.3.1
ICMP Message Type:
8

Layer 2: Ethernet II
Header
0001.9740.884A >>
0001.96A5.8501

Layer 1: Port(s):
Ethernet0/0/0

1. The CEF table has an entry for the destination IP address.
2. The device decrements the TTL on the packet.

Challenge Me < Previous Layer ext Layer >

PDU Information at Device: Router2

OSI Model

Inbound PDU Details

Outb

At Device: Router2
Source: PC0
Destination: PC2

In Layers

Out Layers

Layer7

Layer6

Layer5

Layer4

Layer 3: IP Header
Src. IP: 10.1.1.1,
Dest. IP: 10.1.3.1
ICMP Message Type:
8

Layer 2: Ethernet II
Header
0001.9740.884A >>
0001.96A5.8501

Layer 1: Port
FastEthernet0/0

Layer7

Layer6

Layer5

Layer4

Layer 3: IP Header
Src. IP: 10.1.1.1,
Dest. IP: 10.1.3.1
ICMP Message Type:
8

Layer 2: Ethernet II
Header
0001.96A5.8502 >>
0000.0CDC.6176

Layer 1: Port(s):
FastEthernet0/1

1. The CEF table has an entry for the destination IP address.
2. The device decrements the TTL on the packet.

Challenge Me < Previous Layer ext Layer >

PDU Information at Device: Router2

OSI Model

Inbound PDU Details

Outb

At Device: Router2
Source: PC0
Destination: PC2

In Layers

Out Layers

Layer7

Layer6

Layer5

Layer4

Layer 3: IP Header
Src. IP: 10.1.3.1,
Dest. IP: 10.1.1.1
ICMP Message Type:
0

Layer 2: Ethernet II
Header
0000.0CDC.6176 >>
0001.96A5.8502

Layer 1: Port
FastEthernet0/1

Layer7

Layer6

Layer5

Layer4

Layer 3: IP Header
Src. IP: 10.1.3.1,
Dest. IP: 10.1.1.1
ICMP Message Type:
0

Layer 2: Ethernet II
Header
0001.96A5.8501 >>
0001.9740.884A

Layer 1: Port(s):
FastEthernet0/0

1. The CEF table has an entry for the destination IP address.
2. The device decrements the TTL on the packet.

Challenge Me < Previous Layer ext Layer >

PDU Information at Device: Router0

OSI Model

Inbound PDU Details

Outb

At Device: Router0
Source: PC0
Destination: PC2

In Layers

Out Layers

Layer7

Layer6

Layer5

Layer4

Layer 3: IP Header
Src. IP: 10.1.3.1,
Dest. IP: 10.1.1.1
ICMP Message Type:
0

Layer 2: Ethernet II
Header
0001.96A5.8501 >>
0001.9740.884A

Layer 1: Port
Ethernet0/0/0

Layer7

Layer6

Layer5

Layer4

Layer 3: IP Header
Src. IP: 10.1.3.1,
Dest. IP: 10.1.1.1
ICMP Message Type:
0

Layer 2: Ethernet II
Header
0050.0F73.2D01 >>
0001.9627.AD9B

Layer 1: Port(s):
FastEthernet0/0

1. The CEF table has an entry for the destination IP address.
2. The device decrements the TTL on the packet.

Challenge Me < Previous Layer ext Layer >

3. 观察 PC2 到 PC1 的往返过程

PDU Information at Device: Router1

OSI Model

Outbound PDU Details

At Device: Router1

Source: Router1

Destination: PC2

In Layers

Out Layers

Layer7

Layer7

Layer6

Layer6

Layer5

Layer5

Layer4

Layer4

Layer3

Layer 3: IP Header Src. IP: 10.1.2.254, Dest. IP: 10.1.2.1 ICMP Message Type: 3 ICMP Message Type: 0

Layer2

Layer 2: Ethernet II Header 0000.0CE1.1D02 >> 0060.5C5B.154E

Layer1

Layer 1: Port(s): FastEthernet0/1

1. The device sends back an ICMP Host Unreachable message.

2. The device looks up the destination IP address in the CEF table.

3. The CEF table has an entry for the destination IP address.

Challenge Me

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显示“主机无法达到”的错误报告，由于 Router1 没有 10.1.3.0/24 的路由，也没有默认路由，因此 PC2 回复的数据报会被 Router1 丢弃。

任务四：观察 IP 分片过程

PDU Information at Device: Router0

OSI Model

Outbound PDU Details

At Device: Router0

Source: Router0

Destination: 10.1.3.1

In Layers

Out Layers

Layer7

Layer7

Layer6

Layer6

Layer5

Layer5

Layer4

Layer4

Layer3

Layer 3: IP Header Src. IP: 192.168.2.1, Dest. IP: 10.1.3.1

Layer2

Layer 2: Ethernet II Header 0001.9740.884A >> 0001.96A5.8501

Layer1

Layer 1: Port(s): Ethernet0/0/0

1. The Ping process starts the next ping request.

2. The Ping process creates an ICMP Echo Request message and sends it to the lower process.

3. The device encapsulates the data into an IP packet.

4. The device sets the TTL on the packet.

5. The device looks up the destination IP address in the CEF table.

6. The CEF table has an entry for the destination IP address.

7. Total length of the packet (1528 bytes) is greater than the IP MTU (1500 bytes). This datagram is fragmented.

8. The device sends an IP fragment with the FO 0, a payload length 1480 bytes, and a total length 1500 bytes.

Challenge Me

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Next Layer >>

PDU Information at Device: Router0

OSI Model

Outbound PDU Details

At Device: Router0

Source: Router0

Destination: 10.1.3.1

In Layers

Out Layers

Layer7

Layer7

Layer6

Layer6

Layer5

Layer5

Layer4

Layer4

Layer3

Layer 3: IP Header Src. IP: 192.168.2.1, Dest. IP: 10.1.3.1 ICMP Message Type: 8

Layer2

Layer 2: Ethernet II Header 0001.9740.884A >> 0001.96A5.8501

Layer1

Layer 1: Port(s):

1. The device sends an IP fragment with the FO 1480, a payload length 28 bytes, and a total length 48 bytes.

Challenge Me

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可以发现由于数据报长度超过了以太网帧的负载上限，被拆分成了两个数据报，一个长度为 1500 字节，一个长度为 48 字节。

思考题：

(1) 一个 IP 分组经路由器转发后，有哪些字段会发生变化？

源 MAC 地址和目的 MAC 地址，TTL 值，校验和

(2) 任务二的步骤 2 中，为什么数据单元的源 MAC 地址和目的 MAC 地址在转发时会发生变化？

当数据单元进行转发时，会根据发送端口和进入端口的 MAC 值，来更新数据单元的源 MAC 地址和目的 MAC 地址，因此在转发时会发生改变。

(3) 路由器如何处理无法继续转发数据包？

由于路由器中的路由表中没有与之匹配的路由，或目标网络不可达，会将数据包丢弃，并返回 ICMP 差错报文。

(4) 任务四为什么将 Size 值改为 1500 就可以产生分片？

因为虽然发送的 IP 数据报的大小为 1500，但是封装成以太网帧时还会添加一些控制信息，整个数据包的大小会超过 1500，进而产生分片。

(5) 为什么任务四中的两个分片的长度分别为 1500 和 48？

IP 数据报的首部信息占 20Bytes，ICMP 的首部信息占 8bytes，第一个分片的 IP 数据（不含头部）占 1472bytes，剩下的 28bytes 被分配到了下一个分片，加上 20bytes 的 IP 首部信息，共 28bytes，而 ICMP 的首部信息只在第一个分片中，第二个分片并没有。